ΠΑΝΕΠΙΣΤΗΜΙΟ
ΠΕΛΟΠΟΝΝΗΣΟΥ
Η επένδυση στη γνώση

QUANTIFICATION OF COMPETITIVE BALANCE IN PROFESSIONAL TEAM SPORTS; IMPLEMENTATION AND EMPIRICAL INVESTIGATION IN EUROPEAN FOOTBALL

VASILEIOS MANASIS
DEPARTMENT OF SPORTS MANAGEMENT
UNIVERSITY OF PELOPONNESE

A THESIS SUBMITTED FOR THE
DEGREE OF
DOCTOR OF PHILOSOPHY
AT THE UNIVERSITY OF PELOPONNESE
2012

to Dimitra who believed in this endeavor

QUANTIFICATION OF COMPETITIVE BALANCE IN PROFESSIONAL TEAM SPORTS; IMPLEMENTATION AND EMPIRICAL INVESTIGATION IN EUROPEAN FOOTBALL

Vasileios Manasis
Department of Sport Management, University of Peloponnese
Doctor of Philosophy in Sport Management
Sparta 2012

Supervisors: Vassiliki Avgerinou, Ioannis Ntzoufras, J.James Reade

Thesis Abstract

Competitive balance is an important concept for professional team sports and one of the key issues European football has to address in order to ensure its long-term success. The quantification of competitive balance is a complicated issue, which is mainly associated with its multi-dimensionality aspect as well as the structure of a particular sport. The aim of the present thesis is to provide a systematic approach to an enhanced quantification of competitive balance in professional team sports with particular emphasis on European football.

An essential element of this thesis is the identified three-levelled structure of European football leagues offering multiple prizes. In particular, the first level refers to the competition for the championship title which is considered the most prestigious prize in any league. The second level refers to the qualifying places for European tournaments of the following season. Those tournaments, the lucrative Champions League and the recently restructured Europa League, offer reputation and, most importantly, high monetary prizes and bonuses. Therefore, over and above the championship title, teams also compete for any of the remaining pre-determined top places. Finally, the third level draws attention to the relegation places. Given that European leagues are open, teams that occupy the last league positions are relegated to lower league. Such a demotion has serious repercussions for both the financial status and the prestige of the relegated teams. Consequently, teams strive to avoid relegation and view succeeding in this objective as success in its own right.

In this context, the main issue arising for the quantification analysis is the fact that existing indices measuring competitive balance have not been derived to capture this complex structure of European football. Consequently, our study initially focuses on the examination of all existing indices, the modification of some of them, and the development of special indices for both the seasonal and the between-seasons dimension of competitive balance. The design of new indices is based on an averaging approach and is inspired by the necessity to quantify the competition for each level and rate ranking positions according to their significance for fans. The approach followed, also enables for a comprehensive analysis by creating new bi-dimensional indices that capture both dimensions of competitive balance.

Following that, a methodological framework is constructed for an in-depth exploration of all indices behaviour using an innovative sensitivity analysis followed by an empirical investigation. The sensitivity analysis unveils features of the indices that are not easily distinguishable and indicates their main positive and negative features in the context of the European football league structure. Based on the findings, the indices exhibit diverse behaviour, which illustrates the different aspects of competitive balance they capture. The usefulness of the new composite single-dimensional partial indices is identified while what is also implied is the optimality of the corresponding more comprehensive new bi-dimensional indices.

The empirical analysis provides a powerful guidance and standardization about the practical issues of the competitive balance indices using various statistical methods. Results from the empirical research are associated with the conclusions derived from the sensitivity analysis. Using data from eight European leagues for a period of 45-50 seasons, the large number of the calculated indices (25 in total) unveils interesting facts concerning the historical behaviour of competitive balance in European football. The value of competitive balance greatly differs among the investigated European leagues. In particular, Swedish is the most competitive league followed by Norwegian, French, and German; the ranking continues with English and Italian leagues while Belgian and Greek are the least competitive ones. In general, based on the trend analysis, a worsening of competitive balance though seasons, more notably during the last decade 1999-2008, is also reported. We also found that regardless of the outcome uncertainty during the season, the stronger team finally prevails. Moreover, the ranking in the previous season determines more the success for the championship title than the success for escaping relegation. Lastly, the effectiveness of the promotion-relegation rule in promoting competitive balance and the absence of competition for the championship title are also confirmed.

A reparemeterised *Autoregressive Distributed Lag* (*ADL*) pooled regression econometric model, using the *Estimated Generalised Least Squares - Seemingly Unrelated Regressions* (*EGLS-SUR*) method, has been constructed to determine both the importance of the concept of competitive balance and the relative significance of all discussed indices. Our findings support the assumption of the longstanding "*Uncertainty of Outcome Hypothesis*" (*UOH*) that, in the context of the complex structure of European football, competitive balance affects fan's behaviour manifested by their demand for attending league games. Moreover, our assumption that the averaging approach captures aspects of competitive balance that, although they are important for fans, have so far not been taken into consideration is also supported. Both the seasonal and the between-seasons dimensions are found to be significant, although the latter is shown to have a slightly greater effect on attendance. The relative significance of levels and ranking positions greatly varies as designated by the weighting pattern offered by the optimal *Special Dynamic Concentration* (SDC_K^I) index, which captures all three levels in both dimensions. Explanations derived from the econometric analysis can facilitate policy makers in their effort to preserve the viability of European football leagues, which is threatened by the worsening values of competitive balance.

ΠΟΣΟΤΙΚΟΠΟΙΗΣΗ ΤΗΣ ΑΓΩΝΙΣΤΙΚΗΣ ΙΣΟΡΡΟΠΙΑΣ ΣΤΑ ΕΠΑΓΓΕΛΜΑΤΙΚΑ ΟΜΑΔΙΚΑ ΑΘΛΗΜΑΤΑ: ΕΦΑΡΜΟΓΗ ΚΑΙ ΕΜΠΕΙΡΙΚΗ ΕΞΕΤΑΣΗ ΣΤΟ ΕΥΡΩΠΑΪΚΟ ΠΟΔΟΣΦΑΙΡΟ

Βασίλειος Μανασής
Τμήμα Οργάνωσης και Διαχείρισης Αθλητισμού, Πανεπιστήμιο Πελοποννήσου
Διδάκτωρ στην Οργάνωση και Διοίκηση Αθλητικών Οργανισμών και Επιχειρήσεων
Σπάρτη 2012

Επιβλέποντες καθηγητές: Βασιλική Αυγερινού, Ιωάννης Ντζούφρας, J.James Reade

Περίληψη Διατριβής

Η αγωνιστική ισορροπία είναι μια σημαντική έννοια στα επαγγελματικά ομαδικά αθλήματα και ένα από πιο σημαντικά ζητήματα που πρέπει να διευθετήσουν οι ιθύνοντες του Ευρωπαϊκού ποδοσφαίρου προκειμένου να διασφαλίζεται η επιτυχία του μακροπρόθεσμα. Η ποσοτικοποίηση της αγωνιστικής ισορροπίας συνιστά περίπλοκο ζήτημα το οποίο σχετίζεται κυρίως με την πολυδιάστατη σύστασή της αλλά και με την δομή κάθε αθλήματος. Σκοπός της παρούσας διατριβής είναι να συμβάλει στην συστηματική και ακριβέστερη ποσοτικοποίηση της αγωνιστικής ισορροπίας στα επαγγελματικά ομαδικά αθλήματα δίδοντας ιδιαίτερη έμφαση στο Ευρωπαϊκό ποδόσφαιρο.

Βασικό στοιχείο της διατριβής είναι η διαπίστωση ότι οι Ευρωπαϊκές λίγκες ποδοσφαίρου είναι δομημένες σε τρία επίπεδα και προσφέρουν πολλαπλά έπαθλα. Ειδικότερα, στο πρώτο επίπεδο το ενδιαφέρον εστιάζεται στον ανταγωνισμό για την ανώτερη διάκριση, δηλαδή τον τίτλο της πρωταθλήτριας ομάδας, που θεωρείται κατ' εξοχήν έπαθλο γοήτρου. Στο δεύτερο επίπεδο ο στόχος επικεντρώνεται στις βαθμολογικές θέσεις που οδηγούν στην συμμετοχή σε Ευρωπαϊκές διοργανώσεις κατά την επόμενη αγωνιστική περίοδο. Σημειωτέον ότι η συμμετοχή στο Champions League και στο αναδομημένο Europa League προσφέρει, εκτός από φήμη, υψηλά χρηματικά έπαθλα και bonuses και κατά συνέπεια, ο ανταγωνισμός μεταφέρεται από τον τίτλο του πρωταθλητή στις αμέσως επόμενες υψηλές και προκαθορισμένου αριθμού βαθμολογικές θέσεις. Τέλος, στο τρίτο επίπεδο το ενδιαφέρον στρέφεται στις βαθμολογικές θέσεις που οδηγούν στον υποβιβασμό. Δεδομένου ότι οι Ευρωπαϊκές λίγκες είναι "ανοικτές" στην δομή τους, οι ομάδες που καταλαμβάνουν τις τελευταίες βαθμολογικές θέσεις υποβιβάζονται σε υποδεέστερη λίγκα. Ο υποβιβασμός προκαλεί σοβαρές επιπτώσεις τόσο σε οικονομικό επίπεδο όσο και στο γόητρο των ομάδων. Συνεπώς, οι ομάδες μάχονται για την αποφυγή του υποβιβασμού πράγμα το οποίο, αυτό καθ' εαυτό, συνιστά επιτυχία.

Σε αυτό το πλαίσιο, το κυρίαρχο ζήτημα για την ποσοτική ανάλυση είναι ότι οι υπάρχοντες δείκτες μέτρησης της αγωνιστικής ισορροπίας δεν λαμβάνουν υπ' όψιν την σύνθετη αυτή δομή του Ευρωπαϊκού ποδοσφαίρου. Αρχικά επικεντρώσαμε στην εξέταση των υπαρχόντων δεικτών, στην τροποποίηση μερικών εξ' αυτών και στην δημιουργία ειδικών δεικτών για τις δύο διαστάσεις της αγωνιστικής ισορροπίας τόσο για την διάσταση που αναφέρεται σε μια αγωνιστική περίοδο (seasonal) όσο και για

την διάσταση που αναφέρεται σε δύο ή περισσότερες αγωνιστικές περιόδους (between-seasons). Ο σχεδιασμός των νέων δεικτών που βασίζεται σε μέθοδο μέσων όρων και εμπνέεται από την αναγκαιότητα ποσοτικοποίησης του ανταγωνισμού για κάθε επίπεδο, αποτιμά τις βαθμολογικές θέσεις ανάλογα με την σημασία που τους προσδίδουν οι φίλαθλοι. Η προσέγγιση που ακολουθείται δίνει την δυνατότητα για μια περιεκτική ανάλυση με την δημιουργία δισδιάστατων δεικτών που καλύπτουν, ταυτοχρόνως, και τις δύο διαστάσεις αγωνιστικής ισορροπίας.

Στην συνέχεια, σχεδιάστηκε ένα μεθοδολογικό πλαίσιο για την διερεύνηση της συμπεριφοράς όλων των δεικτών και χρησιμοποιήθηκε μια ανάλυση ευαισθησίας σε συνδυασμό με την εμπειρική εξέταση. Η ανάλυση ευαισθησίας αποκαλύπτει δυσδιάκριτα χαρακτηριστικά των δεικτών και υποδεικνύει τα κύρια θετικά και αρνητικά σημεία τους στο πλαίσιο της σύνθετης δομής του Ευρωπαϊκού ποδοσφαίρου. Βάσει των ευρημάτων, οι δείκτες παρουσιάζουν διαφορετική συμπεριφορά η οποία εμφανώς δείχνει ότι καλύπτουν διαφορετικές όψεις της αγωνιστικής ισορροπίας. Αναγνωρίζεται, εξάλλου, ότι οι νέοι μονοδιάστατοι μερικής -εφαρμογής και σύνθετης δομής- δείκτες είναι χρήσιμοι αλλά ταυτοχρόνως υποδηλώνεται ότι οι αντίστοιχοι δισδιάστατοι και πιο περιεκτικοί δείκτες είναι οι καταλληλότεροι.

Με την χρήση διαφόρων στατιστικών μεθόδων, η εμπειρική ανάλυση παρέχει ασφαλή οδηγό και προτυποποίηση για τα πρακτικά ζητήματα της αγωνιστικής ισορροπίας. Τα αποτελέσματα της εμπειρικής έρευνας συσχετίζονται με τα συμπεράσματα της ανάλυσης ευαισθησίας. Ο υπολογισμός μεγάλου αριθμού δεικτών (25 στο σύνολό τους) από δεδομένα οκτώ Ευρωπαϊκών χωρών και για 45-50 αγωνιστικές περιόδους, αποκαλύπτει ενδιαφέροντα στοιχεία για την ιστορική συμπεριφορά της αγωνιστικής ισορροπίας στο Ευρωπαϊκό ποδόσφαιρο. Οι τιμές της αγωνιστικής ισορροπίας διαφέρουν αρκετά ανάμεσα στις υπό εξέταση Ευρωπαϊκές λίγκες. Ειδικότερα, η Σουηδική είναι η πιο ανταγωνιστική από τις λίγκες και ακολουθούν η Νορβηγική, η Γαλλική και η Γερμανική. Στην κατάταξη έπονται η Αγγλική και η Ιταλική ενώ η Βελγική και η Ελληνική είναι οι λιγότερο ανταγωνιστικές. Σε γενικές γραμμές, με βάση την ανάλυση τάσης, αναφέρεται επιδείνωση της αγωνιστικής ισορροπίας η οποία γίνεται εμφανέστερη κατά την τελευταία δεκαετία 1999-2008. Βρέθηκε ακόμη ότι ανεξάρτητα από την αβεβαιότητα για τα αποτελέσματα κατά την διάρκεια της αγωνιστικής περιόδου, στο τέλος επικρατεί η δυνατή ομάδα. Επιπλέον, η κατάταξη της προηγούμενης περιόδου καθορίζει περισσότερο την κατάκτηση του πρωταθλήματος παρά την παραμονή στην κατηγορία. Τέλος, επιβεβαιώνεται η αποτελεσματικότητα του μέτρου “προβιβασμός-υποβιβασμός” για την βελτίωση της αγωνιστικής ισορροπίας και η έλλειψη ανταγωνισμού για τον τίτλο του πρωταθλητή.

Για τον προσδιορισμό της σπουδαιότητας της έννοιας της αγωνιστικής ισορροπίας και της σχετικής σημασίας όλων των εξεταζόμενων δεικτών κατασκευάστηκε ένα οικονομετρικό μοντέλο με βάση την αναπαραμετροποιημένη *Αυτοπαλίνδρομη Κατανεμημένης Υστέρησης* (*Autoregressive Distributed Lag*) σωρευτική παλινδρόμηση. Για την εκτίμηση του μοντέλου χρησιμοποιήθηκε η μέθοδος του *Γενικευμένου Εκτιμητή Ελαχίστων Τετραγώνων - Φαινομενικά μη Συνδεόμενων Παλινδρομήσεων* (*Estimated Generalised Least Squares - Seemingly Unrelated*

Regressions). Τα ευρήματα στηρίζουν την καθιερωμένη "*Uncertainty of Outcome Hypothesis*" (*UOH*), δηλαδή, ότι στο πλαίσιο της σύνθετης δομής του Ευρωπαϊκού ποδοσφαίρου, η αγωνιστική ισορροπία επηρεάζει την συμπεριφορά των φιλάθλων που εκδηλώνεται με την προσέλευσή τους στους αγώνες. Επιπλέον, στηρίζεται η υπόθεσή μας ότι η μέθοδος μέσων όρων καλύπτει όψεις της αγωνιστικής ισορροπίας που δεν είχαν έως τώρα μελετηθεί αν και σημαντικές για τους φιλάθλους. Από την ανάλυση προκύπτει επίσης ότι και οι δύο διαστάσεις είναι σημαντικές παρά το γεγονός ότι αυτή που αναφέρεται σε περισσότερες αγωνιστικές περιόδους έχει ελαφρώς μεγαλύτερη επίδραση στην προσέλευση στο γήπεδο. Η σχετική σημασία των επιπέδων και των βαθμολογικών θέσεων ποικίλλει αρκετά όπως καταδεικνύεται από το σταθμισμένο πρότυπο που προσφέρεται από τον καταλληλότερο δείκτη *Special Dynamic Concentration* (SDC_K^I) ο οποίος καλύπτει ταυτοχρόνως τα τρία επίπεδα και τις δύο διαστάσεις. Τα αποτελέσματα που απορρέουν από την οικονομετρική ανάλυση θα μπορούσαν, αν ληφθούν υπ' όψιν, να διευκολύνουν τους διοικούντες στην προσπάθειά τους να εξασφαλίσουν την βιωσιμότητα των Ευρωπαϊκών λιγκών που απειλούνται από τις επιδεινούμενες τιμές της αγωνιστικής ισορροπίας.

Acknowledgments

This PhD writing, which is a lonely and isolating experience, is a testimony to my belief in life that “everything is possible”, cultivated from childhood. However, this work would not have been completed without the personal and practical support of many significant contributors.

My thanks go first to the members of my thesis committee Vassiliki Avgerinou, Ioannis Ntzoufras, and James Reade for providing crucial practical guidance, helpful suggestions, and constructive comments. I am truly indebted and heartily grateful to their willingness to help me out. Without their continuous mentoring and knowledge of research method, this study could not have been successfully accomplished.

The opportunity to pursue postgraduate studies did not arise from nowhere, and I owe sincere and earnest thankfulness to Prof. Konstantinos Mountakis for his motivation and invaluable advice.

I would like to extend my special appreciation to Prof. Stefan Kesenne for his insightful suggestions and challenging advices upon visiting his office in Antwerp.

I would like express my gratitude to all those who in one way or another contributed to the successful completion of this work.

The financial aid and sabbatical leave granted by the Ministry of Education is gratefully acknowledged.

Many thanks go to my close friend Leonidas Karaiskos for his enthusiasm, and numerous supportive calls, and Ioannis Skaligos for his faith, and continuous encouragement.

Finally, I want to thank my family for their love, and emotional support throughout the six years of my effort.

Contents

List of Tables

List of Figures

List of Abbreviations

FIFA	Fédération Internationale de Football Association
MLB	Major League Baseball
NFL	National Football League
UEFA	Union of European Football Associations

List of Indices and Notations

ACR_K	*Adjusted Concentration Ratio*
ADC_K	*Adjusted Dynamic Concentration*
ADN_K	*Adjusted Dynamic Index*
AH	*Adjusted Entropy*
aG	*Adjusted G Index*
$AGINI$	*Adjusted Gini Coefficient*
ADF	Augmented Dickey-Fuller unit root test
ADL	Autoregressive Distributed Lag
CR	*Concentration Ratio*
DC^I	*Dynamic Concentration for Relegated Team*
DC_1	*Dynamic Concentration for the Champion*
DN_K	*Dynamic Index*
DN^I	*Dynamic Index for Relegated Teams*
DN_1	*Dynamic Index for the Champion*
H	*Entropy Index*
$EGLS$	Estimated Generalised Least Squares
G	*G* index
HHI	*Herfindahl-Hirschman Index*
ISD	*Ideal Standard Deviation of Winning Percentages*
ID	*Index of Dissimilarity*
DN_t^*	*Index of Dynamics*
τ	*Kendall's tau Coefficient*
MLE	Maximum Likelihood Estimation
MA	Moving Average
$NAMSI$	*National Measure of Seasonal Imbalance*
NCR_K	*Normalised Concentration Ratio*
NCR^I	*Normalised Concentration Ratio for Relegated Teams*
NCR_1	*Normalised Concentration Ratio for the Champion*
nCB_{qual}	*Normalised Quality Index*
HHI^*	*Normalized Herfindahl-Hirschman Index*
nID	*normalized Index of Dissimilarity*
n	Number of Domestic Football Leagues or Countries
P	Number of Points
I	Number of Relegated Teams
N	Number of Teams in the League
K	Number of Top Teams
T	Number of years of seasons
OLS	Ordinary Least Squares
PP	Philips-Perron unit root test

RSD	*Ratio of Standard Deviation*
w_r	*Ratio of Wins to the Total Number of Games*
R	*Relative Entropy*
SUR	Seemingly Unrelated Regressions
r_s	*Spearman's rho*
SCR_K^I	*Special Concentration Ratio*
SDC_K^I	*Special Dynamic Concentration*
SDN_K^I	*Special Dynamic Index*
SD	Standard Deviation
STD	*Standard Deviation of Winning Percentages*
WSD	*STD* in Complete Imbalance
S	*Surprise Index*
w	Winning Percentage
s	Winning Share

Chapter 1. Competitive Balance and the Aim of the Thesis

"*The nature of the industry (of baseball) is such that competitors must be of approximate equal size if any are to be successful*" (Rottenberg, 1956, p. 242).

In his seminal article, Rottenberg (1956), one of the initiators of the economic analysis of sport, made an apt description of the concept of competitive balance when he argued that it is a unique attribute of professional team sports. The importance of competitive balance derives from the fact that it creates an uncertainty of outcome, which instigates the interest of sport fans leading to an increased demand for sport events (El-Hodiri & Quirk, 1971; Rottenberg, 1956). Since competitive balance is such an important concept for professional team sports, it has become a prominent topic of study in sports economics; yet, its quantification still remains an issue. According to Zimbalist (2003), the problem arises from the fact that competitive balance is a multidimensional phenomenon. Therefore, a single index does not yet exist that can captures all its aspects. Moreover, any optimal measure has to be important from the fans' perspective and may differ from sport to sport.

In our view, part of the problem is due to the way the quantification of competitive balance in professional team sports has been approached. The aim of the present study is to provide a systematic approach for an enhanced quantification which is justified both from the perspective of the importance of the concept and of the proliferation of related indices proposed in the literature. This study focuses on the implementation and the empirical investigation in European football, thus meeting the need for advanced knowledge in this field. This is concerned with the fact that association football (soccer) is the only truly global sport, competitive balance is one of the key issues the industry in Europe has to address in order to ensure its long-term success, and lastly, current research into the characteristics of the European football structure is quite limited.

The remainder of this chapter is organized as follows: the next Section 1.1 attempts to elucidate the concept of competitive balance by presenting its definition and discussing its dimensions, followed by the analysis of its importance. Section 1.2 introduces the aim of the thesis and provides a detailed methodological framework. This introductory chapter closes with a description of the structure of this thesis presented in Section 1.3.

1.1 The Concept of Competitive Balance

The majority of Academic Research in the field of sports economics has been focused on exploring theoretical aspects and the importance of competitive balance. Since it has motivated a considerable amount of sports economics publications, various definitions have been introduced to specify the notion of competitive balance. To clearly describe the concept of competitive balance, an extensive analysis of its proposed underlying dimensions is also presented enlightening various aspects of the notion. Moreover, to validate the importance of the concept, some of the most important theoretical propositions in the field are presented and reviewed in detail.

1.1.1 Definition of Competitive Balance

Although competitive balance is a very important topic for professional team sports, it is hard to fully describe the concept since numerous definitions have appeared in the relevant literature. In our view, part of the problem lies in the remark that that the mechanism by which competitive balance asserts its importance is rather complex (Szymanski & Zimbalist, 2005, p. 174).

Topkis (1949), one of the first workers on the issue of competition in team sports, referred to the notion of competitive balance indirectly as he put forth the question: "*If one club buys all the big talents, who is going to pay to watch them playing against the other teams in the league?*". Moreover, he pointed out that sports competition seems to offer far more than it threatens. Each club tries to buy the best players to put together a perfect team, but at the same time not "*too perfect*" one, since "*there would be no money in it*" (Topkis, 1949, p. 708). Neale (1964, p. 2) states that for those participating in a professional championship the phrase "*Oh*

Lord, make us good, but not that good", must be their prayer. He also underlines the importance of the teams' standings differences over several years in his well-known work for the "*League Standing Effect*" (p.5).

In order to preserve the viability of the whole organisation, Jones (1969) uses the term "competitive equality" and employs the concept of competitive balance as the "equilibrium" position of every club which is a member of the league. El-hodiri and Quirk (1971) in their model investigate the issue of "equalization of the competitive playing strengths" as a fundamental distinct feature of the industry of sports. Similarly, Cairns (1987) emphasises the homogeneity of teams with respect to athletic skill while Jassens and Kessene (1986) introduce the term "sporting equality". According to Lenten (2009), competitive balance simply refers to the degree of evenness in sports leagues. In the same way, the degree of equality of playing strengths of teams is a central concept in the economic analysis of professional sports leagues (Owen, Ryan, & Weatherston, 2007).

The term "uncertainty of outcome" has been widely used and discussed as a central feature in sports economics literature (Borland & MacDonald, 2003; Cairns, Jennett, & Sloane, 1986; Humphreys, 2002). The terms "uncertainty of outcome" and "competitive balance" tend to be used exchangeably by many sports economists. Outcome uncertainty and competitive balance are positively related; the more uncertain the outcome, the greater competitive balance is in a league (Lee & Fort, 2008). However, despite being closely related, Kringstad & Gerrard (2007) argue that the two concepts are not exactly equivalent and should be differentiated. They propose that uncertainty of outcome should be narrowly defined as the probability distribution for the alternative outcomes (ex ante) of a specified sporting contest while competitive balance should be considered a more general concept, which also refers to the distribution of actual sporting outcomes (ex post).

A further popular term widely employed in sports economics is "parity" (Cain & Haddock, 2006; Mizak, Stair, & Rossi, 2005). Depken II (1999) uses the term "parity among teams" to describe competitive balance whereas Gladden and Sutton (2003) argue that "parity" refers to the fact that every team has a legitimate chance to win the championship based on the resources available. Using a similar definition, Leeds and von Allmen (2008) describe competitive balance as the "degree of parity" in a league.

Palomino and Rigotti (2000, p. 2) state that "*the more symmetric the winning chances of the competitors the more exciting the tournament is to watch*" and employ the term "*symmetry among teams*" to describe competitive balance which also refers to the expectations of fans regarding to the winner. In a perfectly balanced league fans believe all outcomes are equally possible; therefore, there is a full or complete outcome uncertainty. In a perfectly unbalanced league, the winner is known ex ante with probability one (Buzzacchi, Szymanski, & Valletti, 2003).

In the present thesis, the definition offered by Mitchie and Oughton (2004) is adopted. According to them, competitive balance is literally the balance between the sporting capabilities of teams. The above implies that the more evenly balanced the competitive strengths of the competing teams, the more uncertain is the outcome of each match, and therefore (in the long-term) the outcome concerning championship winner.

1.1.2 The Dimensions of Competitive Balance

The concept of competitive balance is multi-faceted. Consequently, in order to clarify the concept, it is important to offer a detailed presentation of the dimensions along with the factorizations discussed in the literature (see Table 1.1). Sloane (1971), the first observed the simplest two-dimensional factorization of competitive balance, reported as dimensions: 1) the short-run uncertainty that basically concerns competitive balance within a season, and 2) the long-run uncertainty that concerns the domination of the league across seasons by a small group of teams. He emphasised that the latter may shrink fans' interest and eventually lower attendance. A slightly altered classification has been used by Jennett (1984) who comments that there are complicating issues for the measurement of the short-run uncertainty which is determined by the closeness of overall league competition. In particular, he emphasized that games have little significance for the overall outcome at the beginning of the championship but they have more significance towards the end of the season.

Similarly, Szymanski and Zimbalist (2005) also refer to two dimensions of competitive balance, which could be interesting for fans: 1) the ‘within-season’ and 2) the ‘between-season’. The former is important because fans of both weak and strong teams could lose interest in the event of big discrepancies in the relative performances during the season, while the latter may have more severe consequences due to repeatedly successful or failed performances by the same teams. Fort (2003) also refers to those two dimensions using the terms ‘seasonal’ and ‘between-season’ competitive balance while Booth (2005) mentions the ‘within season’ and ‘between seasons’ type. The ‘within season’ focuses on the relative quality of teams in the course of a particular season while the ‘between seasons’ focuses on the relative quality of teams across seasons. The same distinction has been followed by Leeds and von Allmen (2008), who pointed out that the “between seasons” competitive balance refers to team’s specific variation and is related with the opportunity each team has to move up in the standings each year. Finally, according to Hadley, Cieka and Krautmann (2005), the two dimensions of competitive balance are the ‘single-season’ and the ‘inter-seasonal’ dimension. They argue that fans’ interest spans seasons and, as a result, inter-seasonal balance has an effect on demand.

Cairns (1987), offers a three-dimensional factorization of competitive balance by adding the shortest dimension that refers to outcome uncertainty for individual games. In particular, Cairns (1987) distinguishes three temporal forms of outcome uncertainty: 1) for individual games, 2) for the championship, and 3) for the absence of long-run domination of the championship by the same club. The same distinction has been followed by Szymanski (2003), who clearly defines the three dimensions of competitive balance as follows: 1) ‘match uncertainty’, which simply refers to the expectations from a particular game; 2) ‘seasonal uncertainty’, which refers to the closeness of the championship race within a season, and 3) ‘championship uncertainty’, which is the variation of champions over a period of years. This categorisation of competitive balance has also been followed by several others

(Buzzacchi et al., 2003; Goossens, 2006; Kesenne, 2007; Lee & Fort, 2008; Lenten, 2009; Michie & Oughton, 2004; Szymanski & Kuypers, 1999). In the course of the past few years a similar factorisation has emerged, which also makes reference to three different time dependent dimensions; 1) 'match', 2) 'seasonal' or 'medium', and 3) 'long-run' or 'inter-seasonal' dimension (Borland & MacDonald, 2003; Brandes & Franck, 2007; Czarnitzki & Stadtmann, 2002; Quirk & Fort, 1997).

A different three-dimensional approach has been followed by Kringstad and Gerrard (2007) who describe as dimensions of competitive balance: 1) the 'win dispersion', which relates to the distribution of wins between teams, 2) the 'performance persistence', which is the relationship of the win-loss records between seasons, and 3) the 'prize concentration', which refers to the prize-distribution between teams across seasons. Lastly, Vrooman (1996), points out that the three interrelated dimensions of competitive balance are: 1) the 'within-season' closeness, 2) the 'dominance of large-market clubs', and 3) the 'continuity of performance' between seasons. The last one is considered by Vrooman (1996) as the most important.

A more complicated four-dimensional factorization is given by Cairs, Jennet and Sloane (1986). Firstly, they refer to match uncertainty (1), which receives its clearest statement by El-Hodiri and Quirk (1971). They denote the probability of the home team for a win as p and the uncertainty of outcome associated with the match as p(l-p). As p moves away from one or zero, uncertainty increases reaching its maximum for p equal to 0.5. This is valid only when two possible results exist: win or lose (e.g. in basketball). The second and third dimensions refer to the short-run uncertainty of seasonal outcome. In particular, the second concerns closeness of the league (2) while the third dimension takes into account the significance of the games (3) as measured by Jennet (1984). Finally, the fourth dimension is the long-run uncertainty (4); for this last dimension (mentioned also in the previous paragraph) they additionally comment that supporters from both the successful and the non-successful teams may lose interest in cases of long-run domination by only one team.

Based on the above discussion, in our analysis we will employ the popular three-dimensional factorization of competitive balance, which contains the following dimensions:

(1) 'Match uncertainty'

(2) 'Seasonal'

(3) 'Between-seasons'

Table 1.1: Dimensions of Competitive Balance

Number of Dimensions	*Study*	*Dimensions*			
two	Sloane (1971) Fort (2003) Szymanski and Booth (2005) Hadley et al. (2005) Zimbalist (2005) Leeds and von Allmen (2008)			seasonal or within-season or short-run uncertainty	between-season or inter-seasonal or long-run uncertainty
	Jennett (1984)			short-run uncertainty (emphasis in significant games)	long-run uncertainty
three	Cairns (1987) Szymanski (2003) Buzzacchi et al. (2003) Goossens (2006) Kesenne (2007) Lee and Fort (2008) Lenten (2009) Michie and Oughton (2004) Szymanski and Kuypers (1999) Borland & MacDonald (2003) Brandes & Franck (2007) Czarnitzki & Stadtmann (2002) Quirk & Fort (1997)		match or individual games uncertainty	seasonal or medium	long-run domination or championship uncertainty or inter-seasonal
	Vrooman (1996)		within-season	dominance of large clubs	continuity of performance
	Kringstad and Gerrard (2007)		win dispersion	performance persistence	prize concentration
four	Cairs, Jennet and Sloane (1986)	match uncertainty	short-run uncertainty	short-run uncertainty (emphasis in significant games)	long-run uncertainty

1.1.3 The Importance of Competitive Balance

The importance of competitive balance for the welfare of any professional sports league is an essential proposition in sports economics. More specifically, its importance lies in the fact that, ceteris paribus, it increases the demand for following the championship's games both in the stadium and on television. Fans' interest is crucial for professional team sports since it constitutes the essence of the game's demand, and is manifested in many ways, such as watching a game (live or on TV), listening to the radio, buying products associated with the game (for example, team merchandise, products of team sponsors, or gambling) or reading newspaper reports, related articles and books (Neale, 1964). In what follows, we will attempt to elucidate how competitive balance increases the fans' interest and, as a result, the demand for league games. Moreover, we will also discuss the repercussions from the absence of competitive balance and the cooperative or intervening actions in league level to preserve or restore the level of competition. Lastly, we will present empirical evidence on the relative importance of each dimension of competitive balance.

Competitive Balance and the Core Product

According to Sutton and Parret (1992, p. 8), the game between two teams is "*the core product*" in professional team sports. More specifically, they state that:

> *"The core product is defined as the game itself, which is whatever takes place on the field of play including the manner in which the contest is conducted, the style and strategy employed and the interpretation of understood laws, rules, regulations and historical precedents".*

In a seasonal round-robin tournament, a format common to most professional team sports, the "*core product*" is the series of games amongst teams. Sutton and Parret (1992) conclude that fans are actually purchasing the outcome uncertainty of the games or, the unpredictability (see Dobson & Goddard, 2001).

Therefore, the outcome uncertainty of the game is what makes a league product appealing. This has a profound effect on the consumer whose experience of sporting events is described by Madrigal (1995, p. 206) as:

> *"A hedonistic experience in which the event itself elicits a sense of drama".*

The level of "*drama*" will depend on the degree of outcome uncertainty (Borland & MacDonald, 2003). This means that the attractiveness of the product depends upon the display of rivalry amongst opponent teams. It is therefore imperative for sports leagues to be structured accordingly so as to foster the perception of inter-club competitiveness. The uniqueness of the sport product is further explained by Whannel (1992, p. 199):

> *"Like other forms of entertainment, sports offers utopia, a world where everything is simple, dramatic and exciting, and euphoria is always a possibility. Sport entertains, but can also frustrate, annoy and depress. But it is the very uncertainty that gives its unpredictable joys their characteristic intensity".*

As Szymanski and Zimbalist (2005) explain, what fans value in sports more than anything else is the excitement of the competition as well as the uncertainty it generates. Obviously, the result of any contest is not known beforehand; each sports contest is uncertain, yet some are more uncertain than others. They point out that the interest created by watching a past top-rated contest on video cannot be compared to the excitement generated from watching important games live. Although purists might find it interesting to watch important players again, most of us would find it monotonous even watching them for the first time if we already knew the result. Similarly, if the results of a sports league are predictable, then fans' enthusiasm fades away easily. If the championship is not competitive and exciting the sports league is effectively dead. The ultimate purpose of any sport competition is to offer competitive excitement (Haan, Koning, & van Witteloostuijn, 2002).

Competitive balance ensures uncertainty of outcome both for individual games and league championship as a whole. It is the feature that dominates the demand function is sports by increasing attendance and therefore revenue (Jones, 1969). Higher competitive balance has the profound effect of shifting the demand curve for the game demand (live or on TV) to a higher level. The more competitive or attractive a championship, the greater the number of fans buying a ticket, of broadcasters willing to invest, of sponsors becoming attracted to it, and of people reading sport newspapers. This implies that a league which is not competitively balanced does not maximise its earnings (Michie & Oughton, 2004).

Peculiarity of Professional Sports

According to Neale (1964), the first peculiarity of professional sports is the fact that game receipts depend upon athletic competition amongst teams rather than upon business competition. To exemplify this, he offers the example of a boxing competition: The heavy-weight champion always fights against a strong opponent to maximise profits; it is the competition which arouses interest. He intuitively captures this thought by saying "*pure monopoly is a disaster*" (Neale, 1964, p. 2). Sanderson and Siegfried (2003) also point out that all sport contests must deal with the fundamental issue of relative strengths amongst competitors. In connection to this, they mention track and field, auto racing, and swimming, which use qualification in contrast to tennis which produces seedings. Furthermore, men compete with women only on very few occasions, for exhibitions and advertisement mainly, so as to guarantee competitiveness.

Even if the above statement raises doubt, an even stronger suggestion would be that a more balanced league is at least more interesting. Such a proposition is, according to Szymanski (2003), widely accepted. Sports leagues require at least a certain degree of competitive balance to survive, and lack of competitive balance could have more severe consequences than lower revenues. As pointed out by Michie and Oughton (2004, p. 1), unbalanced leagues (or specific teams) could go bankrupt and their existence can be threatened by the creation of rival leagues, which is historically a common case in North American team sports. Such an example in European professional football is the proposal for the formation of the European Super League (Hoehn & Szymanski, 1999; Vrooman, 2007). The increasing gap between the strong or prosperous teams and the weaker or poorer ones is a serious and imminent threat for the popularity, health, stability, and growth of the sport industry (Levin, Mitchell, Volcker, & Will, 2000). Even for the winning team, which easily prevails in a championship series, attendance will in the long-run drop as the standard of competition declines (Downward, Dawson, & Dejonghe, 2009).

Cooperation and Intervention

It is a well-established fact that teams need each other since they do not only compete but also cooperate to produce the "game" (Jones, 1969; Neale, 1964; Rottenberg, 1956). In other words, the "*core product*" in team sports heavily depends on the competing teams (Mullin, Hardy, & Sutton, 2000). This is a unique feature of professional team sports, and as Roselle, the former commissioner of National Football League (NFL), argues "*one of the key things that a sports league needs is unity of purpose. It needs harmony*" (Harris, 1986, pp. 13-14). In his classic work, "*The League*", Harris (1986) describes this unique situation that differentiates professional team sports from any other business sector as '*League Think*' (Gladden & Sutton, 2003). The same opinion is also shared by Knowles, Sherony, and Haupert (1992).

In a free market economy the general strategy adopted by firms is to dominate and outperform competitors in order to cover the whole market or at least establish a very strong position. On the contrary, in professional team sports, such a tactic may be destructive, since sooner or later it will kill the business. No team can be considered as successful unless the remaining teams (its competitors) survive and prosper in such a way that the differences in quality of playing abilities amongst teams are not "too great" (Rottenberg, 1956, p. 254). A sports team needs opponents of more-or-less equal strength (Kesenne, 2007).

Undeniably, imbalance is an inherent, intractable part of all competitions (Sanderson, 2002). In order to achieve and sustain the production of the competitive excitement, it is generally accepted that a cartel-like arrangement is required by the league (Haan et al., 2002). This is actually the objective of '*League Think*', that is, to reverse the process through which weak teams get weaker and strong teams get stronger. The viability of a league depends on the degree to which it can stabilise itself through its own competitive balance and league-wide income potential (Harris, 1986, pp. 13-14).

A general perception is that competitive balance is declining in European football (Arnaut, 2006) while a large number of teams face serious financial difficulties (Davies, 2010; Dietl, Franck, Lang, & Rathke, 2008; Gerrard, 2004). We can refer the serious debt problem of Manchester United and the threatening financial viability of the big Greek teams of Panathinaikos and AEK Athens. From the fans' welfare perspective, however, it may be reasonable to suggest that a certain degree of imbalance in favour of teams with strong fan base is optimal (Szymanski, 2001). Typical examples of such strongly supported teams are in Greece (Oympiakos and Panathinaikos) and in Spain (Barcelona and Real Madrid).

Leagues have four possible types of policy interventions: a) player transfer restrictions, b) salary caps, c) revenue sharing, and, c) tournament restructuring (Gerrard, 2004). Unlike in North American leagues, those interventions cannot be implemented in European football leagues due to various structural reasons (Dietl, Fort, & Lang, 2011; Dietl et al., 2008; Gerrard, 2004). For instance, European football teams are not considered as profit-maximisers (North American teams), but as win-maximisers instead (Davies, 2010; Fort & Quirk, 2004; Kesenne, 2000, 2006; Sloane, 1971). As a result, European teams are overspending on players' wages in the pursuit of sporting success which has resulted in severe financial problems (Szymanski, 2011). For this reason, UEFA proposed a financial FAIR PLAY rule to control financial expenses, but this is predicted to have a negative trend in competitive balance (Sass, 2012).

Empirical Evidence

The majority of econometric evidence supports the theoretical suggestion for a positive effect of competitive balance on demand for professional team sports. However, there is some controversy regarding the relative importance of each dimension of competitive balance. Any potential dimension must to be considered as important from the fans' point of view. This principle is central to our analysis, since if fans were not responsive to any aspects of competitive balance, its study would be meaningless. Fans' interest, being at the heart of the demand, determines an appropriate starting point for the study of competitive balance (Zimbalist, 2003). The evidence that 'match uncertainty' affects attendance is quite weak (Borland & MacDonald, 2003), mainly because most of the fans prefer their home team to be the winner with the biggest possible goal difference. Many factors, which are difficult to control, affect the outcome of a particular game and for various reasons fans can be attracted to a particular game aside from its uncertainty of outcome. From this perspective, 'match uncertainty', the shortest time-dependent dimension, does not constitute a basic dimension of competitive balance. Even though any other dimension incorporates 'match uncertainty' at its core (Michie & Oughton, 2004, p. 1), its examination seems to be an issue only of academic concern (Szymanski & Zimbalist, 2005). The concept of competitive balance mainly concerns long-term dimensions. Furthermore, fans might need more accumulated information, to evaluate the importance of competitive balance.

It is generally accepted that fans' interest is more sensitive to the long-term dimensions, such as 'seasonal' and 'between-seasons' competitive balance (Borland & MacDonald, 2003). 'Seasonal' competitive balance is a medium time-dependent dimension that deals with the relative qualities or strength of teams in the course of a particular season. This dimension is familiar to the fans, since football is organised in seasonal league competitions. Therefore, the uncertainty concerning the winner of the championship title (or any other championship prize within a single season) is essential for interest of the fans. If a prize battle is determined early in the season, fans' interest and enthusiasm for the remaining games will be partly or completely lost. The 'between-seasons' competitive balance, the longer time-dependent dimension, concerns the relative qualities of teams across a number of seasons. It is reasonable to assume that fans might care about the turnover or turbulence of teams over the seasons; in any case, it is not exciting to have the same team winning the title year after year or the same group of teams fighting for relegation

Consequently, it seems that the latter two dimensions are of the utmost importance for the study of competitive balance. A league, which, according to those two dimensions, is not competitive, goes through periods, on the one hand, of very strong and very weak teams (seasonal) and, on the other, of a mix of strong and weak teams, which remain unchanged for years (between-seasons). Under this status of competitive imbalance, the league will eventually suffer (Fort, 2006b).

1.2 The Aim and the Methodological Framework of the Thesis

Due to its prominence, quantification of competitive balance has become the main topic of discussion in sport economics. Thus, a great diversity of different approaches has been introduced in the literature with a view to better quantifying competitive balance. As Zimbalist (2002, p. 112) notices:

> "*there are almost as many ways to measure competitive balance as there are to quantify money supply*".

The above reflects the complicating issue of quantifying competitive balance, which mainly relates to its multidimensionality that makes it difficult to clearly define the concept (Downward et al., 2009). Given that every dimension has to be important from the fans' perspective, this study investigates the quantification of the seasonal and between-seasons dimensions. The proliferation of the proposed indices in the literature urges us for a comprehensive comparative analysis to clarify their strengths and weaknesses when measuring competitive balance.

Any optimal measure or index of competitive balance may differ from one sport to another or even from one league to another (Zimbalist, 2003). This issue reflects the championship structure of a particular sport or league. In this study, we focus on football, which is the most popular professional team sport in the world (Reilly & Williams, 2005). For instance, the FIFA World Cup final is rated as the biggest single-sport mega event in the world (Close, 2010). The specific target of this study is the European professional football, "*the heartland of football, the only truly global team sport*" (Gerrard, 2004, p. 39). In Europe football is a thriving business, and professional leagues show considerable growth in annual turnover figures. Actually, Manchester United is the world's most valuable sports team worthy of more than $1.86 billion (Forbes, 2011). In most European countries, the highest football league usually figures prominently in TV sport broadcasting as well as in recreational spending (Goossens, 2006). The growth is partly explained by the tremendous investment in new stadiums as well as by the adoption of modern methods of sport management, sport marketing, and corporate governance by teams and leagues.

Despite the substantial growth, there are important issues that the industry has to address in order to ensure its long-term success, with the most important one being competitive balance (Michie & Oughton, 2004). European football leagues are complex in structure, in that domestic championships are multi-levelled tournaments offering multiple prizes as opposed to the common single prize offered by North American ones (Kringstad & Gerrard, 2007). The multi-levelled structure of European football has so far not been considered, although the overall competitive balance is determined by the corresponding levels of uncertainty involved in the conquest of all league objectives.

For the quantification of competitive balance, any optimal index has to be important from the fans' perspective. Particularly, those indices to which fans show the greatest sensitivity are the most important ones (Zimbalist, 2003). Therefore, in order to study the fans' responsiveness in Europe, relevant data from many countries are required. The existing number of related studies across countries or leagues is rather limited. Moreover, none of such existing studies is concerned with research at a European level.

The aim of this thesis is to provide a systematic approach for an enhanced quantification of competitive balance in professional team sports with emphasis on European football. After the examination of all existing, the modification of some of them, and the development of specifically designed indices, the methodological framework followed aims for an in depth exploration using an innovative sensitivity analysis, an empirical investigation, and an econometric study.

This thesis deals with the following issues:

a) Examination for the appropriateness of the existing indices in the context of European football (Chapter 2).

b) Modification of existing indices for a cross examination across leagues and/or seasons (Chapter 3).

c) Construction of specially designed indices that take into account the multi-levelled structure of European leagues (Chapter 4 and Chapter 5).

d) Investigation of the indices behaviour in various hypothetical scenarios (Chapter 6).

e) Implementation of the indices in European football leagues (Chapter 7).

f) Identification of optimal indices and important aspects/dimensions of competitive balance in European football (Chapter 8).

Note that although this thesis focuses on European football leagues, the method developed here can also be adopted for other team sports or leagues. Moreover, a number of different approaches have been developed to answer the above issues.

Firstly, it is followed an innovative all-embracing approach in terms of the extensive number of indices included in the analysis and is provided sufficient research tools to designate their main features. More specifically, following a comprehensive review and analysis of the existing indices in Chapter 2, modification and development of a large number of new indices are introduced in Chapters 3-5.

Secondly, a sensitivity analysis is employed in Chapter 6 followed by an empirical investigation in Chapter 7 to illustrate similarities and differences amongst indices. The unique combination of sensitivity analysis and empirical investigation further clarify the properties of the indices and identify what they are actually measuring. The sensitivity analysis is a novel approach in the field of sport economics research, substantiated from the concern for an advanced knowledge of indices behaviour under the specific championship format in European football. Findings from the sensitivity analysis facilitate the results arising from the empirical investigation.

Thirdly, an econometric study in Chapter 8 is conducted to assess the hypotheses supported by the theory. The use of data of adequate sample size enables the adoption of advanced methods which strengthens the conclusions arising from the econometric analysis. In particular, the investigation of eight European domestic football leagues for an extended period of seasons authenticates the findings for both the importance of the concept and the significance of the indices of competitive balance from the fans' perspective.

1.3 The Structure of the Thesis

This thesis is divided into seven additional chapters dealing with the issues described in Section 1.2 followed by a conclusive chapter. More specifically, Chapter 2 reviews the existing indices measuring seasonal and between-season dimensions of competitive balance. Using an all-embracing approach, the objective of this chapter is the examination of the performance and the applicability of these indices to a number of basic characteristics of European football.

The modification of some of the existing indices for a cross examination of competitive balance in European football is presented in Chapter 3. In particular, the identified diversity in the number of teams that make up the league across countries and/or seasons, create implications the proper definition of the indices boundaries. The modification is accomplished by means of normalisation or re-location such that both bounds correspond to the adopted conventional definition.

Chapter 4 aims to provide a more systematic quantification analysis specifically applied to European football. New challenges are created by the complex multi-prized championship structure of European football leagues, which requires a new conceptual approach for the development of especially designed indices. The development of new indices, which is based on simple averaging strategies and focuses on the seasonal dimension, is inspired by the necessity to quantify the competition for each prize and rate ranking positions according to their significance for the fans.

Following a similar averaging approach, a number of new indices for the between-seasons dimension of competitive balance are developed in Chapter 5. By virtue of the properties of the new single-dimensional indices, a number of bi-dimensional indices that capture both the seasonal and the between-seasons dimension are also created. Essentially, the introduction of those indices enables for comprehensive analysis of competitive balance since they consolidate different aspects of competitive balance in a single index.

The sensitivity analysis through the implementation of the indices in various hypothetical leagues in terms of competitive level is the central theme of Chapter 6. Following a systematic classification, the main point of the analysis is to investigate the behaviour of all indices on the path from an initial to a final hypothetically selected league state. We believe that the sensitivity analysis, which is designed to meet the objectives of European football, is a quite innovative approach that further explores the main features and identifies (on the same time) differences and similarities amongst indices.

Moving further, in Chapter 7, a detailed analysis of the behaviour of the indices in several European football leagues for the last 45-50 seasons is presented. In the context of this empirical work, the key points are further elucidated by exploring the value and the trend of indices in both Europe and country-wise. Particular consideration has been given to the issues arising from the measurement, since a large number of indices are employed for a big panel data. The methodological procedure followed provides a powerful guidance and standardization about the practical issues of the competitive balance indices using various statistical methods. Special attention is given to association of the findings from the empirical research with the conclusions derived from the sensitivity analysis.

Chapter 8 seeks to identify the relative importance of all indices discussed and analysed in the previous chapters. In that respect, the constructed econometric model aims to reveal the best or optimal index as well as the aspect of competitive balance that mostly affects the fans' behaviour. Particular importance is placed on the non-stationarity and contemporaneous correlation issues, given the "temporal dominated" nature of the panel data. We should point out that observations arising from the econometric analysis should be of assistance to policy-makers to sustain the viability of European football.

Finally, the concluding Chapter 9 summarises and interprets the overall findings. What is more, it highlights the contributions to the literature made by the present thesis and points to avenues for future research.

Chapter 2. Indices Measuring Competitive Balance

The increase of existing competitive balance indices indicates the progress towards a more efficient and accurate quantification of this notion in sports. However, the existence of a wide variety of different interpretations of competitive balance (Michie & Oughton, 2004), creates a difficulty to create a measure that fully captures all its characteristics. For this reason, as Zimbalist (2002) notices, a great diversity of different approaches has been introduced. This chapter provides a comprehensive review of the existing indices of competitive balance. Compared with other related research works, such as those by Goossens (2006), Groot (2008), Fort (2006a), and Michie and Oughton (2004), the present study examines and compares a large number of the existing indices. In particular, a detailed presentation of the most important and widely used indices will be provided in the current chapter along with a short description of all existing indices. Moreover, the basic characteristics of European football will also be analysed using these indices. In this context, using an all-embracing approach, the objective of the chapter is to determine the applicability and the main features of these indices.

The indices of competitive balance are classified into two broad categories according to the dimension they measure; i.e. the seasonal and between-seasons dimensions. Based on the analysis of Borland and MacDonald (2003), those two dimensions are of the utmost importance for competitive balance. Seasonal indices measure the relative quality or strength of teams during a particular season. The importance of those indices derives from the fact that football is organised in seasonal competitions. Between-seasons indices measure the relative quality of teams across seasons.

It is important to note that competitive balance according to those two dimensions can even shift in opposite directions. Groot (2008) present, in a concise table, all possible combinations between the two dimensions; see Table 2.1. Note that, the downward and upward directions stand for an improvement and worsening respectively of competitive balance. More specifically, in cases I and IV, both dimensions of competitive balance move towards the same direction. Consequently, a clear statement concerning the overall direction of competitive balance can be derived, which is downwards in case I and upwards in case IV. The behaviour of competitive balance in block I is the most attractive from the fans' perspective while that in block IV is the worst-case scenario. However, in cases II and III we cannot draw a clear conclusion for the specific direction of competitive balance. In particular, in case II the seasonal dimension is moving downwards, which implies that the gap between strong and weak teams becomes smaller into the season, while the between-seasons dimension is moving upwards, which indicates that the same strong teams dominate across seasons. Although it is evident that competition is strong during the season, it is the strongest team that finally prevails.

Table 2.1: Seasonal vs. Between-seasons Competitive Balance

Dimensions		Between-seasons Competitive Balance	
	Directions	Down	Up
Seasonal Competitive Balance	Down	I	II
	Up	III	IV

Source: Groot (2008, p. 118)

Similar conclusions can be drawn from the reverse situation in block III. In that case, the seasonal dimension is worsening while the between-seasons dimension is improving. The former signifies that the gap between stronger and weaker teams during a particular season widens while the latter means that there is a greater turnover of teams across seasons. More specifically, while there is a tendency for the stronger teams to win more games into a particular season, the identity of those stronger teams changes through the seasons. From the fans' perspective, it may be argued that this case is preferable and the league is more balanced (Leeds & von Allmen, 2008).

Following the above example, it becomes obvious that the employment of seasonal along with between-seasons indices is imperative for in-depth analysis of competitive balance. The following review of existing indices is organised in two sub-sections, whereby the presentation of seasonal indices is followed by that of between-seasons indices. Both sections conclude with an overview table with a short description, the derived function, the unit of measurement, and the definition of the bounds for all discussed existing indices. Finally, the chapter closes with a concluding section, which presents a summary of the key issues addressed regarding the applicability of the existing indices and proposes alternative ways for a better quantification of competitive balance in the context of European football.

2.1 Indices of Seasonal Competitive Balance

In this section, we present the procedure followed for the development of the existing seasonal indices as well as their characteristic attributes. As many concepts in economics, competitive balance is a latent concept; and therefore, it is still not simple to measure it. For the study of the indices in the context of European football, it is useful to consider a number of basic characteristics that require clarification:

a) In all the remaining of this thesis, a round robin tournament championship is considered, in which every team play twice against all others.
b) The customary in sports literature and prevailing in European football for the last 50 seasons point scheme is adopted (two points for a win, one for a draw, and zero for a loss); see Table A19 in the Appendix. Compared with the modern point system (three points for a win, one for a draw, and zero for a loss), it provides quite robust results (Goossens, 2006).
c) The main units of measurements employed for the calculation of the indices are: the number of points (P), the winning percentage (w), and the winning share (s) defined as the proportion of wins to the total number of wins in the championship. For the calculation of w and s, a draw is estimated as half a win.
d) No team can gather all wins in a championship since teams can only win their own games. This is a characteristic of the distribution of wins and/or points in sports (Owen, 2009; Owen et al., 2007; Utt & Fort, 2002). Based on that characteristic distribution, two extreme cases of competitive balance have been identified; the perfectly balanced and the completely unbalanced league. The former is defined as the case in which all teams share points and wins equally; and thus, each team has a 50 percent winning record at the end of the

season. As far as the latter is concerned, it is defined as the case in which the strongest team wins all games, the next strongest team wins all games against the weaker teams, and so on down to the last team with no wins. Either of those two extreme cases can serve as a point of reference for a reliable calculation of the indices. Given that those benchmarks are considered as the upper and lower bound, their difference provides the feasible range of the indices.

e) The number of teams (N) in European domestic championships varies across countries and/or seasons (see Table A.1 and Figure A.1 in the Appendix). Therefore, for the validity of an index in any cross-examination study it is paramount that both bounds are well documented and insensitive to N.

Based on their main features, seasonal indices are classified into three broad categories:

a) Indices that refer to the dispersion of winning percentages.
b) Indices from Economic Theory.
c) Special indices.

2.1.1 Indices of Dispersion of Winning Percentages

As Bennett and Fizel (1995) point out, since the winning percentage is the "ultimate barometer of competitive balance", different approaches for the measurement of the dispersion of winning percentages have been proposed. In fact, since indices of dispersion are widely cited in the literature, the main emphasis is placed on the process for the development of more sophisticated dispersion indices that are appropriate for the study of competitive balance in European football.

Range

The simplest measure which informs us about the dispersion of winning percentages is *Range*, which simply refers to the difference between the higher (w_f) and the lower (w_l) winning percentages in a league during a particular season.

$$Range = w_f - w_l. \tag{2.1}$$

The main advantage of *Range* is that it is easy to calculate and understand. It can be easily assumed that the bigger the range, that is, the larger the difference between the first and the last team, the more unbalanced the league. The lower bound is zero while the upper bound is one. However useful this measure is, it is difficult to rely on it, since it takes into account only the two extreme teams and ignores the rest (e.g. what happens if the last team has zero points but all the rest compete equally well for the championship?). For that reason, *Range* is not included in the study of competitive balance in European football, and more advanced indices of dispersion are examined.

Standard Deviation

The above major drawback of the *Range* can be partly covered by the *Standard Deviation* of the winning percentages (*STD*), which is a more appropriate measure of dispersion. The *STD* is a rigorous statistic, which properly describes the average squared distance of each team winning percentages from the one expected under the assumption of perfect balance, which is given by:

$$STD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(w_i - \overline{w_i}\right)^2} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(w_i - 0.5\right)^2}\,, \tag{2.2}$$

with $\overline{w_i} = \frac{1}{N}\sum_{i=1}^{N} w_i = \frac{1}{N}\frac{2N(N-1)}{4(N-1)} = 0.5\,,$

where $\overline{w_i}$ stands for the expected winning percentage under the assumption of perfect balance. In essence, *STD* is an informative index concerning the spread of the win distribution. For instance, if the winning percentages of all teams follow a normal distribution, then approximately 68% of the winning percentages lie within one standard deviation from the league's average and approximately 95% lies within two standard deviations respectively. The bigger the *STD*, the smaller the competitive balance, since winning percentages of the teams are very different. In contrast, the smaller the *STD*, the closer the championship and the spread of the teams' winning percentages. The lower bound of the *STD* is zero, and is obtained when teams equally share wins. As far as the upper bound is concerned, it is sensitive to the variation in the number of teams (*N*) that make up the league and it is given by equation (2.8) in page 28. For the comparison of competitive balance across countries or seasons with various *Ns*, the upper bound is affected and, thus, a suitable adjustment is required. The *STD* is sensitive to extreme cases at both ends, which is advantageous when studying competitive balance.

Ratio of Standard Deviation

The sensitivity of *STD* to *N* has been partly circumvented by the most widely cited index in the existing literature, that is, the *Ratio of Standard Deviation* (*RSD*) (Humphreys, 2002; Leeds & von Allmen, 2008)[1]. As a "tried and true" measure of seasonal competitive balance (Utt & Fort, 2002), a detailed description of its major characteristics is presented along with the latest transformation for its proper application to European football. This technique was first developed by Noll (1988) and Scully (1989), who assume that a natural way to measure competitive balance is to divide the observed *STD* by the standard deviation which could have occurred in the case of *Ideal Standard Deviation* (*ISD*), that is, when teams have equal chances to win every game. The function of *RSD* is given by:

$$RSD = \frac{STD}{ISD}. \qquad \textbf{(2.3)}$$

As Quirk and Fort (1997) explain, the *ISD* is calculated as follows:

$$ISD = \frac{0.5}{\sqrt{G}}, \qquad \textbf{(2.4)}$$

where *G* stands for the number of games each team plays in a season and usually equals 2(*N*-1). The *ISD* represents an ideal league with an ideal competitive balance, where the win probability for every team is 0.5. The number of wins follows a binomial distribution. It follows that in the ideal case the average of the winning percentage's binomial distribution is 0.5, and if we divide it by *G*, we get the *ISD*[2].

[1] Amongst others, the *RSD* is used by (Buzzacchi et al., 2003; Vrooman, 1996).

[2] As Groot (2008) shows: $E(x) = pG = 0.5G$ and $E(w) = E(x/G) = E(x)/G = 0.5$; $\sigma^2(w) = \sigma^2(x)/G^2 = 0.25/G$ and, as a result, $ISD = \frac{0.5}{\sqrt{G}}$, where *E* denotes expectation, *p* probability, *G* the

In effect, this index compares *STD* with *ISD*. If *RSD* equals unity, the league is ideally balanced, since *STD* equals *ISD*. The closer the ratio of *RSD* is to unity, the less the deviation of the actual performance of the league from the ideal situation and the greater the degree of competitive balance. However, the lower bound of *RSD* is zero and not unity given that the minimum of *STD* is zero. This means that a championship can be proved to be more equal than a computer-generated championship, where every team has a 0.5 chance to win. In fact, the *RSD*'s application to football renders numbers significant below unity[3,4]. As the ratio of *RSD* increases over unity, competitive balance worsens. However, the upper bound of the index is not well-documented. In particular, since *STD* is a function of *N*, based on equation (2.3), *RSD* is also a function of *N*.

Another limitation of the *RSD* when applied to European football is the fact that its development has been based on the US sport leagues format, where draws are either rare or non-existent (Goossens, 2006; Kesenne, 2007; Michie & Oughton, 2004). More specifically, the calculation of the *ISD* was not originally derived with drawn matches in mind. For instance, approximately 30 percent of the games in football end in a tie. In that case, most of the researchers treat ties as half a win (Buzzacchi et al., 2003; Szymanski & Valletti, 2003). Cain and Haddock (2006) argue that in championships with draws, the distribution of the teams' winning percentages follows a trinomial distribution while Fort (2007) emphasises the implication of various point schemes for the calculation of *RSD*[5].

National Measure of Seasonal Imbalance

In our view, the above limitations derive from the fact that the range of *RSD* is not well defined since its upper bound (RSD^{ub}) is a function of *N*. The RSD^{ub} is attained in the case of a completely unbalanced league, where each team always wins against

number of games of each team, σ^2 the variance of the winning percentages, *w* the winning percentage, and *x* the number of wins.

[3] Goossens (2006) and Groot (2008) show two cases (in Germany season 1969 and in Romania season 1984) where the rule of unity was violated.

[4] Trandel and Maxcy (2011) introduce a new formula for *RSD* to account for home advantage.

[5] According to Owen (2010b), variations in the points schemes results in minor numerical differences for *RSD* values.

a weaker team and loses against a stronger team. The value of the RSD^{ub} has been calculated by Owen (2009) as:

$$RSD^{ub} = 2\sqrt{2}\left[\frac{(N+1)}{12}\right]^{1/2}, \tag{2.5}$$

It can be easily drawn from (2.5) that the value of RSD^{ub} depends on the number of teams that make up the league. This can be verified by differentiating equation (2.5) with respect to N, resulting in:

$$\frac{\partial\left(RSD^{ub}\right)}{\partial N} = \frac{\partial\left[2\sqrt{2}\left(\frac{(N+1)}{12}\right)^{1/2}\right]}{\partial N} = \frac{1}{\sqrt{6}\sqrt{N+1}} > 0. \tag{2.6}$$

Since equation (2.6) is always positive, RSD^{ub} is an increasing function of N, and therefore, *ISD* cannot be used as a benchmark. Given that *RSD* is not appropriate for the analysis of competitive balance in European football, Goossens (2006) put forward a new measure, which proposes an alternative ratio, the so called *National Measure of Seasonal Imbalance* (*NAMSI*). In effect, she compares the *STD* not with the ideal situation (*ISD*) but rather with the most undesirable; that is, the standard deviation in the case of a completely unbalanced league (*WSD*).

$$NAMSI = \frac{STD - STD_{\min}}{WSD - STD_{\min}} = \frac{STD}{WSD} = \sqrt{\frac{\frac{\sum_{i=1}^{N}(w_i - 0.5)^2}{N}}{\frac{\sum_{i=1}^{N}(w_i^{\max} - 0.5)^2}{N}}} = \sqrt{\frac{\sum_{i=1}^{N}(w_i - 0.5)^2}{\sum_{i=1}^{N}(w_i^{\max} - 0.5)^2}}, \tag{2.7}$$

where *WSD* stands for *STD* in case of complete imbalance, $STD_{\min}$ stands for *STD* in a perfectly balanced league, and $w_{i\max}$ stands for the winning percentage of team i in a completely unbalanced league. The intuition behind this measure comes from the fact that a league, which deviates from the ideal situation, does not necessarily require intervention. Conversely, if a league is very close to complete imbalance, reaction is urgently needed.

The advantage offered by *NAMSI*, allows for comparison of countries and/or seasons with a different number of teams and with games ending in draws (Kesenne, 2007). In the calculation of *NAMSI* the $STD_{\min}$ is included instead of the *ISD*. The meaning of $STD_{\min}$ is straightforward, that is, when all teams share wins and each has 0.5 win record at the end of the season. In this case, the league is in perfect balance, since all teams equally share wins and/or points and, thus, the value of $STD_{\min}$ equals zero. *WSD* is reached when complete imbalance occurs; that is, the strongest team wins all games, the next strongest wins all games except those against the strongest and so on[6]. Groot (2008) and Owen (2009, 2010a) calculate *WSD*, and its formula is given by:

$$WSD = \left[\frac{(N+1)}{12(N-1)}\right]^{1/2}. \tag{2.8}$$

The value of *WSD* is affected by the number of teams *N* in the league. In particular, this can be shown by differentiating equation (2.8) with respect to *N* as:

$$\frac{\partial(WSD)}{\partial N} = \frac{\partial\left[\left(\frac{(N+1)}{12(N-1)}\right)^{1/2}\right]}{\partial N} = -\frac{1}{2}\sqrt{\frac{1}{3(N+1)(N-1)^3}} < 0. \tag{2.9}$$

From equation (2.9) it can be drawn that *WSD* is a decreasing function of *N*. More specifically, the larger the *N*, the smaller the *WSD* becomes. The variation of *WSD* for selected *N*, which corresponds to various European football leagues, is presented in Table 2.2. The incremental percentage difference is small and *WSD* decreases at a

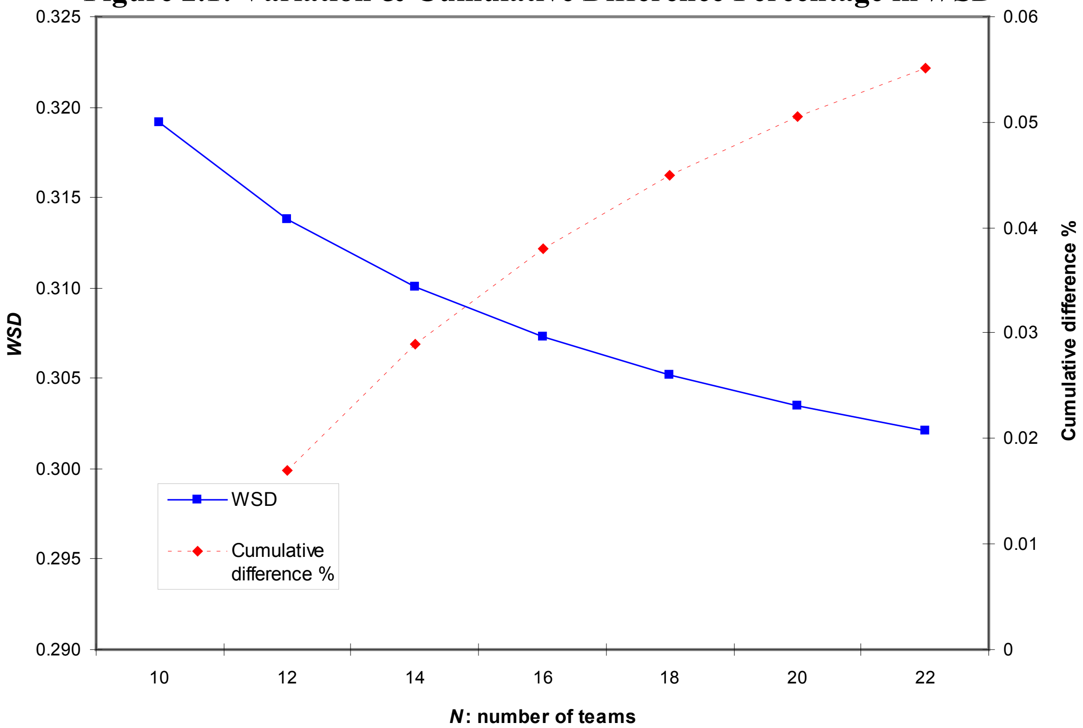
[6] When *N*=4, the strongest team wins all games and has a winning percent record equal to 1 (6 wins in 6 games), the second team has a winning percent record 0.666 (4 wins in 6 games), the third team has a win-percent record 0.333 (2 wins in 6 games), and the last team has a win-percent record 0 (0 wins in 6 games).

diminishing rate[7]. However, the cumulative percentage difference rises to a 5.5%, which is graphically illustrated in Figure 2.1.

Table 2.2: Variation of *WSD*

Number of teams	*WSD*
10	0.319
12	0.314
14	0.310
16	0.307
18	0.305
20	0.303
22	0.302

Figure 2.1: Variation & Cumulative Difference Percentage in *WSD*



Based on the above analysis, the range of *NAMSI* is properly defined by controlling for *WSD*. The new formula of *NAMSI*, after incorporating equation (2.8), is given by:

---

[7] The diminishing rate of the decrease can be verified by the positive second derivative of equation (2.8) with respect to N as follows:

$$\frac{\partial^2}{\partial N^2}\left(\sqrt{\frac{N+1}{12(N-1)}}\right)=\frac{2N+1}{2\sqrt{3}(N-1)^4\left(\frac{N+1}{N-1}\right)^{3/2}}>0$$

$$NAMSI = \frac{STD}{\left[\frac{(N+1)}{12(N-1)}\right]^{1/2}} \quad . \tag{2.10}$$

The range of *NAMSI* is from zero to one. It takes the value of zero in the case of perfect balance while it reaches the value of unity in the most undesirable situation, that is, when *STD* equals *WSD* and the league is completely imbalanced. The lower the *NAMSI*, the more balanced the league is.

Index of Dissimilarity

The *Index of Dissimilarity* (*ID*), introduced in sports economics by Mizak and Stair (2004), is a *Gini*-type index used extensively as a demographic measure. *ID*, when applied in football, is given by:

$$ID = 0.5\sum_{i=1}^{N}\left|\mu - s_i\right|, \tag{2.11}$$

where μ stands for the winning share under a perfectly balanced league, and s_i stands for the winning share of the *i*th team. In essence, *ID* denotes dispersion from the mean (but no quadratic as the *STD*) and indicates the smallest proportion of wins required to be relocated for a perfectly balanced league in which all teams share wins equally. The lower bound of *ID* is zero, which is reached when teams equally share wins in a perfectly balanced league. As far as the upper bound (ID_{ub}) is concerned, it is reached in the case of a completely unbalanced league. However, the ID_{ub} is not included in the calculation of *ID* and, therefore, a normalisation is required for comparison amongst leagues with various *N* (Mizak et al., 2005). Table 2.3 presents the values of ID_{ub} for selected *N* where it can be verified that the value of ID_{ub} is not constant but a decreasing function of *N*. As it is suggested by Mizak et al. (2005), the *normalized ID*, controlled for the variation in ID_{ub}, ranges from zero (perfectly balanced league) to one (completely unbalanced league) and is naturally given by dividing *ID* with ID_{ub}.

Table 2.3: ID_{ub} for various N

N	ID_{ub}
10	0.278
12	0.273
14	0.269
16	0.267
18	0.265
20	0.263
22	0.262

2.1.2 Indices from Economic Theory

Since competitive balance is essentially concerned with inequality of teams' performances, using in this context indices measuring the inequality of income distribution or market power is not surprising. The area of industrial organisation theory offers a wide range of indices measuring the relative industry competitiveness. If we consider professional football league as industrial sector, such concentration indices explain the distribution of teams' success in the league. Industrial economists investigate the concentration of output, which in the professional sport setting is the performance that can be measured by the winning percentage, winning share, total points or goals achieved.

Herfindahl-Hirschman Index

One concentration measure, often used to illustrate the distribution of a variable by measuring its degree of concentration across units, is the *Herfindahl-Hirschman Index* (*HHI*) defined by the quadratic summation of the market shares of all companies in a particular industry (Depken, 1999, 2002; Depken & Wilson, 2006). When applied to the professional sport setting, market share becomes the winning share in the league and the *HHI* is given by:

$$HHI = \sum_{i=1}^{N} (s_i)^2. \tag{2.12}$$

When this measure is employed in professional football, it captures the inequalities amongst teams that take part in the championship. The *HHI* index, which is used to measure the competitive nature of an industry, is often skewed by the number of companies in the industry (Kamerschen & Lam, 1975). Due to the nature of the index, the value of *HHI* decreases as the number of firms or teams increases. In a typical industry, the *HHI* is naturally bounded from below by 1/*N*, which is the state of a perfectly competitive market, and from above by unity, which is the state of pure monopoly. In sport setting, the lower bound (HHI_{ideal}), adopted as "ideal competitive level" for Major League Baseball (MLB) by Depken (1999), is the case of perfect competitive balance amongst the *N* clubs. In that case, each team wins half of its games, i.e. *N*-1, assuming a round robin league format where each team plays twice against every other. The total number of wins in the league equals *N*(*N*-1), and therefore, the value of HHI_{ideal} is given by:

$$HHI_{ideal} = N\left(\frac{(N-1)}{N(N-1)}\right)^2 = \frac{1}{N}. \tag{2.13}$$

From equation (2.13) it can be drawn that the HHI_{ideal} is inversely related to *N*. In an effort to manage the variation in *N* across seasons, Depken (1999) introduces an altered form which deviates from the ideal, that is, the *dHHI* given by:

$$dHHI = HHI - HHI_{ideal} = HHI - \frac{1}{N}. \tag{2.14}$$

Depken (1999), notices that *dHHI* is highly related -although in non-linear fashion- to the *STD*. He presents this relationship with an equation where the *STD* is a function of *N*, the number of games played in a season (*G*), and the *dHHI* index as:

$$STD = \frac{G^2 N}{4} dHHI. \tag{2.15}$$

Essentially, *dHHI* measures the deviation from the ideal distribution of wins for any period regardless of the variation in *N*. However, in a sport setting, the upper bound of the index (HHI_{ub}) is lower than unity due to the constraints imposed by the distribution of wins and/or points in sports. More specifically, in the sport setting, in contrast with a typical industry, the value of unity (perfect monopoly) cannot be attained for HHI_{ub}, since, even if the best team wins all its games, no particular team could win all games played in a championship. HHI_{ub} is reached in the case of complete imbalance. In such a case, the value of the upper bound is less than one and is also affected by *N*. Consequently, although Depken employs *dHHI*, and thus takes into consideration the lower bound of the *HHI*, his approach ignores to re-estimate the upper bound of the *HHI*. The *dHHI* could have been an appropriate index only if the upper bound were unity, as it is the case in a typical industry. Although Michie and Oughton (2004) calculate HHI_{ideal} and HHI_{ub} for a 20 club league as 0.05 and 0.07 respectively, they do not include both of them in their index; this issue also mentioned by Schmidt and Berri (2002). On the contrary, Michie and Oughton (2004) introduce another version of *HHI*, the *HICB*, which measures the percentage increase of *HHI* relative to the ideal case of competitive balance, given by:

$$HICB = \left(\frac{HHI}{HHI_{ideal}}\right)100. \tag{2.16}$$

An increase in *HICB* signifies a more unbalanced league. The lower bound of *HICB* is well defined and equals 100, but the upper bound is sensitive to *N*. For a reliable calculation of the index in leagues with various *N*, a normalisation is required to account for both the lower and the upper bounds. Owen et al. (2007), derive the mathematical expression of HHI_{ub} by:

$$HHI_{ub} = \frac{2(2N-1)}{3N(N-1)}. \tag{2.17}$$

Similarly to HHI_{ideal}, Owen et al. (2007) point out that HHI_{ub} is a decreasing function of *N* since:

$$\frac{\partial HHI_{ub}}{\partial N} = \frac{\partial\left(\frac{2(2N-1)}{3N(N-1)}\right)}{\partial N} = -\frac{4N(N-1)+2}{3(N-1)^2 N^2} < 0. \tag{2.18}$$

Moreover, HHI_{ub} decreases as *N* increases with a diminishing rate. The diminishing decreasing rate is proven by the positive second derivative of equation (2.17) with respect to *N* as:

$$\frac{\partial^2 HHI_{ub}}{\partial N} = \frac{\partial^2\left(\frac{2(2N-1)}{3N(N-1)}\right)}{\partial N^2} = \frac{4(2N-1)(N^2-N+1)}{3(N-1)^3 N^3} > 0. \qquad \textbf{(2.19)}$$

The variation of HHI_{ub} and HHI_{ideal} for selected N is presented in Table 2.4 where we can observe that as N increases, there is a considerable percentage decrease in HHI_{ub}, HHI_{ideal}, and range respectively; also see Figure 2.2.

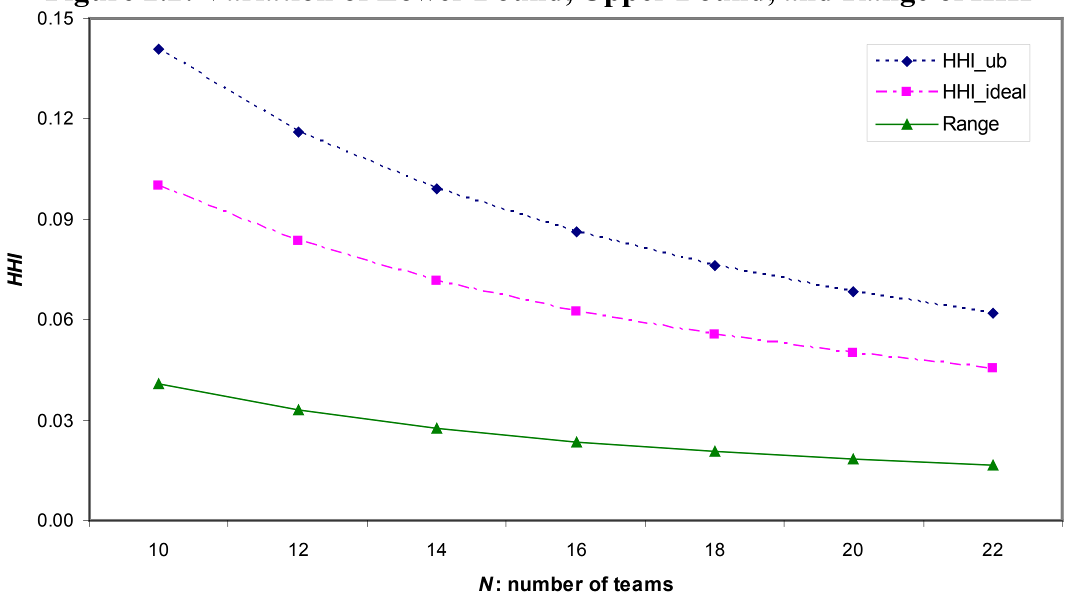
Table 2.4: Lower & Upper Bound of *HHI*

N	HHI_{ideal}	*D%*	*CD%*	HHI_{ub}	*D%*	*CD%*	*Range*	*D%*	*CD%*
10	0,100			0,141			0,041		
12	0,083	0,167	0,167	0,116	0,175	0,175	0,033	0,194	0,194
14	0,071	0,143	0,310	0,099	0,149	0,323	0,027	0,163	0,357
16	0,063	0,125	0,435	0,086	0,129	0,453	0,024	0,141	0,498
18	0,056	0,111	0,546	0,076	0,114	0,567	0,021	0,123	0,621
20	0,050	0,100	0,646	0,068	0,103	0,670	0,018	0,110	0,731
22	0,045	0,091	0,737	0,062	0,093	0,763	0,017	0,099	0,830

**D%*: Percentage Difference

***CD%* Cumulative Percentage Difference

Figure 2.2: Variation of Lower Bound, Upper Bound, and Range of *HHI*



Therefore, if HHI_{ub} is ignored, as in the indices described in this section, the calculation of *HHI* creates unreliable results. Owen et al. (2007) address this issue by proposing a different variation of the index, that is, the normalized *HHI* (*HHI**), which takes into account both the lower and the upper bounds by controlling for the range of *HHI*. Following equations (2.13) and (2.17), the *HHI** is given by:

$$HHI^* = \frac{HHI - HHI_{ideal}}{HHI_{ub} - HHI_{ideal}} = \frac{3(N-1)(NHHI-1)}{N+1} \quad . \tag{2.20}$$

The advantage of *HHI** is that its value ranges from zero (perfectly balanced league) to unity (completely unbalanced league) regardless of the variation in *N*. Thus, the comparison is facilitated by also providing the fluctuation of competitive balance among leagues in countries and/or seasons with various *N*. It is interesting that HHI_{ub} is invariant to the number of games between the same teams, provided that the schedules are balanced. A balanced schedule in a standard league format requires that each team play the same number of games against each of its opponents, which is a realistic assumption for European football leagues. Complicated calculations are required for the unequal benchmark in an unbalanced schedule. However, that is beyond the scope of the present study.

Gini Coefficient

The *Gini Coefficient* (*Gini*) is another index adopted from the field of economics. This index was originally proposed by the Italian statistician and demographer Corrado Gini to measure the degree of income inequality. Schmidt (2001) and Schmidt and Berri (2001) employ this traditional index to measure the deviation of championship from perfect balance. They adopt an approximation suggested by Lambert (1993), who defines *Gini* as follows:

$$Gini = \left(1 + \frac{1}{N}\right) - \frac{2}{N^2 \overline{w_i}}\left(w_N + 2w_{N-1} + 3w_{N-2} + \cdots + Nw_1\right). \tag{2.21}$$

Each team is ranked relative to its winning percent so as:

$$w_N \geq w_{N-1} \geq w_{N-2} \geq \cdots \geq w_1 .$$

In a typical industry, *Gini* has a range between zero (perfect balance) and unity (complete imbalance)[8]. In a professional football context, the lower bound is obtained in the case of perfect competitive balance, that is, when each team wins 50% of its games. The larger is the deviation of a championship from perfect balance, the higher is the value of *Gini*. As far as the upper bound is concerned ($Gini_{ub}$), it is always lower than unity due to the distribution of wins in sports. A single team can only win its own games and not all championship games. For an index to be usable for comparison between leagues with various *N*, both the lower and the upper bounds need to be taken into account. Table 2.5 presents the variation of $Gini_{ub}$ for selected *N*, where it can be easily drawn that its value is substantially lower than unity and inversely related to *N*.

Table 2.5: Variation of $Gini_{ub}$

Number of teams	$Gini_{ub}$
10	0.3667
12	0.3611
14	0.3571
16	0.3542
18	0.3519
20	0.3500
22	0.3485

Given that *Gini* ignores the upper bound, Utt and Fort (2002) re-calculate it in order to correct this defect. They clearly point out that the standard use of *Gini* dramatically overstates the value of competitive balance, which creates bias. Following their suggestion, the *Adjusted Gini Coefficient* (*AGini*) derives from the equation below:

$$AGini = \frac{Gini}{Gini_{ub}}. \qquad \textbf{(2.22)}$$

AGini always receives a value in the range of zero (perfectly balanced league) and unity (completely unbalanced league). The value of $Gini_{ub}$ has to be calculated for

[8] In the case of complete imbalance, the value of unity is approached when *N* tends to infinity.

different values of N participating teams under the assumption of a completely unbalanced league.

Relative Entropy

The *Entropy index* (H) has its origin in the industrial organisation theory (Shannon, 1948; Theil, 1967) and it was introduced to sports economics by Horowitz (1997). The H is a measure of uncertainty given by:

$$H = -\sum_{i=1}^{N} s_i \log_2 s_i . \tag{2.23}$$

The lower bound of H (H_L) is reached in case of a completely unbalanced league. The upper bound of H (H_M), which is reached in case of a perfectly balanced league, it is positively related to N as it is presented in Table 2.6. More specifically, the percentage difference in H_M is as high as 28.7% for the selected N.

Table 2.6: Variation of H_M

Number of teams	$H_M = \log_2 N$	*Percentage difference*
10	3.322	
12	3.585	0.079
14	3.807	0.062
16	4.000	0.051
18	4.170	0.042
20	4.322	0.036
22	4.459	0.032

After calculating H_M values, Horowitz (1997) proposes the *Relative Entropy* (R) in the equation below:

$$R = \frac{H}{H_M} = \frac{-\sum_{i=1}^{N} s_i \log_2 s_i}{-\sum_{i=1}^{N} \frac{1}{N} \log_2 \frac{1}{N}} = \frac{-\sum_{i=1}^{N} s_i \log_2 s_i}{\log_2 N} . \tag{2.24}$$

Given that R controls for H_M, the upper bound of R is one. Thus, as R decreases, so does the level of competitive balance. However, R does not take into account that, when applied to sports, H_L is not zero. Since for well-defined index both bounds should be well documented, R index as defined by equation (2.24) cannot be applied efficiently to the analysis of competitive balance in European football.

Concentration Ratio

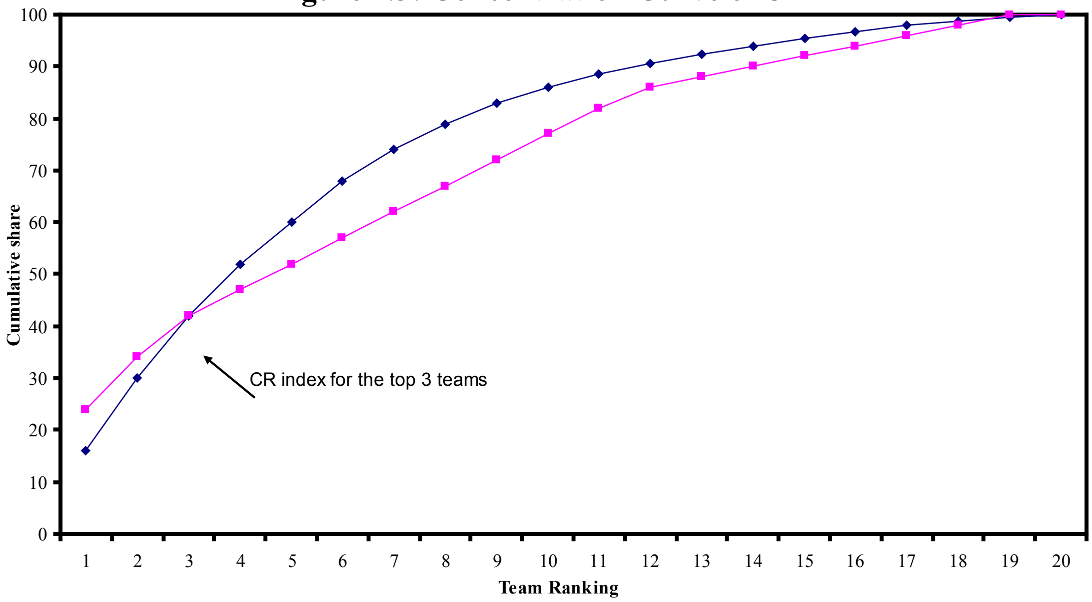
One of the most widely used indices in industrial organisation theory is *Concentration Ratio* (*CR*). Simplicity and limited data requirements make the *CR* index one of the most frequently used indices in industrial organisation for the measurement of a market's share (usually expressed in turnover terms). The selection of the number of firms to be included in the *CR* index is a rather arbitrary decision; however, a preference for a small number is evident, since it enables a clear delineation of a market into dominant and fringe firms (Djolov, 2006). The mathematical expression is defined by the summation of the market shares of the largest K firms in the market, and it takes the form:

$$CR = \sum_{i=1}^{K} s_i, \tag{2.25}$$

where s_i refers to the market share (expressed as a proportion) of the ith firm. The *CR* index ranges from zero to one. The index approaches zero for an infinite number of equally sized firms (given that the number of K firms under examination is relatively small as compared to the total number of firms in the industry). The larger the *CR* index, the more monopolistic the industry is. The *CR* index reaches its upper value when the K largest firms completely cover the market.

In the context of professional team sports, a team's "market share" is interpreted as the number of points won by the team as a proportion of the total points won by all teams in the course of the season (Depken, 1999). Essentially, the *CR* index, as it is applied to football, measures the degree of domination by the top K teams. One important criticism of the *CR* index in the context of sports leagues is that it examines the behaviour of a slice of the league, that is, the top K teams. More specifically, it depends only on one point in the concentration curve. The concentration curve is created if we plot the cumulative point share against the ranking of the teams. The height of the curve above any point on the horizontal axis measures the percentage of the league's total points accounted for by the largest *K* teams. The curve rises from the left to the right and reaches its maximum height of 100 % at a point which corresponds to the total number of teams in the league (Bikker & Haaf, 2002). Consequently, as it is depicted in Figure 2.3, for many fluctuations in the concentration curve the index could remain unchanged.

Figure 2.3: Concentration Curve of *CR*



Despite this significant weakness, the *CR* index is widely employed for three important reasons:

a) It is easily understood.
b) It is highly correlated with more sophisticated measures (Groot, 2008; Kamerschen & Lam, 1975).
c) It clearly captures the degree of domination of the top *K* teams, which is the major cause for the decline of competitive balance in European football (Michie & Oughton, 2004).

However, the application of the *CR* index to football is not straightforward. In contrast to the standard industry, there are two main reasons for arguing that the fundamentals of the *CR* index are markedly different when applied to football. Firstly, the total number *N* of teams that make up a league, is quite limited, whereas the relevant number of firms in the standard industry could be infinitely large. This feature has implications for the value of the lower bound of the index, which concerns cases of perfect balance, that is, when the top K teams win the same number of points as the rest of the teams. Consequently, when the index is applied to football, its lower bound, which equals K/N, substantially deviates from zero, which is the theoretical lower bound in the standard industry.

Secondly, it is not possible that the top K teams gather all the points in a championship, since the remaining teams also have to play against each other. This well-known characteristic of the distribution of points in sports leagues has repercussions on the upper bound of the index. The upper bound concerns cases of complete domination by the top K teams, that is, a league in which the best K teams always win any team with lower ranking. Therefore, the upper bound, which is defined as the ratio of the maximum number of points that the top K teams can gain over the total number of points in the league, is lower than one (which is the case in a monopolistic standard industry). Consequently, for the application of the CR index to football an appropriate adaptation is required since the boundaries of the index differ substantially from the conventional ones.

CR_K Index

Koning (2000) was the first to apply the conventional CR index to football. He introduces his own version of the concentration ratio, denoted as CR_K and defined as the ratio of the total number of points obtained by the top K teams to the maximum number of points those K teams could possibly obtain:

$$CR_K = \frac{\sum_{i=1}^{K} P_i}{2K(2N-K-1)}, \tag{2.26}$$

where P_i is the number of points achieved by the ith team. The CR_K index accounts for the upper bound, since the expression in the denominator is the maximum number of points the top K teams could possibly collect. The upper bound of the CR_K index is one, and is obtained for a league that is completely dominated by the top K teams. The more CR_K deviates from one, the more balanced (or less dominated) is the league. The upper bound is well defined since it is constant and, therefore, insensitive to both N and K. However, no provision has been taken for its lower bound. The lower bound is obtained for a perfectly balanced league as defined in Section 2.1. The number of points the top K teams win in a perfectly balanced league equals $2K(N-1)$. As a result, based on equation (2.26) above, the mathematical expression of the lower bound of CR_K (CR_{K_LB}) is given by:

$$CR_{K\_LB} = \frac{2K(N-1)}{2K(2N-K-1)} = \frac{N-1}{2N-K-1} = \frac{N-1}{2(N-1)-(K-1)} = \frac{1}{2-\dfrac{K-1}{N-1}}. \qquad \textbf{(2.27)}$$

From (2.27) it is obvious that CR_{K_LB} is an increasing function of the number of K teams considered in the index. For K=1, CR_{K_LB} is constant and equal to 0.5, which is its minimum value. Moreover, we can infer that CR_{K_LB} is a decreasing function of the size of league N. The variation of CR_{K_LB} for selected N and K is presented in Table 2.7 and it is graphically illustrated in Figure 2.4. The range of CR_{K_LB} is quite large taking values from 0.5 to 0.64. Therefore, a normalised version of the CR_K index, which will consider for both the lower and the upper bound is required for the analysis of competitive balance across leagues or seasons with a different number of competing teams (*N)* and/or different number of top teams (*K)*.

Table 2.7: Lower Bound of the CR_K Index (CR_{K_LB})

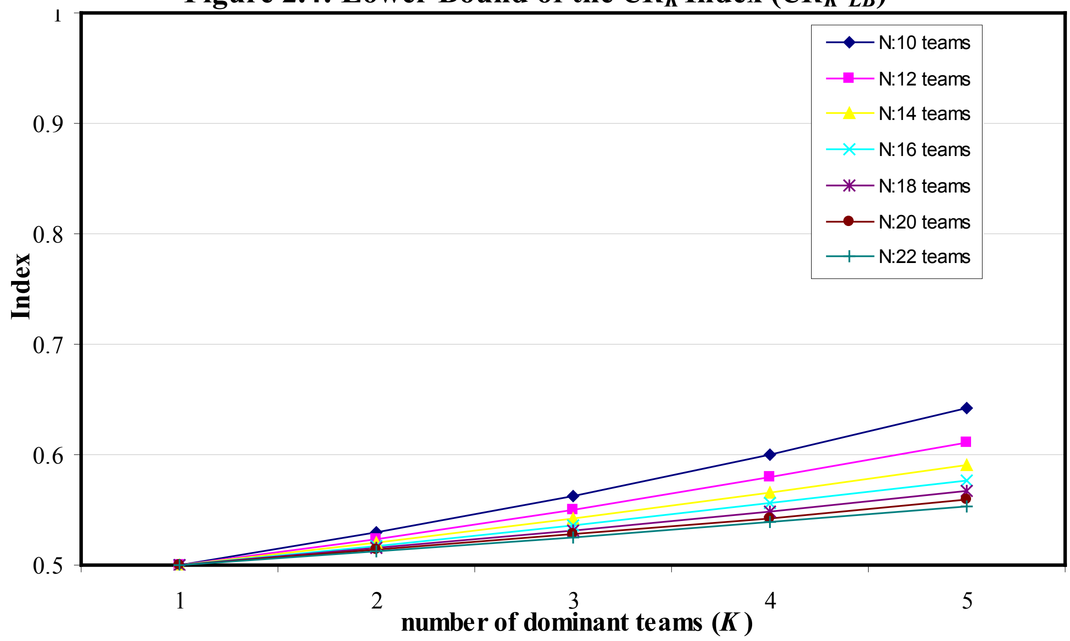
	N						
K	**10**	**12**	**14**	**16**	**18**	**20**	**22**
1	0.500	0.500	0.500	0.500	0.500	0.500	0.500
2	0.529	0.524	0.520	0.517	0.515	0.514	0.512
3	0.563	0.550	0.542	0.536	0.531	0.528	0.525
4	0.600	0.579	0.565	0.556	0.548	0.543	0.538
5	0.643	0.611	0.591	0.577	0.567	0.559	0.553

N: number of teams that make up the league
K: number of top teams under investigation

C5 Index of Competitive Balance

Michie & Oughton (2004) follow a different approach for the application of the *CR* index to football. They introduce the *C5 Index of Competitive Balance* (C_5ICB), which basically examines the degree of inequality between the top five teams and the remaining ones. The C_5ICB index is defined as the ratio of the actual cumulative share of points of the top five teams to the cumulative share of points of the top five teams in a perfectly balanced league.

Figure 2.4: Lower Bound of the CR_K Index ($CR_{K\ LB}$)



The C_5ICB index is defined as[9]:

$$C_5ICB = \frac{\sum_{i=1}^{5} sp_i}{5/N}, \tag{2.28}$$

where sp_i stands for the share of points of the ith team. Essentially, the C_5ICB index is the CR index controlled for the case of a perfectly balanced league. The expression in the denominator K/N with K=5 stands for the value of the CR index in the case of a perfectly balanced league. Consequently, the value of the lower bound of the C_5ICB index is one and is reached when the top five teams win on average the same number of points as the rest of the teams. Any increase in the C_5ICB index implies a reduction in competitive balance and an increase in the dominance of the top five teams. The lower bound is well defined, since it is constant and, therefore, insensitive

[9] For simplification, we do not employ the percentage scale given by Michie & Oughton (2004).

to both N and K. However, the upper bound, which is the case of complete domination by the top five teams, is not specified in the index.

We can generalise the C_5ICB index and, following the same procedure as for the CR_K index, we can investigate the estimation of the upper bound of the C_KICB. As is noted in equation (2.26), the total number of points the top K clubs could possibly obtain in a completely dominated league equals $2K(2N\text{-}K\text{-}1)$, whereas the total number of points allocated to all teams in the league can be estimated as $2N(N\text{-}1)$. Consequently, following equation (2.28), the upper bound of the C_KICB index (C_KICB_{UB}) is calculated by:

$$C_K ICB_{UB} = \frac{\dfrac{2K(2N-K-1)}{2N(N-1)}}{K/N} = \frac{2N-K-1}{N-1} = \frac{1}{CR_{K\_LB}} \quad . \tag{2.29}$$

Interestingly enough, C_KICB_{UB} equals to the inverse of CR_{K_LB}. It can easily be derived from equation (2.29) that for K=1, C_KICB_{UB} is constant and equal to 2, which is the maximum value over different K; for any K greater than one, C_KICB_{UB} decreases. In particular, the magnitude of the decrease is affected by both N and K. This effect can be verified by the inverse inferences deducted from the differentiation of CR_{K_LB} with respect to N and K respectively. Therefore, for K>1, C_KICB_{UB} is an increasing function of the size of league N. Consequently, the larger the N, the closer C_KICB_{UB} gets to its maximum value. Moreover, C_KICB_{UB} is negatively related to K. This implies that the larger the number of K teams under examination, the smaller the upper bound becomes. The variation of C_KICB_{UB} for selected N and K is presented in Table 2.8 and is graphically illustrated in Figure 2.5. The range of possible values of C_KICB_{UB} is quite large as it takes values from 1.55 to 2. As in CR_K, a sufficient normalisation of the C_KICB index must account for its upper bound for the reliable and comparable measurement of competitive balance for leagues or seasons with different sizes (N) and/or number of top K teams.

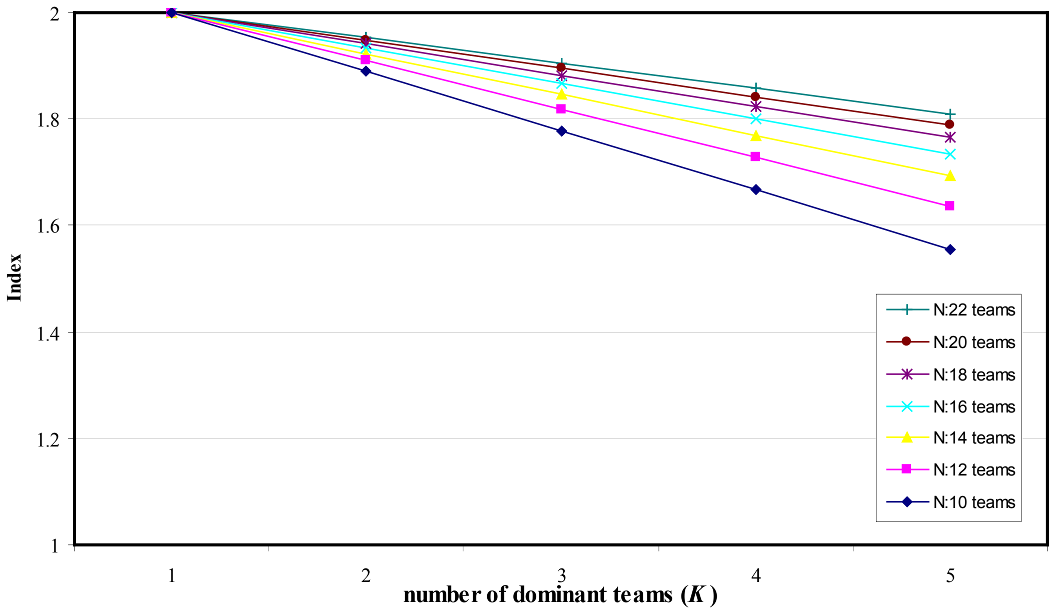
Table 2.8: Upper Bound of the C_KICB Index (C_KICB_{UB})

	N						
K	**10**	**12**	**14**	**16**	**18**	**20**	**22**
1	2.000	2.000	2.000	2.000	2.000	2.000	2.000
2	1.889	1.909	1.923	1.933	1.941	1.947	1.952
3	1.778	1.818	1.846	1.867	1.882	1.895	1.905
4	1.667	1.727	1.769	1.800	1.824	1.842	1.857
5	1.556	1.636	1.692	1.733	1.765	1.789	1.810

N: number of teams that make up the league

K: number of top teams under investigation

Figure 2.5: Upper Bound of the C_KICB Index (C_KICB_{UB})



2.1.3 Special Indices

In this section, it follows is a presentation of the most important derived indices, which are characterised as "special" due to their innovative approach. In particular, surprise points are used as a unit of measurement whereas a regression-based approach and a Maximum Likelihood Estimation (*MLE*) are employed for the estimation of teams' quality. Lastly, the probability of teams' performance based on the idealised normal distribution and a generic rating engine are used for the quantification of competitive balance.

Surprise Index

The so-called *Surprise Index* (*S*) was developed by Groot and Groot (2003). Unlike the above conventional indices of seasonal competitive balance, which utilise only the final league table, *S* uses all the available information of the final cross table, which depicts all games' results in the championship. The logic used to derive this index lies in the fact that fans become excited when a lower ranking team wins a better team. From the fans' perspective, the champion's defeat from the last ranking team is more surprising and intriguing than that from the second runner team. When such surprising results occur, the championship with increased fans' enthusiasm and interest is additionally stimulated. Two surprise points are awarded when a lower ranked team wins against a higher ranked team while one surprise point is granted when the game ends in a draw. The *S* index is the ratio of the actual surprise points (*Ps*) to the maximum surprise points (max*Ps*) achieved in the case of perfect competitive balance and is given by:

$$S = \frac{Ps}{\max Ps} = \frac{1}{\max Ps}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left(R_{ij} + R_{ji}\right)\left(j - i\right), \tag{2.30}$$

where R_{ij} stands for the result of the home team *i* against team *j*. *Ps* is the summation of the surprising results that are weighted against the rank difference (*j*-*i*). The calculation of max*Ps* is given as follows:

$$\max Ps = 2\sum_{i=1}^{N-1}\left(N - i\right)i = \frac{\left(N-1\right)N\left(N+1\right)}{3}. \tag{2.31}$$

For clarification, we consider a league with three teams and calculate the surprise points in Table 2.9. Considering a ranking order in the hypothetical league as A>B>C, the sum of two surprise points based on the results in the first row is derived from the draw game of team A against C (1-1). The win of team A against B (2-0) generates no surprise, since it is an expected result. Based on (2.31), the *Ps* for a league with three teams is equal to 8; thus, *S* is equal to 0.5 in our example.

Table 2.9: Calculation of Surprise Points

	A	B	C	*Ps*
A		2-0	1-1	***2***
B	0-0		1-0	***1***
C	0-3	2-2		***1***
			Total:	***4***
			maxPs	***8***
			S	***0.5***

The value of S ranges from zero to one. The former represents a completely unbalanced league, which is characterised by the fact that it offers no surprises and, therefore, the stronger team always wins. The latter represents a perfectly balanced league, which achieves the maximum surprise points and, thus, *Ps* equals max*Ps*. For clarification, a perfectly balanced league is obtained when the home team always wins or all games are tied. Although S is data-intensive, as it requires the results of each game, it is not sensitive to the number of teams in the championship. The choice of using the rank order based on the final league table is justifiable from Groot and Groot (2003) only for an analysis across a large number of seasons.

Regression-based Approach

An entirely different procedure for the measurement of seasonal competitive balance has recently been introduced by Haan, Koning and Witteloostuijn (2008). Their measurement is based on the standard deviation of team qualities rather than on winning percentages. They differentiate between variation in home advantage and variation in team qualities, on the grounds that they are affected by different structural factors. They used a model presented by Clarke and Norman (1995), whose parameters are simple and easy to interpret. In the Clarke-Norman model, a game takes place between teams i (home) and j (away). A latent random variable GD_{ij} determines the goal difference to the final outcome of the game, which is positive if the home team wins, negative if the away team wins, and zero in case of a draw. The quality parameters of the teams are measured using the following model:

$$GD_{ij} = \theta_i - \theta_j + h_i + \varepsilon_{ij}, \qquad \textbf{(2.32)}$$

where θ_i stands for the quality of the i team, h stands for home advantage, i and j correspond to the home and visiting teams respectively, and ε_{ij} is the error term, which is assumed to follow a normal distribution: $\varepsilon_{ij} \sim N(0, \sigma^2)$. The variable GD_{ij} is influenced by three parameters under estimation: the first and the second parameters comprise the quality θ of the teams i and j respectively. It is assumed that θ are constant throughout the season and independent of the opponent and the stadium. The third factor is the home advantage h_i defined as the goal margin by which the home team is expected to win against an opponent of equal quality. A random factor ε_{ij} is added to the model to capture all other factors that might affect the result of the game, such as delays, the weather conditions, the players' physical health, the referee's decision, etc.

Quality parameters $\theta_i s$ are normalised by imposing sum-to-zero constraints $\sum_{i=1}^{N} \theta_i = 0$. It means that the average quality is zero and a team with positive θ is better than average, while a team with negative θ is below average. If there is no home advantage, GD_{ij} is determined by the difference in θs designated as θ_i - θ_j. Even though the dependent variable in the above model is discrete, estimation with the method of least square is acceptable since it offers a reasonable fit to the data (Haan et al., 2008). Koning (2000), proposes a somewhat altered model, which is based on an ordered probit model and employs the outcome of a game rather than the goal difference as a dependent variable. It is along these lines that θ are interpreted as quality measurements. The variation of θ provides the index of competitive balance. Intuitively, if all teams are of equal quality, all θ as well as the variation of θ would be zero. However, the upper bound of the index is not defined. In particular, as an index of *SD*, the upper bound is sensitive to N; and thus, it cannot be employed to compare countries or seasons with different size of N.

Quality Index

Groot (2008) introduces the *Quality index* (CB_{qual}), which is also based on the distribution of team qualities. The distribution of relative team qualities is argued to be more fundamental than that of winning percentages. Moreover, the measurement of competitive balance based on the distribution of winning percentages might not reveal the latent balance in team strengths. In his model, Groot (2008) follows the logit contest success function, which is extensively used in the sport economics literature (Kesenne, 2005; Kesenne, 2007; Szymanski & Kesenne, 2004). The winning percentage of team *i* against team *j* can be modelled as:

$$w_{ij} = \frac{t_i}{t_i + t_j}, \tag{2.33}$$

where *t* stands for the qualities of the teams based on the amount of the players' talent. One of the main difficulties with the logit function is that it does not allow us to measure team qualities, since they are not directly observable. To overcome this, Groot (2008) derives the distribution of team qualities from the distribution of winning percentages. In a league championship with *N* teams, the above model can be used to indicate winning percentage as a function of team qualities, as it is shown below:

$$w_i = \frac{t_i}{N-1}\left(\sum_{j \neq i}^{N} \frac{1}{t_i + t_j}\right). \tag{2.34}$$

MLE is the appropriate process to estimate t_i used in (2.34). The corresponding *MLE* function is given by:

$$L = \prod_{i\_wins} \frac{t_i}{(t_i + t_j)} \prod_{i\_losses} \left(1 - \frac{t_i}{(t_i + t_j)}\right), \tag{2.35}$$

with the log likelihood function ℓ given by:

$$\begin{aligned} \ell &= \sum_{i\_wins} \ln\left(\frac{t_i}{(t_i + t_j)}\right) + \sum_{i\_losses} \ln\left(1 - \frac{t_i}{(t_i + t_j)}\right) \\ &= \sum_{i\_wins} \ln t_i - \sum_{i\_wins} \ln(t_i + t_j) + \sum_{i\_losses} \ln t_j - \sum_{i\_losses} \ln(t_i + t_j) \\ &= \sum_{i\_wins} \ln t_i + \sum_{i\_losses} \ln t_j - \sum_{i\_wins+losses} \ln(t_i + t_j). \end{aligned} \tag{2.36}$$

Then, the derivative of ℓ with respect to t_i gives:

$$\frac{\partial \ell}{\partial t_i} = \frac{Nw_i^a}{t_i} - \sum_{j=1, j\neq i}^{N} \frac{1}{(t_i + t_j)}, \tag{2.37}$$

where Nw_i^a stands for actual number of wins of team i[10]. Equating with zero, we derive the following for the estimate of t_i:

$$\hat{t}_i = \frac{Nw_i^a}{\sum_{j=1, j\neq i}^{N} \left(\frac{1}{\hat{t}_i + \hat{t}_j} \right)}. \tag{2.38}$$

The estimation of $\hat{t}_i$ can be accomplished using an iterative process starting from $\hat{t}_{i,0} = 1/N$. Each subsequent step is obtained by means of the following function:

$$\hat{t}_{i,k} = \frac{Nw_i^a}{\sum_{j=1, j\neq i}^{N} \left(\frac{1}{\hat{t}_{i,k-1} + \hat{t}_{j,k-1}} \right)}, \tag{2.39}$$

where k stands for the step in the iterative process starting from k=1 and subject to the condition that $\sum_{i=1}^{N} \hat{t}_{i,k} = 1$. The standard deviation of the estimated $\hat{t}$ is the CB_{qual} index. Consequently, the lower bound of the index is zero, which implies no dispersion in relative team qualities as in the state of perfect competitive balance. However, the upper value of the index, as introduced by Groot, is not well documented. Consequently, the observations above concerning the previous quality index also hold for CB_{qual}.

Tail Likelihood

The *Tail Likelihood* (*TL*) was introduced by Lee (2004) and it focuses on the winning percentages of a certain percentage of the top and bottom teams. Actually, it is a

[10] A draw is counted as half a win, half a loss.

modified measure of the *Excess Tail Frequency* which measures the percentage share of teams with winning percentages over the range of two or three standard deviations from the ideal distribution (Fort & Quirk, 1995). More specifically, it measures the probability of those winning percentages that occur in the ideal normal distribution, as described in Section 2.1.1. The *TL* is defined as the sum of densities of those winning percentages with an idealised normal distribution given by:

$$TL_p = \sum_{i=1}^{L} f(Z_i) = \sum_{i=1}^{L} f\left(\frac{w_i - 0.5}{ISD}\right) = \sum_{i=1}^{L} f\left(\frac{w_i - 0.5}{\frac{0.5}{\sqrt{G}}}\right) = \sum_{i=1}^{L} f\sqrt{G}(2w_i - 1),$$

$$\frac{L}{N} < p < \frac{L+1}{N}, \tag{2.40}$$

where *L* stands for the number of top and bottom teams as a certain percentage of the teams in the league, *f* stands for the normal probability density function, and *ISD* stands for the *Idealized Standard Deviation* and is equal to $0.5/\sqrt{G}$, with G=2N(N-1) when all teams play each other twice (see Section 2.1.1). Moreover, *p* is the percentage of top teams that we want consider. It is noted that, *L* is usually not an integer. For instance, the top 20% of the teams in a league with 18 teams is 3.6 and, therefore, TL_{20} is calculated considering a weighted average of the 3rd and the 4th best winning percentages. The lower bound of the *TL* index is zero. However, its upper bound, following the analysis in Section 2.1.1, is not well defined in the literature since it is sensitive to *N*.

Team Lodeings

The *Team Lodeings Index* (*TLI*) is the output of a generic rating engine introduced by Bracewell, Forbes, Jowett, and Kitson (2009). In order to quantify the level of competitive balance, *TLI* measures the relative performance of teams using team Lodeings (L_i). More specifically, it converts game results to a score ratio and then attempts to determine how team A would perform against team C given the performance of team A against B and that of B against C. The calculation of L_i is similar to the calculation of expected values in a chi-square test of independence as:

$$L_i = \frac{2\sum_{m=1}^{h_i} r_{i,m} \sum_{n=1}^{a_i} q_{i,n}}{h_i a_i}, \tag{2.41}$$

where h and α stand for the number of home and away games respectively played by the ith team, r stands for the score ratio in home games, q stands for the score ratio in the away games subtracted by one, and m, n stand for the home and away games respectively. The value of L_i ranges from zero to unity. The standard deviation of L_i represents the *TLI* as a measure of seasonal competitive balance.

$$TLI = SD(L_i), i = 1...N, \tag{2.42}$$

where *SD* stands for standard deviation. The lower bound of *TLI* is zero while the upper bound is not defined in the literature.

Overview Table with Indices of Seasonal Competitive Balance

A summary of all indices classified according to their features is provided in Table 2.10. Moreover, the table presents a short description, the function, and the unit of measurement of all indices. Special attention is paid to the definition of the bounds of the indices, since for a proper application to European football, both bounds must be well documented so as to account for the variability in *N*. It should be noted that bounds are defined as the case of a perfectly balanced and a completely unbalanced league respectively. Consequently, the level of competitive balance is not comparable among all indices presented in Table 2.10. For those indices for which the bounds are not well defined, a modification is required by means of normalisation for the proper quantification of competitive balance in the context of European football.

Table 2.10a: Indices of Seasonal Competitive Balance

	Study	*Indices of Dispersion of Winning Percentages*	*Description*	*Unit of Measurement*	*Lower Bound*	*Upper Bound*	*Relationship with competitive balance*[*]
1	p. 23	$Range = w_f - w_l$	Provides small amount of information since it depends only on the best and worst winning records in the league.	*w*	0 (*PB*)	1 (*CI*)	-
2	p. 24	*Standard Deviation*: $STD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(w_i - 0.5)^2}$	Describes the average squared distance of each team's *w* from the expected in case of perfect competitive balance. The upper bound is sensitive to *N*.	*w*	0 (*PB*)	*N.D.* (*CI*)	-
3	Noll (1988) and Scully (1989), p.25	*Ratio of Standard Deviation*: $RSD = \frac{STD\sqrt{G}}{0.5}$	Since it includes *STD*, its upper bound is also a function of *N*. The 'ideal competitive balance' of unity has been violated by empirical results.	*w*	0 (*PB*)	*N.D.* (*CI*)	-
4	Goossens (2006), p. 26	*National Measure of Seasonal Imbalance*: $NAMSI = \frac{STD}{\left[\frac{(N+1)}{12(N-1)}\right]^{1/2}}$	The index is properly controlled for the *STD*'s sensitivity to *N* by accounting for the case of complete imbalance.	*w*	0 (*PB*)	1 (*CI*)	-
5	Mizak et al. (2005), p. 30	*Index of Dissimilarity*: $ID = 0.5\sum_{i=1}^{N}\lvert\mu - S_i\rvert$	The index describes the dispersion of winning shares from the mean. It is necessary to account for its upper bound.	*s*	0 (*PB*)	*N.D.* (*CI*)	-

w: winning percent; *s*: winning share; *PB*: Perfect Balance; *CI*: Complete Imbalance; *N.D.*: Non defined.

[*]The relationship of the index with the level of competitive balance is defined as positive/negative if a higher value of the index is related with a more/less balanced championship.

Table 2.10b: Indices of Seasonal Competitive Balance

	Study	*Indices from Economic Theory*	*Description*	*Unit of Measurement*	*Lower Bound*	*Upper Bound*	*Relationship with competitive balance**
6	Owen et al. (2007), p.31	*Normalized HHI*: $HHI^* = \frac{3(N-1)(NHHI-1)}{N+1}$	The index measures the degree of concentration across units. It is defined by the quadratic summation of teams' winning shares.	*s*	0 (*PB*)	1 (*CI*)	-
7	Utt and Fort (2002), p.35	*Adjusted Gini Coefficient*: $AGini = \frac{Gini}{Gini_{ub}}$	The index measures the deviation of a championship from perfect balance.	*w*	0 (*PB*)	1 (*CI*)	-
8	Horowitz (1997), p.37	*Relative Entropy*: $R = \frac{-\sum_{i=1}^{N} s_i \log_2 s_i}{\log_2 N}$	It is an index of uncertainty from information theory. The lower bound is not defined when applied to sports.	*s*	*N.D.* (*CI*)	1 (*PB*)	+
9	Koning (2000), p.40	CR_K *Index*: $CR_K = \frac{\sum_{i=1}^{K} P_i}{2K(2N-K-1)}$	The index captures the degree of domination by the top *K* teams. The lower bound is a function of *N*.	*P*	*N.D.* (*PB*)	1 (*CI*)	-
10	Michie and Oughton (2004), p.41	*C5 Index of Competitive Balance*: $C_5ICB = \frac{\sum_{i=1}^{5} sp_i}{5/N}$.	This index also captures the degree of domination by the top *K* teams. The upper bound is a function of *N*.	*sp*	1 (*PB*)	*N.D.* (*CI*)	-

w: winning percent; *s*: winning share; *P*: number of points; *sp*: share of points; *PB*: Perfect Balance; *CI*: Complete Imbalance; *N.D.*: Non defined.

*The relationship of the index with the level of competitive balance is defined as positive/negative if a higher value of the index is related with a more/less balanced championship.

Table 2.10c: Indices of Seasonal Competitive Balance

	Study	*Special Indices*	*Description*	*Unit of Measurement*	*Lower Bound*	*Upper Bound*	*Relationship with competitive balance**
11	Groot and Groot (2003), p.45	*Surprise Index*: $S = \frac{1}{M}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(R_{ij}+R_{ji})(j-i)$	This innovative index, which uses information from the final cross table, it employs surprising point to estimate the level of competitive balance of a championship.	Surprise Points	0 (*CI*)	1 (*PB*)	+
12	*Haan* et al. (2008), p.46	*Regression-based Approach Model*: $GD_{ij} = \theta_i - \theta_j + h_i + \varepsilon_{ij}$	The index is the *SD* of teams' qualities estimated from the probit model. The upper bound is a function of *N*.	Team Quality	0 (*PB*)	*N.D.* (*CI*)	-
13	Groot (2008), p.47	*Quality Index* (*CB_{qual}*): $\hat{t}_{i,k} = \frac{Nw_i^a}{\sum_{j=1,j\neq i}^{N}\left(\frac{1}{\hat{t}_{i,k-1}+\hat{t}_{j,k-1}}\right)}$	The index is the *SD* team' qualities derived with log likelihood estimation using winning percentages. The upper bound is also a function of *N*.	Team Quality	0 (*PB*)	*N.D.* (*CI*)	-
14	Lee (2004), p.49	*Tail Likelihood*: $TL = \sum_i f(Z_i)$	The index measures the probability of winning percentages at the top and bottom of the ladder. The upper bound is sensitive to *N*.	Z scores	0 (*PB*)	*N.D.* (*CI*)	-
16	Bracewell et al. (2009), p.50	*Team Lodeings* (*TLI*): $L_i = \frac{2\sum_{m=1}^{h_i} r_{i,m}\sum_{n=1}^{a_i} q_{i,n}}{h_i a_i}$	The index is the *SD* of teams lodeings, which is the output of a generic rating engine, and it measures the relative performance of the teams. The upper bound is a function of *N*.	Lodeigns	0 (*PB*)	*N.D.* (*CI*)	-

PB: Perfect Balance; *CI*: Complete Imbalance; *N.D.*: Non defined.

*The relationship of the index with the level of competitive balance is defined as positive/negative if a higher value of the index is related with a more/less balanced championship.

2.2 Indices of Between-Seasons Competitive Balance

In this section, we focus on the measurement of the between-seasons dimension, which is the longest time-wise dimension of competitive balance extending across at least two consecutive seasons. This dimension captures an important aspect of competitive balance measuring whether the same group of teams either dominates the league or fights to avoid relegation across different seasons. The characteristics and the reasoning behind the between-seasons indices are presented in this section which concludes with a short description of the indices excluded by this survey followed by an overview table and some closing remarks.

2.2.1 Measurement Characteristics and Scarcity of Between-seasons Indices

The between-seasons dimension has the distinguishing attribute of capturing the mobility or relative performance of teams across seasons. In contrast to the seasonal dimension, the identity of teams matters in the calculation of the between-seasons dimension, since we need to know the performance of each team from season to season. This is explicitly illustrated in Table 2.11 by a hypothetical six-team league similar to the one presented by Humphreys (2002). In two different hypothetical scenarios A and B, the winning record of each team is calculated along with the seasonal standard deviation of winning percentages (*STD*) for a five-season span. In both cases, the *STD* equals 0.342 for every season, which means that the level of competitive balance, according to this measure, is the same for every season.

Consequently, the league is equally balanced in scenarios A and B according to the seasonal measure of *STD*. However, it is obvious that the relative standings across seasons are quite different between those two cases. In scenario A, team A completely dominates the league while team F is perpetually the weakest team for the whole 6-year period. In contrary, in scenario B, there is a perfect variability in the teams' standings and every position is equally shared amongst teams. This turbulence of relative standings can be only captured by suitable between-seasons indices of competitive balance where the identity of the teams is distinguishable over the seasons.

Table 2.11: A Hypothetical League in Two Different Scenarios

Scenario A																		
	Season																	
Team	**1**			**2**			**3**			**4**			**5**			**6**		
	W	L	Win%	W	L	Win%	W	L	Win%	W	L	Win%	W	L	Win%	W	L	Win%
A	5	0	1	5	0	1	5	0	1	5	0	1	5	0	1	5	0	1
B	4	1	0.8	4	1	0.8	4	1	0.8	4	1	0.8	4	1	0.8	4	1	0.8
C	3	2	0.6	3	2	0.6	3	2	0.6	3	2	0.6	3	2	0.6	3	2	0.6
D	2	3	0.4	2	3	0.4	2	3	0.4	2	3	0.4	2	3	0.4	2	3	0.4
E	1	4	0.2	1	4	0.2	1	4	0.2	1	4	0.2	1	4	0.2	1	4	0.2
F	0	5	0	0	5	0	0	5	0	0	5	0	0	5	0	0	5	0
	STD:		*0.342*			*0.342*			*0.342*			*0.342*			*0.342*			*0.342*

Scenario B																		
	Season																	
Team	**1**			**2**			**3**			**4**			**5**			**6**		
	W	L	Win%	W	L	Win%	W	L	Win%	W	L	Win%	W	L	Win%	W	L	Win%
A	5	0	1	4	1	0.8	3	2	0.6	2	3	0.4	1	4	0.2	0	5	0
B	4	1	0.8	3	2	0.6	2	3	0.4	1	4	0.2	0	5	0	5	0	1
C	3	2	0.6	2	3	0.4	1	4	0.2	0	5	0	5	0	1	4	1	0.8
D	2	3	0.4	1	4	0.2	0	5	0	5	0	1	4	1	0.8	3	2	0.6
E	1	4	0.2	0	5	0	5	0	1	4	1	0.8	3	2	0.6	2	3	0.4
F	0	5	0	5	0	1	4	1	0.8	3	2	0.6	2	3	0.4	1	4	0.2
	STD:		*0.342*			*0.342*			*0.342*			*0.342*			*0.342*			*0.342*

In contrast to the variety of existing seasonal competitive balance indices, the number of between-seasons indices presented in the literature is quite limited (Buzzacchi et al., 2003). This number becomes even smaller when we focus on the implementation of such between-seasons indices on European football. This is justified by two important factors related to the structural features of measuring the between-seasons dimension:

a) **Teams' identity matters:** In contrast to the closed North American leagues, European football leagues are open to new promoted teams substituting the worst teams of the previous season. Essentially, there are noticeable differences in the championship structure between a closed and an open league. In the former, identity of the teams remains exactly the same for a long period (except for seasons of expansion or contraction), whereas in the latter it continuously changes from season to season due to the promotion and relegation rule. More specifically, for every season in any domestic European football league, the last teams in the classification are demoted to the immediate lower division and are replaced by the promoted teams from the lower division. Consequently, even between two adjacent seasons, two, three, or even four teams change according to the specific relegation rule of the league.

Therefore, only indices that account for the promotion-relegation rule can be utilised for the study of competitive balance in European football. In an attempt to circumvent such a strict limitation, two different approaches emerged in the literature. In particular, Groot (2008) conveys the ranking of the relegated teams to the promoted ones while Gerrard (1998) reduces the total number of teams by excluding relegated teams. It is reasonable to assume that the former approach is preferable from the fans' perspective. Moreover, the latter excludes valuable information. In the present study the compromise proposed by Groot (2008) is followed, since it is assumed that it does not introduce an unacceptable degree of bias. This compromise cannot be applied for a period longer than two adjacent seasons since the teams' identity in the league dramatically changes.

b) **The unit of measurement of the between-seasons indices:** The two proposed units of measurement are: a) the *ranking mobility*, and b) the *change in winning percentages/shares* across seasons. The former stands for relative performance while the latter for absolute level of success. It can be safely assumed that in the long run, relative performance is more significant than the absolute level of success from the fans' perspective. Obviously, the change in the teams' winning percentages across seasons matters to the fans, but it is doubtful that this is at least equally important as ranking mobility. Normally, fans cannot easily judge teams' winning percentages from season to season. On the contrary, they can spontaneously recall at least the approximate ranking position of all teams. In particular, they can easily recall the exact position of teams at the top of the ladder in the span of one or even two and/or three seasons.

Following that, indices of ranking mobility across two adjacent seasons, although they do not account for the promotion-relegation rule, they can be applied to European football under the above-mentioned compromise. However, the same rationale cannot be followed for the indices of winning percentages change. While it seems natural to assign the ranking of the relegated to the promoted teams, a similar procedure for the winning percentages appears to be quite arbitrary. Consequently, indices based on the winning percentage change cannot be applied on European football data.

2.2.2 Indices Appropriate for European Football

An index especially designed for European football is the so called *G* index (Buzzacchi et al., 2003). In the following, we present the *G* index along with three additional indices that can be applied on European football using the above-discussed compromise.

G index

Essentially, the *G index* (*G*), which was developed by Buzzacchi et al. (2003), not only accounts for the promotion and relegation rule, but it also permits for a comparison across leagues and/or seasons with various number of teams. Additionally, it accounts for the number of teams promoted in and relegated from any division in a particular championship format. It is a *Gini type* index which measures the cumulative frequency of teams entering the top *K* positions in the highest league over a fixed period. Moreover, it measures the turnover in the top *K* positions relative to the expected frequency in a perfectly balanced league in which the win in every game is purely random. Buzzacchi et al. (2003) compare the observed frequency with a theoretical benchmark which represents the number of teams entering the top *K* places in an ideally balanced league. The elaborated benchmark considers a typical European championship format with a number of *L* divisions, where *p* teams are promoted and *r* teams are relegated each season in leagues with *N* teams. The probability that a team is in division *l* in year *t* is given by:

$$d(l,t) = d(l,t-1)\frac{N_l - r(l) - p(l)}{N_l} + d(l-1,t-1)\frac{r(l-1)}{N_{l-1}} + d(l+1,t-1)\frac{p(l+1)}{N_{l+1}}, \quad \textbf{(2.43)}$$

where $1 \le l \le L$, $r(L) = p(1)=0$, $d(0,t) = d(L+1,t)=0$. The starting year is 0, t is any year in the period under examination T. Each team starts at t=0 in league l with probability 1, consequently $d(l,0)=1$ and 0 otherwise. Given that the probability a team is in one of the top K positions in the highest league in year t is estimated by the joint probability $d_l(1,t)K/N_1$, the probability that the same team is at least once in any of the top K positions after year T is given by:

$$w_l\left(K-T\right)=1-\prod_{t=0}^{T}\left[\sum_{l=2}^{L}d_l\left(l,t\right)+\frac{N_1-K}{N_1}d_l\left(1,t\right)\right]=1-\prod_{t=0}^{T}\left[1-\frac{d_l\left(1,t\right)K}{N_1}\right]. \quad \textbf{(2.44)}$$

Based on equation (2.44), the expected number of teams that will have been in any of the top K places after T years is given by:

$$y\left(K,T\right)=\sum_{l=1}^{L}N_l w_l\left(K,T\right). \quad \textbf{(2.45)}$$

The G index is proposed by Buzzacchi et al. (2003) after calculating the benchmark case in (2.45); the index quantifies the observed values as:

$$G\left(T\right)=\frac{\sum_{T=1}^{T}y^L\left(K,T\right)-\sum_{T=1}^{T}y_a^L\left(K,T\right)}{\sum_{T=1}^{T}y^L\left(K,T\right)}, \quad \textbf{(2.46)}$$

where T stands for the years under consideration and $y^L\left(K,T\right)$ and $y_a^L\left(K,T\right)$ stand for the expected and observed numbers respectively for teams entering at least once in the top K positions in the highest league. The value of the lower bound of G is zero and signifies a perfectly balanced league. However, the upper bound of the index, which indicates a completely unbalanced league, is not well defined and is only referred to as “close to one”. Therefore, a modification is required for the proper application of G to European football.

Indices of Ranking Mobility in two Adjacent Seasons

A variety of indices measuring the degree of ranking mobility between two adjusted seasons exists. The compromise under which those indices are applicable to European football is straightforward. More specifically, using t as a benchmark season, promoted teams in season t-1 are assigned to the ranking position of the relegated ones. The exact ranking order of the promoted teams is determined by the respective ranking position in the lower division in season t-1.

Index of Dynamics

Haan, Koking & van Witteloostuijn (2002) propose the DN_t index to measure ranking mobility from season to season by summation of the absolute number of ranking changes of all teams. Consequently, the mathematical expression of DN_t is given by:

$$DN_t = \sum_{i=1}^{N} \left| r_{i,t} - r_{i,t-1} \right|, \tag{2.47}$$

where $r_{i,t}$ stands for the ranking position of team i in year t. As it is illustrated in the following example, DN_t is a quite simple index, which can be calculated in a straightforward manner. Consider a six-team league and the final rankings in two consecutive seasons denoted as A and B.

Table 2.12: A six-team League: Ranking Changes

Teams	Season A	Season B	Change
A	1	6	5
B	2	5	3
C	3	4	1
D	4	3	1
E	5	2	3
F	6	1	5
		Sum of Change:	18

As it can be inferred from the above example, upward and downward movements in the rankings are treated identically. In addition, the summation of change in rankings is affected by the number of N teams. If the number of teams is N, the maximum of DN_t equals $N^2/2$. However, in view of the fact that DN_t depends on the number of teams that comprise the league, Haan et al. (2002) introduces the normalised *Index of Dynamics* (DN_t^*) in league rankings[11]:

$$DN_t^* = \frac{2}{N^2}\sum_{i=1}^{N}\left|r_{i,t} - r_{i,t-1}\right|. \tag{2.48}$$

The DN_t^* index is insensitive to *N* and its value ranges from zero to one. The former represents the case of a completely unbalanced league (no ranking mobility) while the latter the case of a perfectly balanced league (maximum ranking mobility). In the above example, the value of DN_t^* equals one, since it reaches the maximum ranking mobility from season A to season B.

Kendall's tau coefficient

Groot (2008) introduces the application of the *Kendall's tau coefficient* (τ) to rank correlation. The τ index illustrates the overall ranking turnover within a league between two seasons. The calculation of τ is based on the number of transpositions required to transform a particular rank order to another specific order. For example, suppose the following ranking in a league with four teams:

	Teams			
	A	*B*	*C*	*D*
season 1:	1	2	3	4
season 2:	3	1	2	4

Note that when teams are orderly listed in *season 1*, two transpositions are required to transform the ranking in *season 1* into the ranking of *season 2*. More specifically, team *C* in *season 1* has to advance two positions in season 2. The number of observed transpositions (s) is the basis for the calculation of the τ index. In essence, s is compared with the maximum possible transpositions (s_{max}), which is equal to $N(N-1)/2$. The formula of the τ index is given by:

[11] Even though they do not refer to Haan et al. (2002), Mizak, Neral, and Stair (2007) propose the *Adjusted Churn*, which is fundamentally the same as DN_t^*.

$$\tau = 1 - \frac{2s}{s_{\max}} = 1 - \frac{4s}{N(N-1)}. \quad \textbf{(2.49)}$$

The theoretical upper and lower bounds of this statistical index are -1 and 1. The upper bound is obtained when there are no transpositions (s equals zero), and it stands for a completely unbalanced league. As far as the lower bound is concerned, it is obtained when the number of transpositions is maximum (s equals stands s_{max}), and it stands for a perfectly balanced league. According to Groot's interpretation, a perfectly balanced league is defined when the ranking of the teams in one season are independent of their ranking in the adjacent season. In that case, s equals $N(N\text{-}1)/4$ and, therefore, the value of the τ index is zero. Groot's interpretation raises comparability issues, since there are several cases in European football with values that are either negative or close to zero based on our preliminary results from application in eight European countries. However, in Groot's empirical results for England, negative values are non-existent or very rare.

Spearman's rho

A competitor to *Kendall's* τ is *Spearman's rho* (r_s) correlation coefficient for ranked data (Daly & Moore, 1981; Maxcy, 2002; Maxcy & Mondello, 2006). Although Kendall bases his statistic on the number of inversions or ranking transpositions, Spearman treats ranks as scores and then calculates the correlation between two sets of ranks. The calculation of the r_s index is accomplished by simply applying the *Pearson's correlation coefficient* (r) (Howell, 1987):

$$r_s = \frac{S_{XY}}{\sqrt{S_X S_Y}}, \quad \textbf{(2.50)}$$

with $S_{XY} = \sum_{i=1}^{N} X_i Y_i - \frac{\sum_{i=1}^{N} X_i \sum_{i=1}^{N} Y_i}{N}, S_X = \sum_{i=1}^{N} X_i^2 - \frac{\left(\sum_{i=1}^{N} X_i^2\right)^2}{N},\ S_Y = \sum_{i=1}^{N} Y_i^2 - \frac{\left(\sum_{i=1}^{N} Y_i^2\right)^2}{N},$

where X, Y are the rankings of teams in two different seasons. An alternative formula is given by Snedacor and Cohran (1967):

$$r_s = 1 - \frac{6\sum_{i=1}^{N} D_i^2}{N\left(N^2 - 1\right)}, \tag{2.51}$$

where D_i=(X_i-Y_i) stands for the difference in rankings of teams between the two seasons. The interpretation of r_s is similar to that of the τ index, and its value ranges from -1 (perfect balance) to 1 (complete imbalance).

2.2.3 Indices not Applicable to European Football

In this section, we present indices that cannot be applied to European football due to the promotion-relegation rule. Generally, their distinguishing feature is that their unit of measurement is based on the ranking over long periods (more than two) or winning percentage change across seasons. In both cases, the compromise adopted previously cannot be followed. Our review, therefore, focuses only on the main features of those indices.

Indices of Ranking over Long Periods

There exist indices of ranking mobility that refer to a much longer period than that of two adjacent seasons. Apparently, for a period of many seasons, the teams' identity in the league changes dramatically and, therefore, the compromise to overlook the promotion-relegation rule cannot be applied. For instance, in a three-season span for a league with 18 teams in total and 3 relegated teams, the change in the teams' identity could rise up to 50 percent; as a result, those indices of ranking mobility cannot be applied to European football.

Hirfindahl-Hirchman Index

One of the most frequently used indices of ranking over long periods is the *Hirfindahl-Hirchman Index* (*HHI*). In effect, there are two widely used applications of the *HHI* for the measurement of the between-seasons dimension. Firstly, the *relative Hirfindahl-Hirchman Index (rHHI)*, which measures concentration of title winners or other top places over a long period of time (Eckard, 1998). More specifically, the *rHHI* is calculated by summing the quadratic team shares minus the expected value of *HHI* under the assumption of perfect balance (i.e. all shares are assumed equal for the period under study) which corresponds to equal shares for the period under investigation.

$$rHHI = \sum_{i=1}^{N} s_i^2 - HHI_{equal}, \tag{2.52}$$

where s_i stands for the share of times the i team appears at the top places for the examined period, HHI_{equal} stands for the value of HHI under equal shares for all the N teams in the league. Secondly, the *Hirfindahl-Hirchman Index adjusted* (*HHI-adj*), which was introduced by Gerrard (2004). Although *HHI-adj* has a similar application to *rHHI,* it takes into account the maximum value of *HHI* (HHI_{max}):

$$HHI - adj = \frac{\sum_{i=1}^{N} s_i^2}{HHI_{\max}}, \tag{2.53}$$

where $HHI_{\max}$ stands for the value of *HHI* under domination by the same teams for the whole examined period.

Gini Coefficient

Besides *HHI, Gini Coefficient* (*Gini*) has also been employed for measuring the concentration in any of the top positions in a league over a period of many seasons (Fizel, 1997; Quirk & Fort, 1997). Adapting from equation (2.21), x now stands for the appearances of each team per season at the top places.

Markov-based Approach

Hadley, Cieka, and Krautman (2005) introduce a *Markov-based approach* to estimate transitional probabilities of teams from one state to another over a period of two decades whereas Krautmann and Hadley (2006) employ this approach clustering a number of seasons specified by structural factors in MLB. The different states are defined in terms of a team's ranking at the end of season. In this state-dependent approach, the outcome is treated as a binary variable and at time (t+1) it is determined by the state at time t. The transitional probabilities are calculated as the proportion of transitions from one state to the other. For instance, consider a league with 20 teams and six available spots each season for qualifying in European championships. If four teams continue and two new teams gain the right to participate in European championships the following season, the transitional probabilities are calculated as: P^{EE}=4/6 and P^{NE}=2/14, where P^{EE} stand for the transitional probabilities to continue playing in European Championships while P^{NE} stands the possibility for a new team to gain one of these positions.

Hope Statistic

Similarly to the *Markov-based approach*, the *Hope Statistic*, introduced by Kaplan, Nadeau, and O'Reilly (2011), handles success as a binary variable. Instead of using winning percentages, the *Hope statistic* employs a chosen number of wins out of a specified ranking spot as an indicator of hope. According to this index, the value of one or zero is assigned to teams that finish with fewer or more wins than the chosen number of wins away from the specified ranking spot respectively. The chosen number of wins is quite arbitrary. For instance, Kaplan et al. (2011) use the number of 8 wins while O'Reilly, Kaplan, Rabinel, and Nadeau (2008) use 5.5 wins away from the post-season spot. The formula of this index is given by:

$$Hope = \frac{\dfrac{\sum_{t=1}^{T} GBL_{N,i}}{T}}{\sqrt{\dfrac{\sum_{t=1}^{T}\left(GBL_{t,i} - \overline{GBL_{t,i}}\right)^2}{T}}} = \frac{\overline{GBL_N}}{\sigma GBL_t}, \tag{2.54}$$

with $GBL_{N,i} = \dfrac{\sum_{t=1}^{T} GBL_{t,1}}{N}$, $GBL_{t,1} = \dfrac{\sum_{t=1}^{T} GBL_{t,1}}{T}$,

where *GBL* stands for the binary variable taking the values of one or zero based on the number of team's *i* wins away from the specified ranking spot, and *T* stands for the number of seasons under investigation.

Indices of Winning Percentage Chance Across Seasons

A large number of indices that measure winning percentage/share change of teams across seasons exist. In what follows, we briefly review the most important of those indices mainly employed in closed leagues either in the United States or Australia.

Correlation Coefficient

The *Correlation coefficient* of teams' winning percentages up to a three seasons lag was utilised by Balfour and Porter (1991) to investigate the effects of free agency in competitive balance both in MLB and the NFL. Similarly, Butler (1995), employs the *Correlation* of winning percentages for an adjacent season for the analysis of competitive balance in MLB. The calculation of the index is based on *Pearson's correlation coefficient* as in equation (2.50).

ANOVA-based indices

The *ANOVA-based measure* (*VAR*), developed by Eckard (1998, 2001a, 2001b), is a more sophisticated measure that encompasses both the seasonal and the between-seasons dimensions. More specifically, Eckard decomposes the total variance of team winning percentages into time varying and a cumulative component as:

$$VAR = VAR_{time} + VAR_{cum}, \tag{2.55}$$

where VAR_{time} stands for the mean of seasonal winning percentages variances of the teams, and VAR_{cum} stands for the variance of cumulative teams' winning percentages over the period under investigation.

Alternatively, Humphreys (2002) introduces the *Competitive Balance Ratio* (*CBR*) which also accounts for both the seasonal and the between-seasons dimensions. In particular, *CBR* scales the relative magnitude of the average variation in winning percentages of all teams in the league ($\overline{\sigma_T}$) by the average variation in winning percentages of each team across seasons ($\overline{\sigma_N}$) given by:

$$CBR = \frac{\overline{\sigma_T}}{\overline{\sigma_N}}. \tag{2.56}$$

Both the *ANOVA-Based* and *CBR* are calculated over a period of several seasons; what is more, there is some controversy over their resemblance (Eckard, 2003; Humphreys, 2003). An index similar to the *ANOVA-Based* and *CBR* spirit is James's index which is measured for a decade and is also composed of two elements: a) the average standard deviation of winning percentages for teams in each season, and b) the standard deviation among teams as a whole (James, 2003).

Instability index

A simpler index is the *Instability index* (*Is*), developed by Hymer & Pashigian (1962), which is given by the sum of the absolute change in teams' winning share from season to season:

$$Is = \sum_{i=1}^{N} \left| s_{i,t} - s_{i,t-1} \right|, \qquad \textbf{(2.57)}$$

where $s_{i,t}$ stands for the winning share of team i in season t.

Linearised Turnover Gain Function

Lastly, the *Linearised Turnover Gain Function* (*LTFG*), was recently introduced by Lenten (2009). It uses the winning percentages of two consecutive seasons to produce a quadratic metric that takes the form of a turnover gain function. In essence, *LTGF* quantifies the gains for a more competitive championship, when a team moves towards the 0.5 winning percentage record. *LTGF* is given by:

$$LTFG = \frac{\sum_{i=1}^{N} Y_{i,t}}{N}, \qquad \textbf{(2.58)}$$

where $Y_{i,t}$ stands for the gains of team i in season t in a league with N teams. The values of $Y_{i,t}$ are calculated according to the teams' winning percentages (w) given by Table 2.13:

Table 2.13: Conditions for the Gain Function

Values of $Y_{i,t}$	*Conditions*
0	$w_{i,t-1}=0.5$ $w_{i,t} \leq w_{i,t-1}<0.5$ $0.5<w_{i,t-1} \leq w_{i,t}$
$\lvert w_{i,t}-w_{i,t-1}\rvert$	$w_{i,t-1}<w_{i,t}<0.5$ $w_{i,t-1}>w_{i,t}>0.5$
$\lvert w_{i,t-1}-0.5\rvert$	$w_{i,t}<0.5<w_{i,t-1}$ $w_{i,t-1}<0.5<w_{i,t}$

Overview Table with Between-seasons Indices of Competitive Balance

A summary of the existing between-seasons indices of competitive balance along with their unit of measurement is provided in Table 2.14. Based on the previous analysis, the definition of the boundaries is presented and the indices are classified according to their applicability to European football. *G* index requires normalisation since its upper bound is not well documented. From this table it can be inferred that most of the existing indices cannot be applied in European football due to the promotion-relegation rule, which either greatly affects the identity of the teams across seasons or prevents the use of the suggested compromise when winning percentage changes across seasons are employed.

Table 2.14a: Indices of Between-Seasons Competitive Balance

No	Study	Index	Description	Unit of measurement*	Appropriate for use in European football*	Range of the Index	
						Lower	Upper
1	Buzzachi et al. (2003), p.58	*G index*: $G(T)=\frac{\sum_{T=1}^{T}y^{L}(K,T)-\sum_{T=1}^{T}y_{a}^{L}(K,T)}{\sum_{T=1}^{T}y^{L}(K,T)}$	This index measures the frequency of teams in the top *K* places for a number of seasons *T*. The upper bound is not well documented.	*R*	☑	0 (*PB*)	*N.D.* (*CI*)
2	Haan et al. (2002), p.60	*Index of Dynamics*: $DN_{t}^{*}=\frac{2}{N^{2}}\sum_{i=1}^{N}\left\|r_{i,t}-r_{i,t-1}\right\|$	It measures the ranking mobility in the league in two adjacent seasons.	*R*	✓	0 (*CI*)	1 (*PB*)
3	Groot (2008), p.61	*Kendall's tau Coefficient*: $\tau=1-\frac{4s}{N(N-1)}$	This index measures the number of transpositions in two adjacent seasons.	*R*	✓	-1 (*PB*)	1 (*CI*)
4	Howell (1987), p.62	*Spearman's rho*: $r_{s}=\frac{S_{XY}}{\sqrt{S_{X}S_{Y}}}$	It is the application of Pearson's *r* to ranks.	*R*	✓	-1 (*PB*)	1 (*CI*)
5	Eckard (1998), p.63	*Relative HHI*: $rHHI=\sum_{i=1}^{N}s_{i}^{2}-HHI_{equal}$	It measures the concentration of title winners or top places over seasons.	*R*	✗	*N.A.*	
6	Gerrard (2004), p.63	*HHI adjusted*: $HHI-adj=\frac{\sum_{i=1}^{N}s_{i}^{2}}{HHI_{\max}}$	It measures the concentration of title winners or in top places across seasons.	*R*	✗		
7	Fizel (1997), p.64	*Gini Coefficient*	It measures the concentration in any of the top places across seasons. The formula is derived from the application of *Gini* to seasonal dimension.	*R*	✗		

R: Ranking based measurement; *PB*: Perfect Balance; *CI*: Complete Imbalance; *N.D.*: Non defined; *N.A.*: Not Applicable.

*☑: Yes; ✓: Yes, using the discussed compromise; ✗: No.

Table 2.14b: Indices of Between-Seasons Competitive Balance

No	Study	Index	Description	Unit of measurement*	Appropriate for use in European football*	Range of the Index	
						Lower	Upper
8	Hadley et al. (2005), p.64	*Markov-based Approach*	It measures the transitional probabilities from one state to another over a long period of seasons.	*R*	✖	*N.A.*	
9	Kaplan et al. (2011), p.65	*Hope Statistic*: $Hope = \frac{\overline{GBL_N}}{\sigma GBL_t}$	This index handles success as a binary variable and employs the number of wins out of a specified ranking spot as a hope indicator.	*R*	✖		
10	Butler (1995), p.66	*Correlation coefficient*	It measures the correlation of winning percentages across seasons using Pearson's correlation.	*w*	✖		
11	Eckard (1998), p.66	*ANOVA-based measure:* $AVAR = VAR_{time} + VAR_{cum}$	The index decomposes variance of winning percentages into a seasonal and an across-seasons component.	*w*	✖		
12	Humphreys (2002), p.66	*Competitive Balance Ratio*: $CBR = \frac{\overline{\sigma}_T}{\overline{\sigma}_N}$	It scales the average seasonal variation in winning percentages by the respective average variation across seasons.	*w*	✖		
13	Hymer and Pashigian (1962), p.67	*Instability index*: $Is = \sum_{i=1}^{N} \lvert s_{i,t} - s_{i,t-1} \rvert$	It measures the change in winning shares in two adjacent seasons.	*s*	✖		
14	Lenten (2009), p.67	*Linearised Turnover Gain Function*: $LTFG = \frac{\sum_{i=1}^{N} Y_{i,t}}{N}$	It quantifies the gains in terms of promoting competitive balance for two consecutive seasons by employing a turnover gain function.	*w*	✖		

Ranking based measurement; *w*: winning percent; *s*: winning share; *N.A.*: Not Applicable.

*☑: Yes; ✓: Yes, using the discussed compromise; ✖: No.

2.3 Concluding Remarks

The aim of this chapter was to provide a comprehensive review of the existing indices of competitive balance introduced in the literature in the context of European football using an innovative all-embracing approach. It must be emphasised that the above review refers only to the seasonal and between-seasons dimensions, since those are considered the most important from the fans' perspective. The preceding review deals with the first issue of this thesis, which relates to the appropriateness of the indices for the study of competitive balance in European football and, in doing so, we offered a detailed discussion of their development, their derived function, and their main features. An overview of all discussed indices is presented in Table 2.10 (p.52) and Table 2.14 (p.69). Two important issues emerge for the next chapter as far as the proper application of some indices is concerned due to the basic characteristics of European football. In particular, due to the promotion-relegation rule, which greatly affects the identity of a league over seasons thus making it difficult to accurately calculate competitive balance, a number of between-seasons indices are excluded. Moreover, for a reliable calculation, a proper transformation of some indices is suggested to account for the variability in the number of teams across leagues and/or seasons. There are many existing indices of seasonal competitive balance and there is a controversy about their relative efficacy (Fort, 2006a). For that reason, in the context of European football, the behaviour of all appropriate indices (Chapters 6 & 7) along with their relative efficacy (Chapter 8), it will be tested.

Chapter 3. Modification of Existing Indices of Competitive Balance

Although the number of indices in the literature is quite extensive, the majority of those indices, with a few exceptions, cannot be applied in European football data. An accurate cross-examination across countries and/or seasons requires to modify or extend some of the existing indices. The major characteristic that is taken into account in this work, is the diversity in the size of leagues *N* across seasons and/or countries. Therefore, all indices have to be relatively robust to different values of *N* in order to be able to compare competitive balance. The value of *N* ranges from 10 to 22 teams for eight European countries for a period of 45-50 years. An overview of the diversity of *N*, is illustrated in Table A.1 and Figure A.1 in the Appendix.

The implications generated for the measurement of competitive balance, demand modification of the indices via normalisation such that both bounds are well defined and comparable across leagues of different size. In the present study, the conventional values of zero and one are adopted to stand for the upper and lower bounds corresponding to perfect balance and complete imbalance respectively. Following the overview Tables 2.10 and 2.14, there is a number of existing indices whose range is non-defined and, therefore, inconsistent with the conventional definition. Consequently, a modification via re-location or rescaling is needed for both seasonal and between-seasons indices. The introduction of the modified indices is followed by a concluding section and an overview table which includes the procedure followed for the modification and the derived function of the indices.

3.1 Modified Indices of Seasonal Competitive Balance

Based on their specific features, three seasonal indices are excluded from the study of competitive balance in European football:

a) *Range*: since it is a relatively crude index and it will be sufficiently replaced by other more sophisticated indices.
b) *STD* and *RSD*: although they are extensively cited in the literature, they are replaced by the *NAMSI* index, which is specifically designed for European football; see Section 2.1.1. for further details for *NAMSI*.

On the other hand, due to their definition and computation, it is not easy to modify the following indices: *Regression-based Approach*, *Tail Likelihood*, and *Team Lodeings*. Thus, in the following we present the modified version of the remaining seasonal indices of Table 2.10 (p.52).

3.1.1 Normalised Index of Dissimilarity

As was discussed in Section 2.1.1, Mizak et al. (2005) suggest that the *normalized Index of Dissimilarity* (*nID*) must be adapted according to the variability of *N*. Essentially, this controls for the upper bound (ID_{ub}). Therefore, we will be concerned with the calculation of ID_{ub}. Based on the European championship format, teams confront each other twice. Therefore, the total number of games equals $N(N\text{-}1)$. In a completely unbalanced league the first team collects $2(N\text{-}1)$ wins, the second team wins all the games except those against the first [$2(N\text{-}1)\text{-}2$] and so on down the line to the last team with no wins. As is shown in Table 3.1, the winning share of the *i*th team equals $2(N\text{-}i)/N(N\text{-}1)$[12].

Table 3.1: Wins & Winning Share in a Completely Unbalanced League

Team	Wins	Y_i
1	$2(N\text{-}1)$	$2/N$
2	$2(N\text{-}2)$	$2(N\text{-}2)/N(N\text{-}1)$
3	$2(N\text{-}3)$	$2(N\text{-})/N(N\text{-}1)$
…	…	…
i	$2(N\text{-}i)$	$2(N\text{-}i)/N(N\text{-}1)$
…	…	
$N\text{-}1$	2	$2/N(N\text{-}1)$
N	0	0
Total:	$N(N\text{-}1)$	1

Since the interest is for the summation of the absolute deviations from equal parity, the calculation includes the first *N*/2 teams multiplied by two as follows:

$$ID_{ub} = 2\left[0.5\sum_{i=1}^{N/2}(s_i - \mu)\right] = \sum_{i=1}^{N/2}\left(\frac{2(N-i)}{N(N-1)} - \frac{1}{N}\right) = \frac{N}{4(N-1)}, \qquad \textbf{(3.1)}$$

[12] It must be noted that the winning share in perfectly balanced league equals 1/*N*.

where μ stands for the expected winning share under a perfectly balanced league, and s_i stands for the winning share of the ith team. The sensitivity of ID_{ub} to the variation of N can be verified by considering the first derivative of (3.1) with respect to N:

$$\frac{\partial ID_{ub}}{\partial N} = -\frac{1}{4(N-1)^2} < 0. \tag{3.2}$$

From (3.2), it may be concluded that ID_{ub} is a decreasing function of N. The *normalised ID* (*nID*) can be now be defined as:

$$nID = \frac{ID}{ID_{ub}} = \frac{\dfrac{0.5\sum_{i=1}^{N}|\mu - s_i|}{N}}{\dfrac{N}{4(N-1)}} = \frac{2(N-1)}{N}\sum_{i=1}^{N}\left|\frac{1}{N} - s_i\right|, \tag{3.3}$$

which ranges from zero (perfectly balanced league) to one (completely unbalanced league).

3.1.2 Adjusted Entropy

Following Section 2.1.2, *Relative Entropy* (R), given by equation (2.24), cannot be employed for a comparison amongst seasons or countries with different N, since its lower bound (H_L) is not well defined. Moreover, as illustrated in Table 3.2, H_L is positively related to N. The percentage increase of H_L (for selected N) may rise up to 28.7%. The variation of the range of R (presented in Table 3.2) is also illustrated in Figure 3.1. Since both bounds (lower H_L and upper H_M) differ from zero, a normalisation of *Entropy index* (H) is required, which should satisfy two conditions:

a) For a reliable calculation of the index, a point of reference is necessary. Hence, for comparability issues, H_M is chosen as a benchmark from which H is subtracted. By choosing H_M as a benchmark, the boundaries of the indices match those of the conventional ones. If H_L was chosen as point of reference, the boundaries of the index would stand for the states of complete imbalance (zero) and perfect balance (unity) respectively.

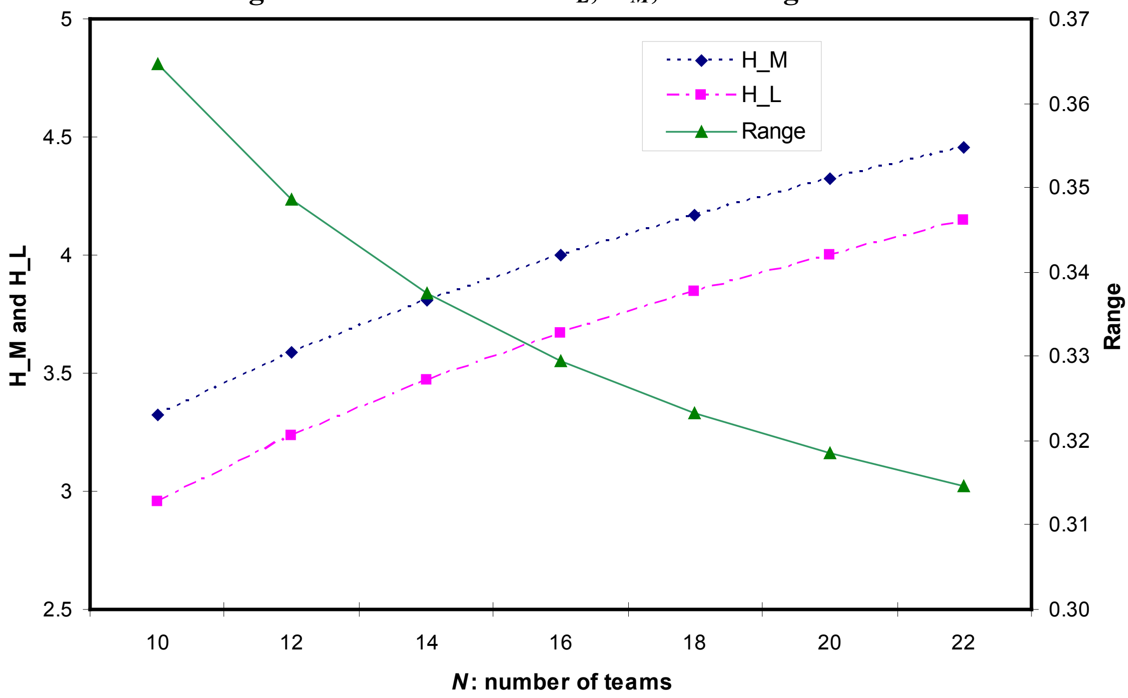
b) The measurement of the index, which is re-located to zero has to be controlled for the variability in both bounds. Intuitively, this can be accomplished by dividing with the feasible range of the index instead of H_M.

Table 3.2: Variation of Lower & Upper Bound of *H*

N	H_L	*D%*	*CD%*	H_M	*D%*	*CD%*	*Range*	*D%*	*CD%*
10	2.957			3.322			0.365		
12	3.236	0.086	0.086	3.585	0.073	0.073	0.349	0.046	0.046
14	3.470	0.067	0.154	3.807	0.058	0.132	0.338	0.033	0.079
16	3.671	0.055	0.208	4.000	0.048	0.180	0.329	0.024	0.103
18	3.847	0.046	0.254	4.170	0.041	0.221	0.323	0.019	0.122
20	4.003	0.039	0.293	4.322	0.035	0.256	0.318	0.015	0.138
22	4.145	0.034	0.327	4.459	0.031	0.287	0.315	0.012	0.150

**D%:* Percentage Difference
***CD%:* Cumulative Percentage Difference

Figure 3.1: Variation of H_L, H_M, and Range of *H*



The ratio of the above two conditions provides the *Adjusted Entropy* (*AH*), which is given by:

$$AH = \frac{H_M - H}{H_M - H_L}. \qquad \textbf{(3.4)}$$

The value of *AH* ranges from zero to one. Those two extremes correspond to cases of perfect competitive balance and complete imbalance respectively. The major advantage of this index is that it can be easily interpreted and contrasted against other related indices.

3.1.3 Normalised Concentration Ratio

The *Concentration Ratio* (*CR*) is considered as one of the most widely used indices because it is relatively simple and easy to understand. Most importantly, it provides valuable and distinctive information by measuring the degree of domination of a league by a small number of teams. CR_K and C_5ICB as well their deficiencies, were reviewed and discussed in Section 2.1.2. In particular, we examined the effect of the number of teams which make up the league (N) and the number of dominant teams under examination (K). Both the upper and the lower bounds of the index are greatly affected, and this needs to be taken into account in order to avoid misleading results.

In order to circumvent these deficiencies, we propose a new normalisation of the *CR* index based on its boundaries. Goossens and Kesenne (2007) introduce another normalisation of the index using a different interpretation of the lower bound. As noted in Section 2.1.2, the lower bound of *CR* is equal to K/N that represent perfect competitive balance. However, the lower bound is an increasing function of K and a decreasing function of N. This is also illustrated in Table 3.3 and in Figure 3.2. The upper bound (CR_{ub}), representing a completely dominated league, is obtained if we consider that the total number of points allocated to all teams equals $2N(N\text{-}1)$ while the maximum number of points the top K teams could possibly collect is $2K(2N\text{-}K\text{-}1)$. Therefore, CR_{ub} is given by:

$$CR_{ub} = \frac{K(2N-K-1)}{N(N-1)}. \tag{3.5}$$

As expected, CR_{ub} depends on both N and K. More specifically, variation in the upper bound can be ascertained by differentiating (3.5) with respect to N and K as follows:

$$\frac{\partial \dfrac{K(2N-K-1)}{N(N-1)}}{\partial N} = \frac{2KN(K-N+1)-K(K+1)}{N^2(N-1)^2} < 0, \text{ for } N>1,\ K\geq 1,\ N\geq K+1. \tag{3.6}$$

$$\frac{\partial \dfrac{K(2N-K-1)}{N(N-1)}}{\partial K} = \frac{2N-2K-1}{N(N-1)} > 0, \text{for } N>1,\ K\geq 1,\ N\geq K+1/2. \tag{3.7}$$

Equations (3.6) and (3.7) show us that the CR_{UB} is a decreasing function of N and an increasing function of K. This effect is depicted in Table 3.3 and in Figure 3.2 for selected N and K. In Table 3.3 we also present the range of the CR index, which significantly varies for different realistic values of N and K. This sensitivity of the range on different values of N and K, underlines the necessity for a normalised version of CR enabling comparisons between different leagues. Such a normalisation should satisfy two conditions:

a) For a reliable calculation of the index, a point of reference is required. For that reason, the lower bound is chosen as a benchmark for the measurement. Consequently, the subtraction of the lower bound from the observed value provides a re-located to zero measurement. The upper bound could also be chosen. In that case, the observed value is subtracted from the upper bound and the measurement is modified accordingly.

b) The value of the index has to be rescaled to account for the variability of both bounds. This can be achieved by dividing the re-located to zero measurement by the range of the feasible values of the index.

Consequently, following (2.25), the ratio of the above two conditions formulates the *Normalised Concentration Ratio* (NCR_K), defined as:

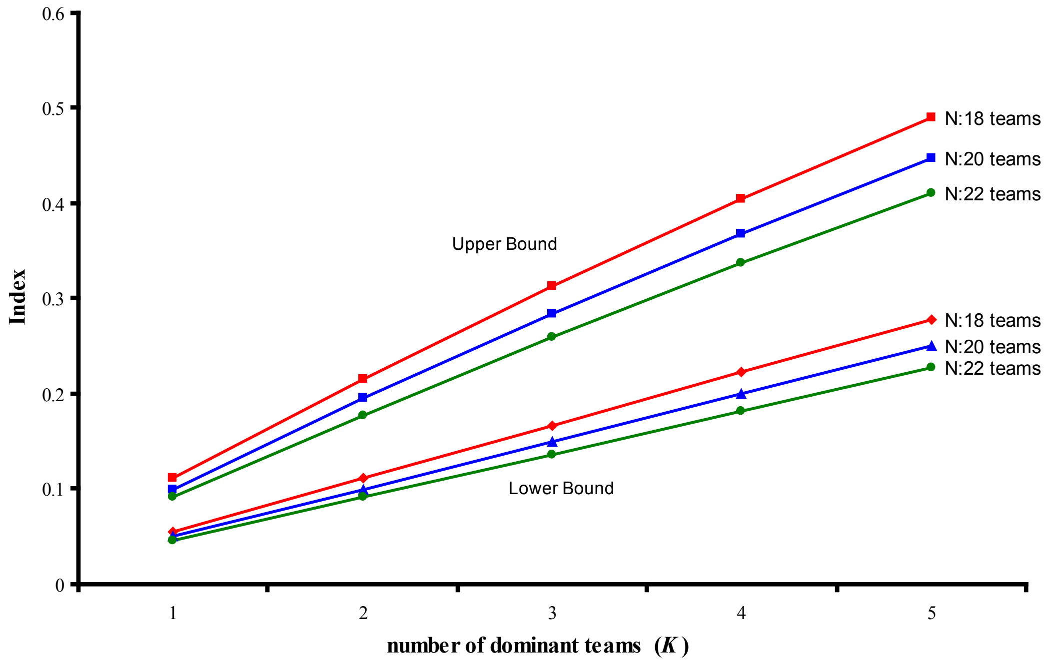
Table 3.3: Lower Bound – Upper Bound – Range of the *CR* Index

K:	*N*=18 Lower	*N*=18 Upper	*N*=20 Lower	*N*=20 Upper	*N*=22 Lower	*N*=22 Upper
1	0.056	0.111	0.050	0.100	0.045	0.091
2	0.111	0.216	0.100	0.195	0.091	0.177
3	0.167	0.314	0.150	0.284	0.136	0.260
4	0.222	0.405	0.200	0.368	0.182	0.338
5	0.278	0.490	0.250	0.447	0.227	0.411

K:	*N*=18 *Range*	*N*=20 *Range*	*N*=22 *Range*
1	0.056	0.050	0.045
2	0.105	0.095	0.087
3	0.147	0.134	0.123
4	0.183	0.168	0.156
5	0.212	0.197	0.184

**N:* number of teams that make up the league
***K:* number of top teams under investigation

Figure 3.2: Upper & Lower Bounds of the *CR* Index



$$NCR_K = \frac{\sum_{i=1}^{K} s_i - \frac{K}{N}}{\frac{K(2N-K-1)}{N(N-1)} - \frac{K}{N}} = \frac{\frac{\sum_{i=1}^{K} P_i}{2N(N-1)} - \frac{K}{N}}{\frac{K(N-K)}{N(N-1)}} = \frac{\sum_{i=1}^{K} P_i - 2K(N-1)}{2K(N-K)}, \text{ for } K<N. \quad \textbf{(3.8)}$$

Now, NCR_K ranges from zero to one. It approaches zero in the case of a perfectly balanced league and one in the case of a league completely dominated by the top K teams. The major advantage of the NCR_K index is that it provides a zero–one rescaled measurement of competitive balance. This is an important advantage since it enables us to make reliable comparisons across leagues of different size or across measurements with different number of top teams examined. This is of crucial importance if we are interested in studying competitive balance across different leagues or different seasons, where the size of the league is not constant. Additionally, a different number of the top K teams under examination may be required in order to study competitive balance according to the league's specific interest, such as the number of teams qualifying in European competitions or experts' opinion or policy makers' aspiration. For instance, in England it may be appropriate to examine the degree of domination of the top four teams, since four teams participate in the Champions League, whereas the equivalent number in Germany is three and in Greece is two.

For the application of NCR_K to the modern point system (3-1-0), a variety of different combinations of championships can be derived with different numbers of total points (depending on the wins/draws ratio) when assuming perfect balance. This creates a further complication in the definition of this index since the lower bound depends on the number of draws in the league. A possible solution for handling this ambiguity is to convert the winning points to two and then re-calculate the minimum number of points obtained by the top K teams [originally equal to $2K(N-1)$] by multiplying with the factor of $(2w_r+1)/2$; where w_r stands for the ratio of the observed total number of wins over the total number of games in the league under investigation.

One limitation of the NCR_K (already discussed in Section 2.1.2) is that while it focuses on the behaviour of the top *K* ignores the remaining of the teams. Moreover, although it captures the degree of domination of the top *K* teams with respect to the rest of the teams, it does not convey any information regarding the level of competition among the top *K* teams. This has been verified by the fact that NCR_K depends on only one point in the concentration curve, illustrated in Figure 2.3.

3.1.4 Surprise Index

Given that, for comparability issues, we adopt indices with values in the zero-one intervals, the *Surprise Index* (*S*) is re-located by subtracting the observed values from unity. Therefore, following equation (2.30), the *S* is given by:

$$S = 1 - \frac{Ps}{\max Ps}, \tag{3.9}$$

where *Ps* stands for the number of surprise points and max*Ps* for the maximum attainable surprise points. According to (3.9), the boundaries of *S* correspond to the conventionally defined range. Therefore, the value of zero is obtained in the case of a perfectly balanced league, whereas the value of unity in that of a completely unbalanced league.

3.1.5 Normalised Quality Index

The *Quality Index* (CB_{Qual}) is an innovative measure, which essentially measures the dispersion of team qualities. As long as its calculation is based on *SD*, its lower bound is well defined to zero corresponding to a perfectly balanced league. On the other hand, the upper bound (CB_{qual}^{ub}), observed in the case of a completely unbalanced league; is not well defined in the literature yet. Table 3.4 presents the calculation of CB_{qual}^{UB} for selected *N*, which is usually found in European leagues. It can be easily drawn from this table that CB_{qual}^{ub} decreases as *N* increases. Therefore, an alteration is required for a suitable comparison among leagues and/or seasons with various *N*. This can be accomplished by controlling with CB_{qual}^{ub}; in that case, we get the proposed *normalised Quality Index* (nCB_{qual}) as:

Table 3.4: Variation of CB_{qual}^{ub}

N	CB_{qual}^{ub}
10	0.254
12	0.223
14	0.199
16	0.179
18	0.163
20	0.149

$$nCB_{qual} = \frac{CB_{qual}}{CB_{qual}^{ub}}. \tag{3.10}$$

The index ranges from zero (perfectly balanced league) to one (completely unbalanced league) regardless of the variation in *N*. The CB_{qual}^{ub} is calculated for a different *N* under the assumption of complete imbalance; that is, the strongest team wins all games, the second stronger team wins all games against the weaker teams, and so down to the last team with no wins.

3.2 Modified Indices of Between-seasons Competitive Balance

According to Table 2.14 (p.69), the number of between-seasons indices applicable to European football is quite limited, as was explained in Section 2.2.1, due to the implications generated by the promotion-relegation rule. However, an appropriate modification to the zero-one interval is also required.

3.2.1 Adjusted *G* Index

As was shown in Section 2.2.2., *G* is the only index especially designed to adapt to the promotion-relegation rule. The lower bound of *G* is well defined as it equals zero and it is obtained in the case of perfect balance. Theoretically, *G* could take negative values if the observed $y_a^L(K,T)$ number is larger than the expected $y^L(K,T)$ number of teams. However, to our knowledge no such values have been referred to so far in any empirical study. On the other hand, the upper bound (G_u) of the index is not well defined and is only referred to be close to unity. In fact, the value of G_u, which is the case of a completely unbalanced league, is always lower than one. That can be easily derived from (2.46), in which the nominator is smaller than the denominator. It is important to point out that the minimum value of the observed number $y_a^L(K,T)$ is always K regardless of T. In effect, this stands for the case of a completely unbalanced league in which the top K teams dominate the league over a period of T seasons. Intuitively, K comprises another benchmark which has to be taken into consideration when calculating G. Therefore, for comparability issues, we propose the *Adjusted G Index* (aG) given by:

$$aG = \frac{\sum_{T=1}^{T} y^L(K,T) - \sum_{T=1}^{T} y_a^L(K,T)}{\sum_{T=1}^{T} y^L(K,T) - K}. \tag{3.11}$$

The value of aG ranges from zero (perfect balance) to one (complete imbalance). However, the main attribute of aG is that it provides better estimation in cases close to complete imbalance which is our main concern. For illustration purposes, consider closed leagues in which four teams enter the top three places over a period of ten years[13]. The calculation of both G and aG is presented in Table 3.5 for some realistic values of N. It can be easily derived that the calculation differs substantially between the two indices. Moreover, G over-estimates the level of competitive balance in comparison with aG. In particular, the value of aG is close to complete imbalance (from 0.851 to 0.928), whereas G offers lower and a wider range of values (from 0.588 to 0.764). It must be noted, the difference between the two indices is higher for small values of N.

Table 3.5: Calculation of *G* and *aG* for *T*:10, *K*=3

N	G	aG
10	0.588	0.851
12	0.647	0.880
14	0.686	0.897
16	0.714	0.909
18	0.735	0.917
20	0.751	0.923
22	0.764	0.928

[13] A closed league is selected only for the sake of simplicity. However, the same conclusions can also be drawn for open leagues.

3.2.2 Index of Dynamics

Following equation (2.48), the new formula of DN_t^* index is given by:

$$DN_t^* = 1 - \frac{2}{N^2}\sum_{i=1}^{N}\left|r_{i,t} - r_{i,t-1}\right|. \tag{3.12}$$

Based on equation (3.12), the range of DN_t^* is conventionally defined from zero (maximum ranking mobility) to one (no ranking mobility).The former is obtained in the case of a dynamically perfectly balanced league, whereas the latter in that of a dynamically completely unbalanced league.

3.2.3 Kendall's tau Coefficient and Spearman's rho

As is depicted in Table 2.16, the theoretical range of the *Kendall's tau Coefficient* (τ) and *Spearman's rho* (r_s) statistical indices is from -1 to 1. For an effective comparison among indices, following equations (2.49) and (2.51), a similar re-location is attempted for both indices as follows:

$$\tau = \frac{1 + \left[1 - \frac{4s}{N(N-1)}\right]}{2}, \tag{3.13}$$

$$r_s = \frac{1 + \left[1 - \frac{6\sum_{i=1}^{N} D^2}{N\left(N^2 - 1\right)}\right]}{2}. \tag{3.14}$$

It must be pointed out that the brackets in (3.13) and (3.14) include the original formulas for the indices τ and r_s respectively. The new range of the indices is from zero to one, which stands for the cases of a dynamically perfectly balanced and a dynamically completely unbalanced league respectively. The former is defined by the maximum number of transpositions or the ranking difference while the latter by the absence of transpositions or ranking difference from season to season. Using this transformation, the behaviour of both indices can be effectively contrasted with the remaining indices of competitive balance.

3.3 Conclusion

Following the discussion in the previous chapter, the present chapter provided answers to the second issue of this thesis by modifying some of the existing indices for a cross examination of competitive balance in European football. In this context, the variability of participating teams N in European football leagues is identified creating the need for indices with a fixed range which is insensitive to N. The modification is accomplished by means of normalisation or re-location for a similar definition of competitive balance boundaries. In particular, the formula of the *normalised Index of Dissimilarity* (*nID*) was introduced to account for the sensitivity of the upper bound to N (number of teams in the league) of the existing *Index of Dissimilarity* (*ID*). Given that the lower bound (H_L) is not zero, as it is the case in the standard industry, the *Relative Entropy* (R) is modified by introducing the *Adjusted Entropy* (*AH*). The *Normalised Concentration Ratio* (NCR_K) is a modified *Concentration Ratio* (*CR*), which solves the deficiencies of existing applications in sports. Similarly, the *Normalised Quality Index* (nCB_{qual}) adjusts for the sensitivity of the upper bound to N of the existing CB_{qual} while the *Adjusted G* is a modification of the existing G index, which accounts for the feasible range. Lastly, a modification of the *Surprise Index* (S), the *Index of Dynamics* (DN_t^*), *Kendall's tau* (τ), and *Coefficient Spearman's rho* (r_s) was accomplished by means of a proper re-location to correspond to the conventionally adopted range from zero to unity.

In the next chapter, the championship format in European football will be thoroughly examined. The structure of European football leagues is argued to be more complex than other leagues. In particular, the top teams qualify to participate in European tournaments whereas the bottom teams are relegated to a lower league. Therefore, given that domestic leagues organise multi-prize championship tournaments, a more systematic analysis is suggested as well as the development of specially designed indices for the proper quantification of multilevel competitive balance.

Overview Table with Modified Indices of Competitive Balance

The modified indices introduced in this chapter along with their derived function and the action followed, they are presented in the overview Table 3.6.

Table 3.6: Modified Indices of Competitive Balance

Dimension	*Index*	*Function*	*Action*
Seasonal	*normalised Index of Dissimilarity*	$nID = \frac{2(N-1)\sum_{i=1}^{N}\left\|\frac{1}{N} - Y_i\right\|}{N}$	*ID* index (Mizak et al., 2005) is divided by $N/4(N\text{-}1)$.
	Adjusted Entropy	$AH = \frac{H_M - H}{H_M - H_L}$	*H* index (Horowitz, 1997) is relocated and divided by its range (H_M-H_L).
	Normalised Concentration Ratio	$NCR_K = \frac{\sum_{i=1}^{K} P_i - 2K(N-1)}{2K(N-K)}$	*CR* is relocated to zero and rescaled to its range.
	Surprise Index	$S = 1 - \frac{Ps}{\max Ps}$	*S* index (J. Groot & Groot, 2003) is re-located by subtraction from unity.
	normalised Quality Index	$nCB_{qual} = \frac{CB_{qual}}{CB_{qual}^{ub}}$	CB_{qual} index (L. Groot, 2008) is divided by its upper bound CB_{qual}^{ub}.
Between-seasons	*Adjusted G*	$aG = \frac{\sum_{T=1}^{T} y^L(K,T) - \sum_{T=1}^{T} y_a^L(K,T)}{\sum_{T=1}^{T} y^L(K,T) - K}$	*G* index (Buzzacchi et al., 2003) is modified to account for the feasible range.
	Index of Dynamics	$DN_t^* = 1 - \frac{2}{N^2}\sum_{i=1}^{N}\left\|r_{i,t} - r_{i,t-1}\right\|$	DN_t^* index (Haan et al., 2002) is re-located by subtraction from unity.
	Kendall's tau Coefficient	$\tau = \frac{1 + \left[1 - \frac{4s}{N(N-1)}\right]}{2}$	τ index (L. Groot, 2008) is re-located by adding unity and then divided by two.
	Spearman's rho	$r_s = \frac{1 + \left[1 - \frac{6\sum_{i=1}^{N} D^2}{N(N^2-1)}\right]}{2}$	r_s index (Howell, 1987) is re-located by adding unity and then divided by two.

The origin, the derived function, the unit of measurement, and a short description of the existing seasonal and between-seasons indices are presented in Table 2.10 (p.52) and Table 2.14 (p.69) respectively.

Chapter 4. Quantification of Competitive Balance in European Football; Development of Specially Designed Seasonal Indices

In this chapter we develop new seasonal indices which account for the defects or problems of the existing ones. The objective is to provide a more systematic analysis for the measurement of competitive balance specifically for European football leagues. Although there are various championship formats in Europe, an important common characteristic refers to the complex multi-prize structure of European football leagues as opposed to the more common single-prize North American leagues (Kringstad & Gerrard, 2007). In addition to the competition for the championship, domestic leagues act as qualifiers, and the best teams compete for a position in the lucrative European tournaments of Champions League and Europa League. Moreover, the worst teams struggle to avoid relegation, which is very important from the fans' perspective. A thorough analysis of competitive balance in this context must take into consideration this complex structure. New challenges are created by the complex championship structure, which requires a new conceptual approach for the development of specially designed indices to measure the degree of competition for winning any of the important prizes awarded in the league.

The discussion for the complex structure of European football leagues is followed by the introduction and a detailed description of the new specially designed indices of seasonal competitive balance. Lastly, the concluding section highlights key points raised in the chapter, and presents an overview table which includes the procedure followed and a brief description of the new seasonal indices.

4.1 Structure of European Football Leagues

European football leagues present a complex tournament structure offering to competing teams multiple prizes as opposed to North American offering a single prize. Essentially, European championships can be regarded as three-levelled tournament structures. Similarly, the term stage is employed by Kringstad and Gerrard (2007), who consider European championships as two-stage tournaments with reference to the domestic round-robin championship, which acts as qualifier for a European tournament. More specifically, in any domestic league, teams compete in a three-level tournament for the following ordered sets of prizes or punishments:

a) The first level refers to the competition for the championship title which is considered the most prestigious prize in any league. In principle, teams compete for the domestic championship title by taking up the first ranking place and any team aspires to that title irrespective of other aspirations it may have. Therefore, it is reasonable to assume that for any team the first place in the final ranking is the most desirable position.
b) The second level refers to the qualifying places for European tournaments of the following season. Currently, there are two such tournaments: the lucrative Champions League and the recently restructured Europa League. Those tournaments, especially the Champions League, offer reputation and, most importantly, high monetary prizes and bonuses for both participation and successful results. Therefore, over and above the championship title, teams also compete for any of the remaining pre-determined top places.
c) Finally, the third level draws attention to the relegation places. Given that European leagues are open, teams that, due to their poor performance, occupy the lowest league positions, are relegated to lower leagues (divisions). Such a demotion has serious repercussions for both the financial status and the prestige of the relegated team. Consequently, teams strive to avoid relegation and view succeeding in this objective as success in its own right.

The use of this three-level tournament structure by European leagues has been partly motivated by the desire to maximise the fans' demand for attending or watching as many games of increased importance as possible. However, there is evidence that domestic leagues are dominated by a small number of teams at an escalating rate (Goossens, 2006; Michie & Oughton, 2004). More importantly, there is a rising gap between the top teams and the rest (Michie & Oughton, 2005a, 2005b). In a complex tournament structure, domination in the first level may be less worrying if there is satisfactory competitiveness for the other two levels. For instance, championship domination by a particular team (first level) may be compensated for by an adequate degree of competition for both qualification for European tournaments and avoidance of relegation to a lower division. Intuitively, in a complex tournament structure, the overall degree of competitive balance is determined by the corresponding degrees in the three aforementioned levels. Evidently, such an approach has to account for the relative importance of levels or ranking places. It is realistic to assume that the competition for the championship title is more important than that for relegation. Additionally, a higher ranking place is advantageous when participating in European tournaments; thus, the top qualifying places in the second level have to be rated accordingly. From our perspective, the weighting scheme for ranking places when measuring the overall competitive balance in European football should meet the following criteria:

a) The first place (first level) receives the highest weight.
b) The qualifying places for European tournaments (second level) receive lower weights than the corresponding ones of the first place. These weights must be decreasing as ranking positions increase.
c) The relegation places (third level), receive even lower weights than the corresponding ones for the qualifying places and a higher than the corresponding weights for the remaining ranking positions in the middle of the league.

According to the review in the Chapter 2, there are several indices of competitive balance which have been applied to professional team sports. Essentially, most of the existing indices quantify the dispersion between the strength of competing teams using different units of measurement as a proxy; however, none of them account for the special characteristics for the complex structure of European football leagues. For instance, *RSD* and *NAMSI* equally treat teams in the top and the bottom of the ladder while *HHI** rate teams according to their winning share. Therefore, the design of special indices using a suitable weighting pattern is required when measuring competitive balance in European football. In our view, Kringstad and Gerrard (2007, p. 170) implied this in writing about "*the need to move beyond competitive balance*". Thus, a new conceptual approach has to be adopted for the development of alternative indices which will take into consideration the competition at each level and rate them accordingly.

4.2 New Indices of Seasonal Competitive Balance

Following the discussion in Section 4.1., the objective of this thesis is to provide a systematic approach to the quantification of competitive balance, as it is specifically applied to European football. Conceptually, the design of special indices is inspired by the necessity to quantify the competitiveness at each distinct inter-divisional level separately and weight each ranking position according to their importance. For the development of such indices, the NCR_K index is employed. The selection of NCR_K (over other competing indices) is based on the following three criteria:

a) It has a straightforward interpretation.
b) It is relatively insensitive to N and/or K and its range is well defined in zero-one interval.
c) Due to its mathematical function, it can be adjusted to capture the competitiveness in any level described in Section 4.1.

The NCR_K measures the strength of the top K teams relative to the remaining ones in a league. Therefore, it quantifies the degree of competition for the top K places, or else the degree of domination of the top K teams in a league.

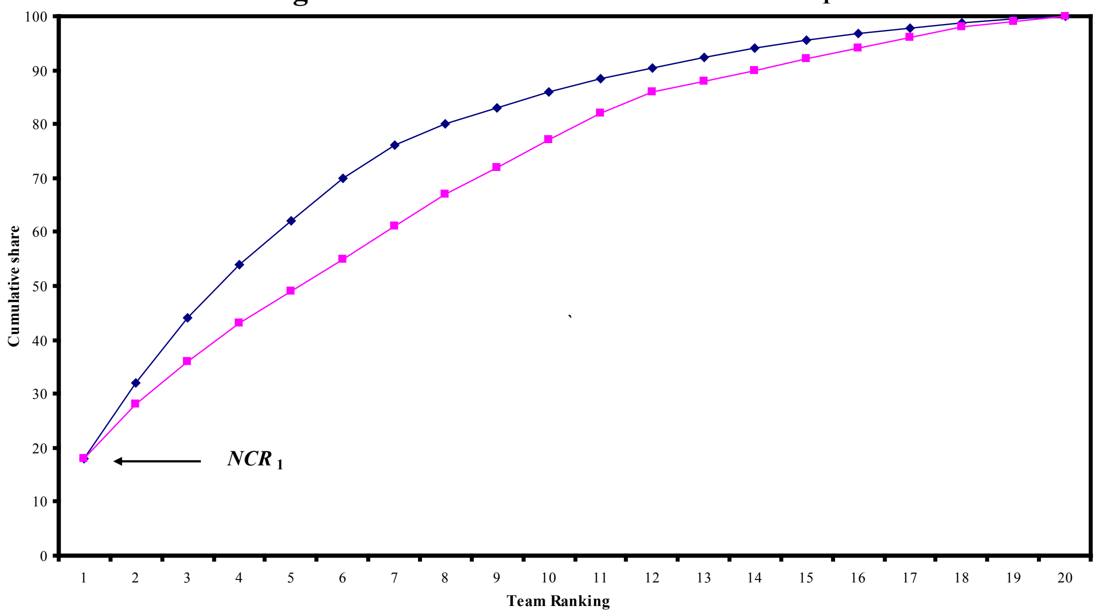
4.2.1 Normalised Concentration Ratio for the Champion

Obviously, NCR_K for K=1 effectively captures the competitiveness for the first level (championship title in a league). Hence, it can be interpreted as the domination degree of the champion. Following the calculation of the NCR_K in equation (3.8), the *Normalised Concentration Ratio for the Champion* (NCR_1) is given by:

$$NCR_1 = \frac{1}{2(N-1)} P_1 - 1, \qquad \textbf{(4.1)}$$

where P_1 stands for the number of points of the champion. The range of the index is from zero to one. The former stands for absence of domination in which the champion collects 50% of the maximum attainable points. In such a case, the league is in a perfectly balanced state since all teams share points equally. As far as the latter is concerned, it stands for a complete domination, in which the champion collects the maximum attainable number of points. The higher the index, the more dominant the champion becomes. The main limitation of NCR_1 (and respectively of NCR_K) is that it focuses only on the behaviour of the champion ignoring the remaining teams. This can be confirmed by the relevant concentration curve in which the NCR_1 depends on only one point in Figure 4.1.

Figure 4.1: Concentration Curve of NCR_1



4.2.2 Adjusted Concentration Ratio

With respect to the second level, the design of a special index is a somewhat complicating issue. This derives from the fact that the performance of the K-1 teams in the second level (from the second to Kth ranking position) clearly depends on the champion's performance. More specifically, the required state of a completely unbalanced league cannot be clearly defined for teams in the second level. To overcome this issue, we will attempt a joint calculation of the first and second level via a single index. Therefore, we introduce the *Adjusted Concentration Ratio* (ACR_K), which captures both levels. The development of the ACR_K is grounded on two assumptions:

a) The first level is more important than the second level from the fans' perspective. Therefore, the two levels must be rated according to their relative significance.

b) In the second level, the higher the ranking place, the more interesting and motivating it becomes from the fans' point of view; thus, ranking places must be rated accordingly.

To clarify, consider a league of ten teams in which only the first two participate in European tournaments; the champion (first place) and the runner up (second place). The competition for the championship corresponds to the first level, whereas that for the second place corresponds to second level. Although NCR_1 index effectively captures the competition for the first level, NCR_2 alone cannot capture each of the levels, since it rates them equally, thus rendering the development of an index which accounts for the relative significance of each level very useful. Evidently, the champion is more important than the second team, despite the fact that both participate in European tournaments, and that should be taken into consideration when measuring competitive balance. By intuition, the relative significance of the two levels (or positions) is effectively captured by employing the average of the NCR_1 and NCR_2 indices. In doing that, the resultant average index captures the relative significance and the degree of domination of each level. Essentially, the resultant average index also captures the degree of competition between the two levels, as is illustrated in the hypothetical scenarios presented in Table 4.1.

From the third place down, Leagues A and B display identical results though there is a considerable point difference between the champion and the second team. The NCR_1 and NCR_2 indices effectively demonstrate the degree of domination by the champion and by the top two teams respectively. However, NCR_2 does not account for the relative importance of those teams. Alternatively NCR_2 fails to capture neither the degree of competition between the top two teams nor the degree of domination of each particular team[14]. Arguably, *League B* is more balanced than *League A*, although that cannot be concluded from the NCR_2. Consequently, the average of the two indices provides an enhanced estimation of competitive balance, since it adjusts for the relative significance of the two levels. The higher rating of the first level is

[14] The NCR_2 would be appropriate only if the top two places were equally important.

attributed to the fact that it appears in the calculation of both the NCR_1 and NCR_2 indices.

Table 4.1: Average of the NCR_1 & NCR_2

Team Ranking	*League A: Points*	*League B: Points*
1	36	30
2	24	30
3	20	20
4	18	18
5	16	16
6	16	16
7	14	14
8	14	14
9	12	12
10	10	10
NCR_1	1	0.667
NCR_2	0.75	0.75
Average (NCR_1, NCR_2)	0.875	0.708

Obviously, this process may be generalised for any number in the top K positions provided that their value is unequally rated. The top K qualification positions for European tournaments are not equally rated. A special bonus is given to any qualifying team based on the ranking position. For instance, in Greece, the first team directly qualifies for the Champions League pools; the second runner team is forced to participate in extra qualifying Champions League rounds while the third team qualifies for the Europa League.

Thus, the ACR_K is derived by adjusting for the relative significance of the top K positions and effectively captures both the first and the second level. Following the calculation of the NCR_K in equation (3.8), ACR_K is given by:

$$ACR_K = \frac{\sum_{i=1}^{K} NCR_i}{K} = \frac{1}{K}\left[\sum_{i=1}^{K} wt_i P_i - C_K\right], \text{ for } K<N, \tag{4.2}$$

where C_K is a constant term given by:

$$C_K = \sum_{i=1}^{K} \frac{N-1}{N-i}, \quad \text{for } K<N, \tag{4.3}$$

and wt_i stands for the weight attached to the ith team given by:

$$wt_i = \sum_{j=i}^{K} \frac{1}{2j(N-j)}, \text{ for } i<K<N. \tag{4.4}$$

The value of ACR_K ranges from zero to one. The lower bound stands for absence of domination in which each of the top K teams collects 50% of the maximum attainable points. In such a case, the league is in a perfectly balanced state, since all teams equally share points. As far as the upper bound is concerned, it stands both for complete domination by the K teams and complete imbalance among the K teams. In particular, the upper bound is obtained when:

a) The top K teams collectively gather the maximum attainable number of points; that is, they always win against the remaining teams.
b) Within the group of K teams, any team always wins against any weaker team and loses from any stronger one.

Since components indices are relatively robust to the variation in N and K as described previously, then ACR_K will also have a similar behaviour. The interpretation of the ACR_K is not simple, given that the index possesses two different qualities:

a) The degree of concentration or domination by the top K teams.
b) The degree of competition among the top K teams.

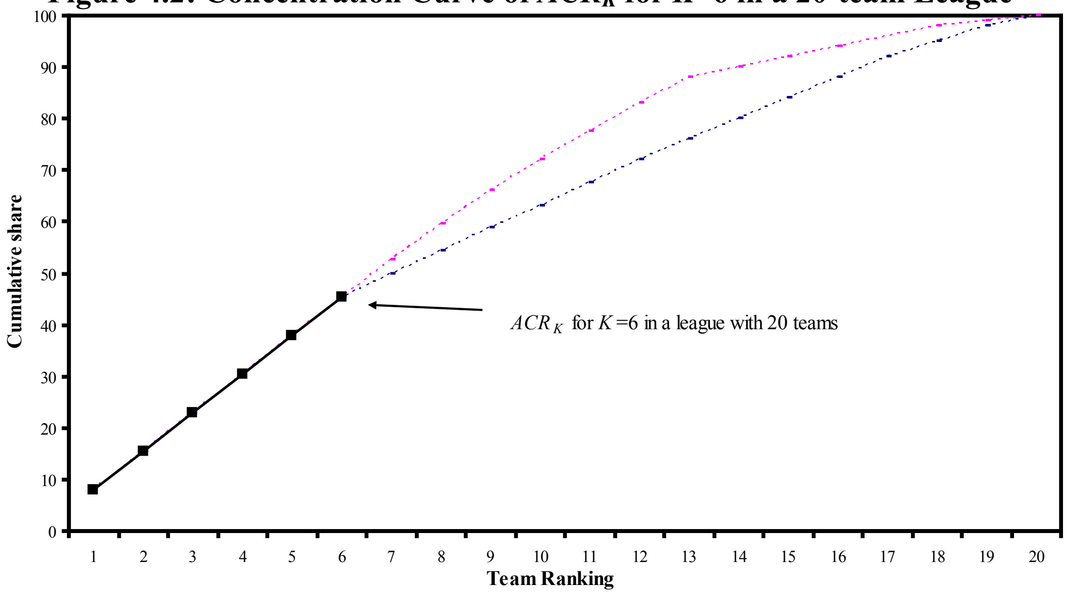
Given that NCR_K captures only the first quality, its subtraction from ACR_K, following equations (3.8) and (4.2), effectively compares those two qualities:

$$ACR_K - NCR_K = \frac{\sum_{i=1}^{K-1} NCR_i - (K-1)NCR_K}{K}. \quad \textbf{(4.5)}$$

If the expression in the numerator in equation (4.5) is zero, the level of domination by the top K teams equals the level of competition among the top K teams. If this expression is positive, the level of domination by the top K teams contributes more to a balanced league than the level of competition among the same teams. Moreover, if this expression is negative, then the level of competition among the top K teams contributes more to a balanced league than the level of domination by same teams.

The two qualities of the ACR_K can be depicted in the concentration curve for a league with 20 teams for K=6. What is demonstrated in Figure 4.2 is that the ACR_6 depends on six points in the concentration curve. From that, it can be easily drawn that the ACR_K provides more information than the respective NCR_K. A limitation of the index is that it does not offer any information for the competition introduced by teams after the Kth position. However, such a limitation is to be expected based on the design of the index.

Figure 4.2: Concentration Curve of ACR_K for K=6 in a 20-team League



The ACR_K is distinguished from the other indices as a result of two unique features worthy of closer examination:

a) K simpler indices are employed for the calculation of the index. Consequently, ACR_K can be decomposed into its various components and, therefore, the ingredient sources of the overall competitive balance may be determined. Hence, depending on the particular interest generated by a league, important observations may be drawn from the degree of competition in any component index.
b) ACR_K rates the top K teams at a decreasing function of their ranking position. Therefore, the employed averaging approach naturally offers a weighting pattern according to the criteria set in the previous section.

In particular, the weight wt_i, from equation (4.4), attached to the ith team is derived from the partial sum of the harmonic series with first term 1/[2(N-1)] and last term 1/[2K(N-K)]. Then, wt_i forms a sequence of the partial sums defined as follows:

$$
\begin{aligned}
wt_1 &= \frac{1}{2(N-1)} + \frac{1}{4(N-2)} + \frac{1}{6(N-3)} + \ldots + \frac{1}{2K(N-K)} \\
wt_2 &= \frac{1}{4(N-2)} + \frac{1}{6(N-3)} + \ldots + \frac{1}{2K(N-K)} \\
wt_3 &= \frac{1}{6(N-3)} + \ldots + \frac{1}{2K(N-K)} \\
&\ldots\ldots \\
wt_K &= \frac{1}{2K(N-K)}.
\end{aligned}
\tag{4.6}
$$

It is important to note that the first weight wt_1 includes all the terms, the second all except the first one and so on concluding with the last weight wt_K which is equal to the last term of the sequence (4.6). Each weight wt_i is an increasing and a decreasing function of K and N respectively. More importantly, from sequence (4.6) it can be derived that wt_i is a decreasing function of the ranking position, which is denoted here by index i[15]. This is reasonable, since the higher the ranking position (i.e. the lower i), the greater the interest from the fans' perspective. Furthermore, for a given

[15] For realistic values of $K \leq N/2$, wt_i decreases at a decreasing rate.

K, the rate of the decrease in wt_i is an increasing function of N which is also reasonable, since the champion should be rated higher in a 20-team rather than in a 10-team league.

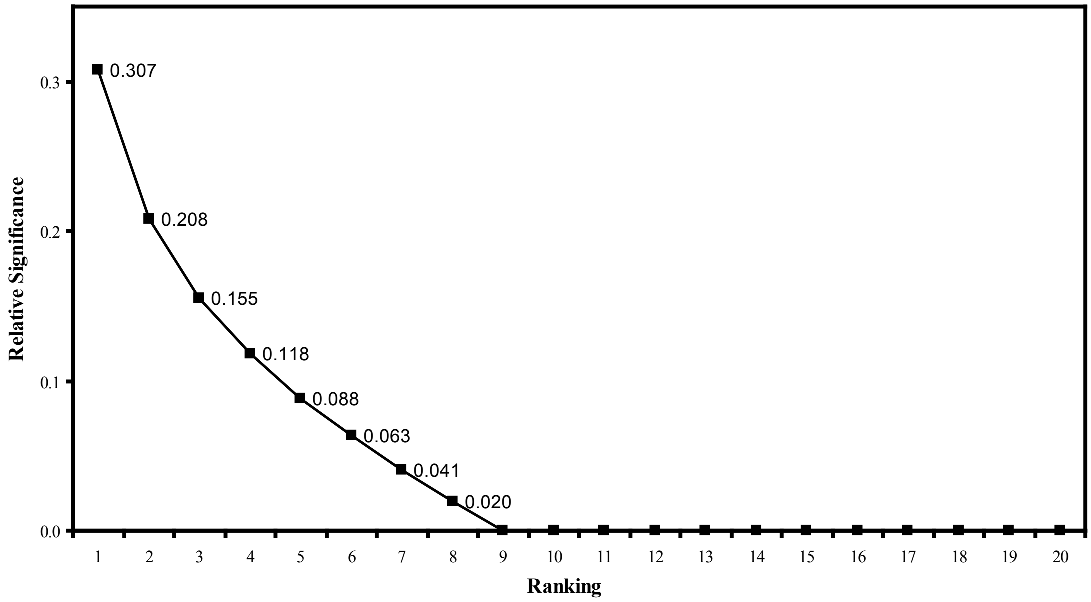
To illustrate wt_i, let us consider a 20-team league in which the top eight qualify for European tournaments. Based on this specific league format, the appropriate concentration index for the measurement of competitive balance is ACR_K for K=8, which rates the top eight positions, as is presented in Table 4.2.

Table 4.2: Relative Significance in ACR_K for K=8

<table>
<tr><th rowspan="2">Ranking</th><th colspan="3">Relative Significance</th></tr>
<tr><th>Position</th><th colspan="2">Level</th></tr>
<tr><td>1</td><td>0.307</td><td>0.307</td><td>A: 0.307
per position</td></tr>
<tr><td>2
3
4
5
6
7
8</td><td>0.208
0.155
0.118
0.088
0.063
0.041
0.020</td><td>0.692</td><td>B: 0.098
per position</td></tr>
<tr><td>9-20</td><td>0</td><td></td><td></td></tr>
<tr><td></td><td>Sum: 1</td><td>1</td><td></td></tr>
</table>

As can be verified from Table 4.2, ACR_K attaches more weight to the first ranking place which is the champion. In addition, the relative significance per team is much higher for the first level in comparison to the second one. The relative significance of the top K positions is graphically illustrated in Figure 4.3, in which there is no weight attached to teams after the 8th position since they are not included in the calculation of the index. Additionally, the relationship between the weights wt_i and ranking position i is clearly illustrated. The weight's increase from the eighth to the first position is advantageous since the fans' interest progressively increases and is culminated in the championship winner. We should point out that the definition of ACR_K using the weighting expression in equation (4.2) enables us to appropriately modify the index using alternative weighting patterns in order to capture special league characteristics such as indifference between ranking positions which lead to the same prize. For instance, ACR_K may equally rate the second and the third ranking places by simply replacing in equation (4.2) the second term of the summation (NCR_2) with this of NCR_3.

Figure 4.3: Relative Significance in ACR_K for K=8 in a 20-team League



4.2.3 Normalised Concentration Ratio for Relegated Teams

Considering that the promotion-relegation rule is a significant aspect of the European football structure, this aspect of competition cannot be ignored. Therefore, the *Normalised Concentration Ratio for Relegated Teams* (NCR^I) is introduced to capture the relative weakness of the I relegated teams as compared to the remaining ones. In essence, this index demonstrates how much weaker the I bottom teams are than the remaining teams in the league.

In order to scale NCR^I in the zero-one interval, initially the number of points the I teams can gather in both a perfectly balanced and, in terms of relegation, a completely unbalanced league are calculated. The former is obtained when the last I teams collect the maximum number of points (I_{pb}) while the latter are obtained when the last I teams gather the minimum number of points (I_{ub}).

In the state of a perfectly balanced league, each of the bottom I teams gathers the average number of points allocated in the championship which is 2(N-1). As a result, I_{pb} is given by:

$$I_{pb} = 2I(N-1). \tag{4.7}$$

In the state of a completely unbalanced for relegation league, the last I teams can only gather points from the games played between them, that is, any I team always loses from any team above the (N-I)th position. Therefore, considering that the total number of games among the last I teams equals I(I-1), the I_{ub} is given by:

$$I_{ub} = 2I(I-1). \tag{4.8}$$

From equation (4.7), it is noted that I_{pb} is an increasing function of both N and I. Similarly, from equation (4.8) it can be drawn that I_{ub} is also an increasing function of I. Following the procedure in equations (2.25) and (3.8) and according to equations (4.7) and (4.8), the formula of NCR^I is given by:

$$NCR^I = \frac{I_{PB} - \sum_{i=N-I+1}^{N} P_i}{I_{PB} - I_{UB}} = \frac{2I(N-1) - \sum_{i=N-I+1}^{N} P_i}{2I(N-1) - 2I(I-1)} = \frac{2I(N-1) - \sum_{i=N-I+1}^{N} P_i}{2I(N-I)} \Rightarrow \tag{4.9}$$
$$NCR^I = \frac{N-1}{N-I} - \frac{1}{2I(N-I)}\left(\sum_{i=N-I+1}^{N} P_i\right), \text{ for } I<N.$$

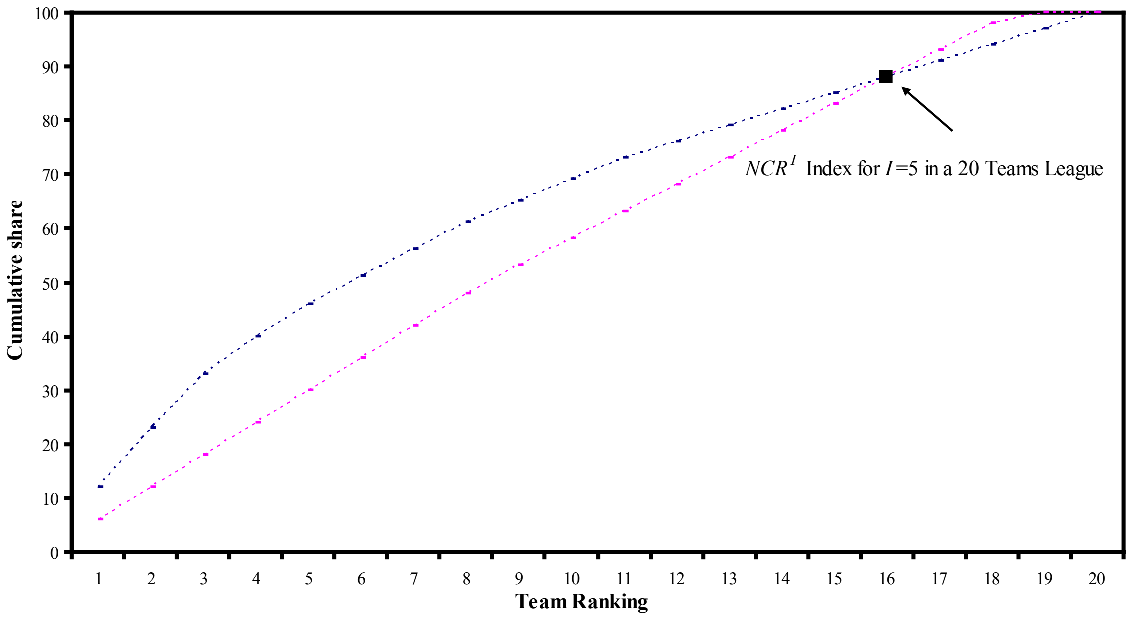
Based on realistic numbers, usually I=2,3, or 4, and therefore it is safe to assume that the number of I relegated teams is even lower than N/2. In concordance with the other indices, the value of NCR^I index ranges from zero to one. The index reaches its lower bound (zero) if the I teams are strong enough to collect the maximum attainable number of points. In that case, the league is in a perfectly balanced state, since all teams share points equally and, thus, the I teams are not weak. As NCR^I increases, the I teams become relatively weaker. As NCR^I approaches its upper value, the I teams become even weaker in relation to the rest. In that case, the I teams obviously reach their maximum weakness, and they gather points only from other relegated teams; alternatively, there is no competition for relegation. The index is interpreted as the degree of competition for relegation or the degree of weakness of the I relegated teams.

The major advantage of the NCR^I is that it provides a reliable measurement of the degree of weakness of the bottom I teams which is insensitive to N and I. This property is important since variation of I across different National leagues or seasons exist. This is due to the fact that the promotion-relegation rule is frequently changing across leagues and/or seasons to cover local or time specific needs of the teams particularly in a league. For example, in 2008, for Germany and England we should examine the degree of weakness of the bottom three teams (since those were relegated to the lower division), whereas in Belgium and in Norway the corresponding relegation positions were four and two respectively. The number of relegated teams for eight European leagues across 50 seasons is presented in Table A.5 and Figure A.3 in the Appendix.

Similarly to NCR_K, for the application of NCR^I to the modern 3-1-0 point system, one solution is to convert the winning points from three to two and multiply by the factor $[(2w_r+1)/2]$ the maximum number of points that are obtained by the I teams in a perfectly balanced league $[I_{pb}=2I(\mathrm{N}-1)]$.

The limitations of NCR^I are similar to those of NCR_K. More specifically, as was noted for NCR_K in Section 2.1.2 and Section 3.1.3, NCR^I captures the behaviour of the last I ignoring the remaining teams. Thus, no information is provided either for the behaviour of the remaining (N-I) teams or for the level of competition among the I teams. The former may be explained by the design of the index, whereas the latter is not considered particularly important from the fans' perspective. Those limitations can be verified by the fact that NCR^I depends on only one point in the concentration curve in Figure 4.4, as is the case for CR and NCR_K (see Figure 2.3).

Figure 4.4: Concentration Curve of NCR^I for I=5 in a 20-team League



4.2.4 Special Concentration Ratio

After presenting the concentration indices designed for the first, the first and second, and the third levels, the *Special Concentration Ratio* (SCR_K^I) is introduced, which captures all three levels embodied in the European multi-prized leagues. SCR_K^I rates all levels and ranking positions in a weighting pattern with similar order according to the significance awarded from the fans' perspective. Additionally, SCR_K^I is a custom-built index, which can be easily adapted according to the specific interest generated by a domestic league or easily decomposed to its component indices.

For the development of SCR_K^I, the ACR_K and NCR^I indices are employed capturing the first two and the third levels respectively. Intuitively, the SCR_K^I captures the behaviour of the top K and bottom I teams. The calculation of SCR_K^I is fairly simple, since its component indices have similar features and capture different aspects of competitive balance. Essentially, the design of SCR_K^I is based on the procedure followed for ACR_K. This can be simply accomplished, if NCR^I is considered to be a component index of ACR_K. Therefore, following equations (4.2) and (4.9), the introduced SCR_K^I is given by:

$$SCR_K^I = \frac{\sum_{i=1}^{K} NCR_i + NCR^I}{K+1} = \frac{1}{K+1}\left[\sum_{i=1}^{K} wt_i P_i - \sum_{i=N-I+1}^{N} wt_I P_i - C_K + C_I\right], \tag{4.10}$$

for *I<N, K<N*, *I+K<N*.

It is safe to assume that the number of *I* relegated is lower than the top *K* teams. The weight wt_i attached to the *K* teams and the constant term C_K are the same as these in equation (4.2) while wt_I stands for the weight attached to the bottom *I* teams given by:

$$wt_I = \frac{1}{2I(N-I)}, \quad \text{for } I<N, \tag{4.11}$$

and C_I is a constant term derived from NCR^I and calculated as:

$$C_I = \frac{N-1}{N-I}, \quad \text{for } I<N. \tag{4.12}$$

Similarly to the previous indices, SCR_K^I index ranges from zero to one. The lower bound of the index is obtained in case each top *K* and bottom *I* teams gather 50% of the maximum attainable number of points. Consequently, all teams share points equally, which is the case of a perfectly balanced league. In essence, the lower bound is obtained when component indices measuring all levels of competitiveness will be constrained to their minimum values and stands for a perfectly balanced league, which is defined by the following three features:

a) Absence of domination by the top *K* teams.
b) Perfect balance among the top *K* teams.
c) Absence of weakness of the *I* relegated teams.

On the other hand, the upper bound is reached when all the following conditions are simultaneously true:

a) Each of the top K teams gets the maximum attainable number of points, provided that any team always wins against any weaker and loses from any stronger.
b) The bottom I teams collectively gather the minimum number of points; that is, they only gather points from the other relegated teams.

Consequently, the upper bound is obtained when component indices measuring all levels of competitiveness will reach their maximum values and stands for a completely unbalanced league, which is defined by the following three features:

a) Complete domination by the top K teams.
b) Complete imbalance among the top K teams.
c) Maximum weakness of the I relegated teams, or else a completely unbalanced for relegation league.

As it is expected, the interpretation of SCR_K^I is not simple, given that it possess three different qualities:

a) The degree of concentration or domination by top K teams.
b) The degree of competition among the top K teams.
c) The degree of competition for relegation or the degree of weakness of the I relegated teams.

The SCR_K^I has the properties of being relatively insensitive to N, K, and I. This is derived from the robustness of its components ACR_K and NCR^I discussed in Section 4.2.2 and Section 4.2.3. The existence of robustness is crucial given the variability in N, K, and I across European football leagues, as is presented in Table 4.3. The variation in N enables an analysis of competitive balance across leagues and/or seasons. Additionally, the variation in K and/or I allows for various adjustments according to the league's specific structure.

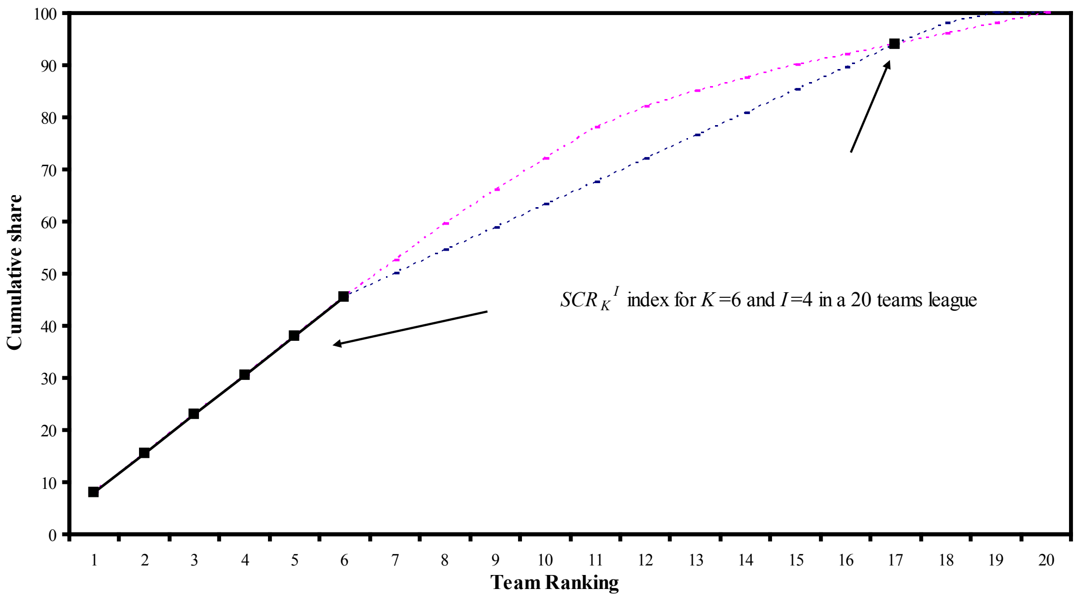
The properties of SCR_K^I for K=6 and I=4 in a league with 20 teams are illustrated in the concentration curve in Figure 4.5 where it is underlined that the index depends on 7 points on the concentration curve. It can be easily derived that SCR_K^I provides more information than the previously mentioned concentration indices. More specifically, it provides information for teams at both the top and the bottom of the ladder.

Table 4.3: Values of *N*, *K*, and *I* in European football leagues from 1999 to 2008

		ENG	GER	FRA	ITA	BEL	GRE	SWE	NOR
N:	14						1	9	**10**
	16						**8**	**1**	
	18		**10**	3	5	**10**	1		
	20	**10**		**7**	**5**				
K:	3-4					7	2	**8**	4
	5-6	1	**1**	**3**		**3**	**8**	2	**6**
	7-9	**9**	9	7	**10**				
I:	1-2			1		9		1	**1**
	3	**10**	**10**	**9**	**5**		**8**	**8**	9
	4				5	**1**	2	1	

In Bold, the values of *N*, *K*, and *I* for the last season in the dataset (2008-09).
The number of *I* relegated teams includes teams participating in play-out games.
Only in Sweden for the season 2007-08, there is one relegated team.
Complete data for the values of *N*, *K*, and *I* is presented in Appendix A.

Figure 4.5: Concentration Curve of SCR_K^I for *K*=6 and *I*=4 in a 20-team League



A minor limitation of SCR_K^I is that it does not provide any information for teams after *Kth* and before the relegation position. This may be important when the sum of *K* and *I* is small with comparison to *N*. In that case, a proper solution is to extend the number of top *K* teams which seems justifiable since positions close to the *K*th could also be considered as important since they have legitimate chances to qualify in

European tournaments. A similar extension can also be applied for the number of bottom I teams. However, this limitation is to be expected based on the design of the index and is justified by the assumption that teams at the top and the bottom of the ladder are more important from the fans' perspective.

Similarly to the ACR_K, the SCR_K^I also embodies two important features:

a) SCR_K^I is a composite index comprised by K+1 simpler indices. However, when studying competitive balance it can be decomposed into its various components without losing any important information. Consequently, the ingredient sources of the overall competitive balance may be determined by the degree of competition in any component index.

b) The weighting pattern offered by SCR_K^I meets the criteria set in Section 4.1. More specifically, for realistic values of K and I, SCR_K^I rates the top K teams - at a decay pattern of weights- higher than the bottom I teams. Any of the I teams is rated higher than the teams in the middle of the ladder (N-K-I) since those are not included in the index. We should point out that this weighing pattern is not necessarily an optimal one, but it provides a simple and plausible benchmark for the study of competitive balance in European football.

In particular, the wt_i attached to the top K teams is identical to that in the ACR_K index, given by sequence (4.6). On the other hand, wt_I in equation (4.11) is the same for all I relegated teams based on the assumption that on the one hand the choice between any these positions is indifferent and on the other the competition among relegated teams is not intriguing either for the fans or the teams themselves. As expected, wt_I is a decreasing function of both N and I. Yet, an undesirable property of wt_I is that is higher than wt_K concerning the realistic values of $I<K\leq N/2$. However, this doubtful behaviour can be easily corrected by increasing the value of K and/or I. Increasing K is justifiable since in that manner we can also measure the competitiveness of the teams which struggle for the last position leading to European tournaments; similar justification may be also attached to a possible increase of I.

Note that wt_I may be also higher than $wt_{K\text{-}1}$ but only for $I<K/3$, which is not common in top European football leagues.

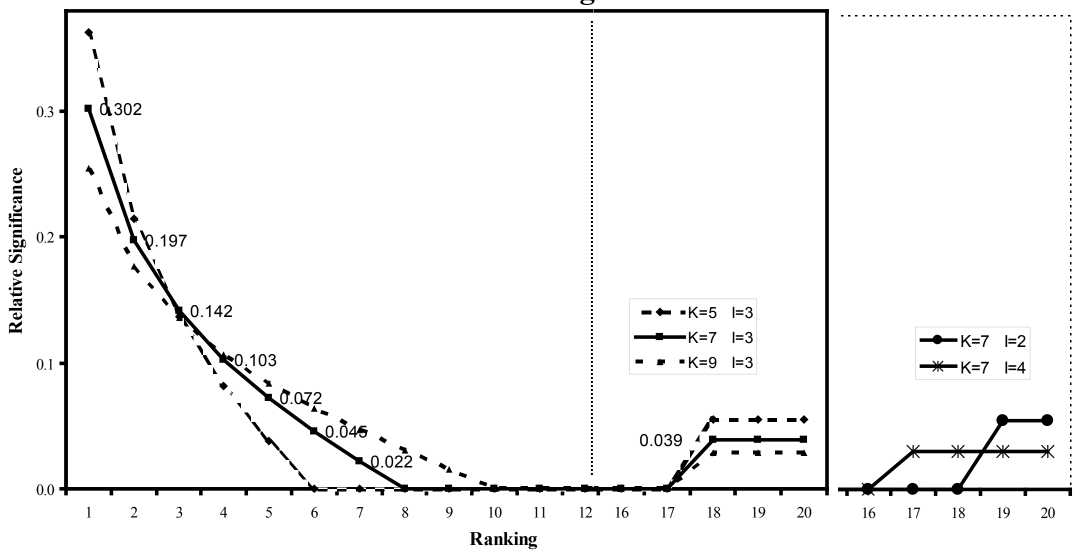
To illustrate the variation in wt_i and wt_I, consider a 20-team league, in which the top seven qualify for European tournaments and the last three are relegated to a lower division. In that case, the appropriate concentration index for the estimation of the level of competitive balance is SCR_K^I for K=7 and I=3. Based on the calculation of the index, the relative significance given to various levels and positions is presented in Table 4.4. As can be verified from this table, the highest relative significance is given to the first position, which is the champion. For all other top positions, the weight decreases at a diminishing rate. Additionally, any of the Ith teams is rated higher than the Kth team while there is no weight attached to the N-K-I teams at the middle of the ladder, since they are not included in the calculation of the index.

Table 4.4: Relative Significance in SCR_K^I for *K*=7 and *I*=3

Ranking	*Relative Significance*		
	Position	*Level*	
1	0.302	0.302	*A:* 0.302 *per position*
2 3 4 5 6 7	0.197 0.142 0.103 0.072 0.045 0.022	0.581	*B:* 0.097 *per position*
8-17	0		
18-20	0.039 X 3	0.117	*C:* 0.039 *per position*
Sum:	1	1	

The behaviour of the weights (wt_i and wt_I) is graphically illustrated in Figure 4.6 for a 20-team league with K=5, 7 & 9 European places and for I=2, 3 & 4 relegation places. Note that, for K=7, the relative significance for the top K teams remains almost unchanged regardless of the variation in I. Figure 4.6 also confirms that the highest relative significance is given to the first place while the weight for the remaining places decreases, and the weight attached to the relegated teams is between the corresponding weights for the Kth and the (K-1)th places with the exception of K=7 and I=2 where I<K/3.

Figure 4.6: Relative Significance in SCR_K^I for K=5, 7, 9 and I=2, 3, 4 in a 20-team League



To conclude the introduction to SCR_K^I, the steps followed in the calculation are presented algorithmically in Table 4.5. In particular, what is shown are the algorithmic steps for the calculation of SCR_8^3 index interpreted as:

a) The degree of domination of the top eight teams with respect to the remaining 12 teams.
b) The degree of competition among the top eight teams.
c) The degree of competition for the three relegated places or the degree of weakness of the three relegated teams with respect to the remaining 17 teams.

It can be easily drawn from Table 4.5 that SCR_8^3 can be decomposed into its three level- components as:

a) Level 1: Step 1
b) Levels 1 & 2: Average from step 1-8
c) Level 3: Step 9

Table 4.5: Algorithmic Steps for the Calculation of SCR_8^3

Steps	*Action*	*Equation*	*Description*
1	NCR_1	$NCR_1 = \frac{P_1 - 2(20-1)}{2(20-1)}$	**First Level** NCR_1
2	NCR_2	$NCR_2 = \frac{P_1 + P_2 - 4(20-1)}{4(20-2)}$	**First & Second Level** $ACR_8 = \frac{\sum_{i=1}^{8} NCR_i}{8}$
3	NCR_3	$NCR_3 = \frac{P_1 + P_2 + P_3 - 6(20-1)}{6(20-3)}$	
4	NCR_4	$NCR_4 = \frac{P_1 + P_2 + P_3 + P_4 - 8(20-1)}{8(20-4)}$	
5	NCR_5	$NCR_5 = \frac{P_1 + P_2 + P_3 + P_4 + P_5 - 10(20-1)}{10(20-5)}$	
6	NCR_6	$NCR_6 = \frac{P_1 + P_2 + P_3 + P_4 + P_5 + P_6 - 12(20-1)}{12(20-6)}$	
7	NCR_7	$NCR_7 = \frac{P_1 + P_2 + P_3 + P_4 + P_5 + P_6 + P_7 - 14(20-1)}{14(20-7)}$	
8	NCR_8	$NCR_8 = \frac{P_1 + P_2 + P_3 + P_4 + P_5 + P_6 + P_7 + P_8 - 16(20-1)}{16(20-8)}$	
9	NCR^3	$NCR^3 = \frac{6(20-1) - P_{18} - P_{19} - P_{20}}{6(20-3)}$	**Third Level** NCR^3
10	SCR_8^3	$SCR_8^3 = \frac{\sum_{i=1}^{8} NCR_i + NCR^3}{8+1}$	**First, Second, and Third Level** SCR_8^3

P_i stand for the number of points collected by the ith team.

4.3 Conclusion

In this chapter it is attempted to answer the third issue of the thesis by creating specially designed indices which take into account the characteristics of European football leagues. In this context, the multi-prized structure of such leagues as well as its importance for both the fans and the teams themselves is identified. This chapter provides a more systematic analysis for an enhanced quantification of the seasonal dimension of competitive balance. The development of new seasonal indices is suggested based on simple averaging strategies which aim at capturing the competitiveness at any of the three important levels in multi-prized European football leagues:

a) The first level, which is the championship title.
b) The second level, which is the qualifying places for participation in European tournaments the following season.

c) The third level, which is the relegation places.

The simple averaging approach, is inspired by the necessity to quantify the competition at each level and to rate the ranking position according to its significance for the fans. For the design of the following new seasonal indices, the modified NCR_K index is employed:

i. The *Normalised Concentration Ratio for the Champion* (NCR_1), which captures the first level and is interpreted as the degree of the champion's domination.

ii. The *Adjusted Concentration Ratio* (ACR_K), which captures the first two levels and is interpreted as: a) the degree of concentration or domination by the top K teams, and b) the degree of competition among the top K teams.

iii. The *Normalised Concentration Ratio for Relegated Teams* (NCR^I), which captures the third level and is interpreted as the degree of weakness of the I relegated teams.

iv. The *Special Concentration Ratio* (SCR_K^I), which captures all three levels.

In the next chapter, following a similar procedure, new indices that refer to the between-seasons dimension of competitive balance will be created. Moreover, for a comprehensive analysis of competitive balance in European football, the development of bi-dimensional indices that capture both dimensions will be attempted.

Overview Table with New Indices of Seasonal Competitive Balance

The derived function along with a short description of all new indices of seasonal competitive balance that were introduced in the present chapter, they are presented in Table 4.6**.**

Table 4.6: New Indices of Seasonal Competitive Balance

Index	***Function***	***Description***
Normalised Concentration Ratio for the Champion	$NCR_1 = \frac{1}{2(N-1)} P_1 - 1$	NCR_K for K=1: captures the first level (the degree of the champion's domination).
Adjusted Concentration Ratio	$ACR_K = \frac{\sum_{i=1}^{K} NCR_i}{K} = \frac{1}{K}\left[\sum_{i=1}^{K} w_i P_i - C_K\right]$	Average of the first K NCR_i indices: captures the first two levels (the degree of concentration or domination by the top K teams and the degree of competition among the same teams).
Normalised Concentration Ratio for Relegated Teams	$NCR^I = \frac{N-1}{N-I} - \frac{1}{2I(N-I)}\left(\sum_{i=N-I+1}^{N} P_i\right)$	CR is suitably adapted to account for the third level (the degree of weakness of the I relegated teams).
Special Concentration Ratio	$SCR_K^I = \frac{\sum_{i=1}^{K} NCR_i + NCR^I}{K+1}$	The ACR_K and NCR^I are averaged in a single index: captures all three levels.

Chapter 5. Quantification of Competitive Balance in European Football; Development of Between-seasons and Bi-dimensional Indices

Following the discussion in Chapter 4 for the multi-levelled structure of European football leagues and the development of seasonal indices, the objective here is to develop specially designed indices for the between-seasons dimension of competitive balance. Moreover, a number of bi-dimensional indices that capture levels from both dimensions are also created, thus, enabling a comprehensive analysis of competitive balance. This chapter initially introduces the new indices for the between-seasons dimension followed by the bi-dimensional indices. Finally, a concluding section presents a summary of the new indices' features and addresses new issues for a further investigation of their qualities.

5.1 New Indices of Between-seasons Competitive Balance

For the development of between-seasons indices is employed the *Index of Dynamics* (DN_t^*), which measures the degree of overall ranking mobility of teams participating in two adjacent league seasons. Since ranking mobility generates uncertainty this establishes its importance for the fans' interest. Essentially, the DN_t^* index, which meets the criteria set in Section 4.2 for the NCR_K index, is calculated by equally rating ranking places. However, the relative significance of the various levels and/or ranking positions in European football is not the same; and thus, they have to be rated accordingly. Based on the procedure followed for the seasonal dimension, a proper adjustment of DN_t^* is necessary to effectively capture the three levels of competitiveness which lead to different prizes-goals.

5.1.1 Dynamic Index

The *Dynamic Index* (DN_K) is analogous to the NCR_K index in the seasonal dimension; thus, it can be interpreted as the degree of dynamic domination by the top K teams. Following the procedure for DN_t^* in equation 2.48, for the proper design of DN_K, it is necessary to identify the maximum ranking mobility for the top K teams ($maxDN_K$), reached when the top K teams are the ones ended at the bottom K places of the previous season. To illustrate, consider a league which exhibits maximum ranking mobility, that is, an inverse ranking order from season to season, as is shown in Table 5.1.

Table 5.1: Maximum Ranking Mobility

r in Season t	*r in Season t*-1	$\lvert r_{i,t} - r_{i,t-1} \rvert$
1	*N*	*N*-1
2	*N*-1	*N*-3
3	*N*-2	*N*-5
4	*N*-3	
…		…
i	*N*-(*i*-1)	*N*-(2*i*-1)
…		
N-3	4	
N-2	3	*N*-5
N-1	2	*N*-3
N	1	*N*-1
	Total:	$\frac{N^2}{2}$

It should be reminded that the maximum ranking mobility stands for a dynamically perfectly balanced league. In that case, the ranking difference for the first team equals *N*-1, for the second team *N*-3, and so on down to the middle of the ladder. The absolute ranking difference for the bottom half of the ladder is identical as far as the reverse order is concerned. Hence, the maximum absolute ranking change for the *i*th team equals *N*-(2*i*-1) and the $\max DN_K$ is given by:

$$\max DN_K = \sum_{i=1}^{K} \lvert r_{i,t} - r_{i,t-1} \rvert = \sum_{i=1}^{K} \left(N - (2i-1)\right) = K(N-K), \tag{5.1}$$

for any $K \leq N/2$. Following the procedure in equations (2.48) and (3.12), DN_K is given by:

$$DN_K = 1 - \frac{\sum_{i=1}^{K} \lvert r_{i,t} - r_{i,t-1} \rvert}{\max DN_K} = 1 - \frac{\sum_{i=1}^{K} \lvert r_{i,t} - r_{i,t-1} \rvert}{K(N-K)} = 1 - \frac{\sum_{i=1}^{K} r_i}{K(N-K)}, \quad \text{for } K \leq N/2, \tag{5.2}$$

where $r_{i,t}$ and r_i stand for the ranking position of team i in season t and for the absolute ranking difference of the ith team from season t-1 to season t, respectively. DN_K ranges from zero (maximum ranking mobility by the top K teams) to one (no ranking mobility by the top K teams). The former stands for absence of dynamic domination, which is reached when the top K teams are derived from the bottom K places of the previous season. As far as the latter is concerned, it stands for a completely dynamically dominated league, which is obtained when the ranking position of the top K teams remains unchanged across two adjacent seasons. As DN_K increases, the mobility of the top K teams decreases and, thus, they become more dynamically dominant. A major advantage of this index is that it can be used for the study of competitive balance across leagues with various N.

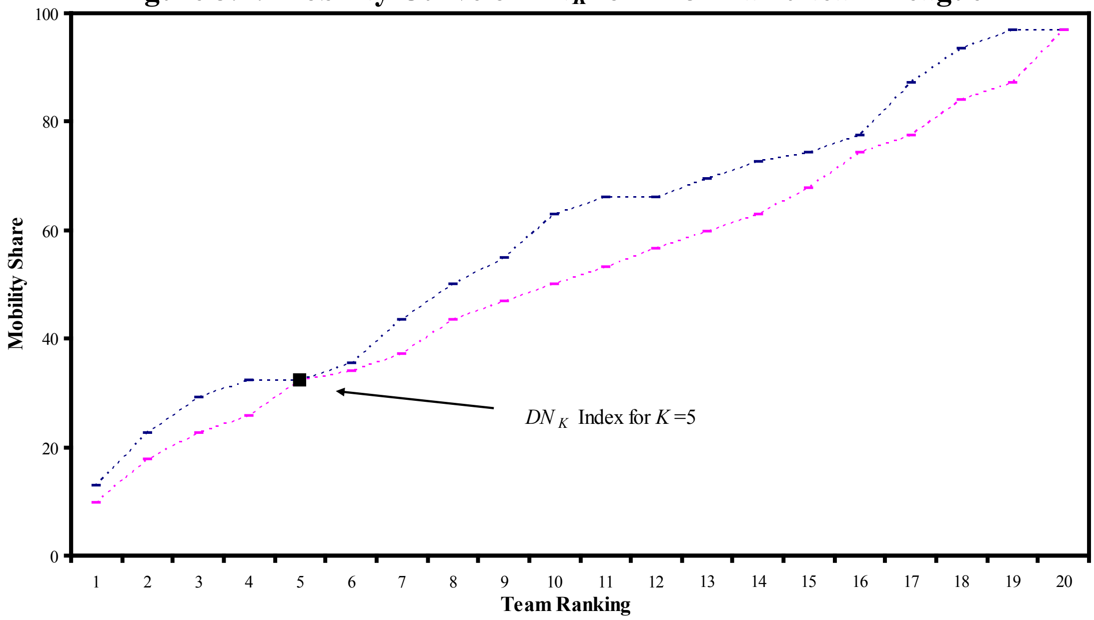
The interpretation of DN_K is fairly simple: it captures the mobility or dynamic domination by the top K teams from season to season. However, one limitation of the index is that equally treats ranking changes regardless of the original ranking position of the team. For instance, the ranking movement of the first team (champion) to the fourth place is treated equally to that of the third team to the sixth place. Additionally, it ignores the mobility of the N-K teams, which is justified by the design of the index. The properties of DN_K are illustrated in the mobility curve in Figure 5.1. The mobility curve is created, if we plot the cumulative share of the absolute ranking change of the teams. The height of the curve at any point measures the percentage of the league's total ranking change accounted for by the top K teams. The curve has always an upward direction from left to right and reaches the maximum height at the point which corresponds to the last team of the league. In particular, it is shown that DN_K depends on only one point in the mobility curve. Thus, for a variety of different mobility curves the index may remain unchanged.

5.1.2 Dynamic Index for the Champion

For K=1, it can be easily derived that DN_1 captures the first level and it can be interpreted as the degree of the champion's (the first team's) ranking mobility. Following equation (5.2), the *Dynamic Index for the Champion* (DN_1) is given by:

$$DN_1 = 1 - \frac{|r_{1,t} - r_{1,t-1}|}{\max DN_1} = 1 - \frac{r_1}{(N-1)}. \tag{5.3}$$

Figure 5.1: Mobility Curve of DN_K for K=5 in a 20-team League

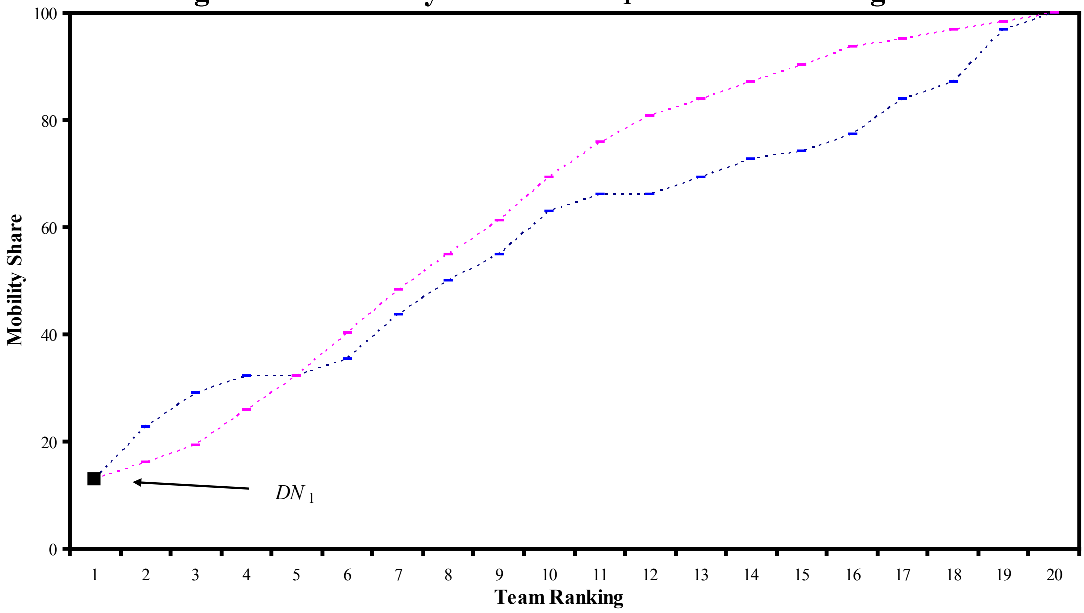


The index ranges from zero to one. The former is obtained in the case of maximum ranking mobility, which is interpreted as the absence of dynamic domination in a league by the champion; that is, the champion comes from the last ranking place of the previous season. As far as the latter is concerned, it is obtained in the case of no ranking mobility, which is interpreted as a league which is completely dynamically dominated by the champion; that is, the champion wins the championship for two consecutive seasons. The higher the DN_1, the more dynamically dominant the champion becomes. A limitation of the index, which is justified by its design, is that ignores the ranking mobility of the remaining teams. Figure 5.2 depicts the characteristic features of the index.

5.1.3 Adjusted Dynamic Index

The *Adjusted Dynamic Index* (ADN_K) is now introduced as a natural development of DN_K. This index captures both the first and the second levels in the multi-prized tournament structure of European football. For the definition of ADN_K, we follow a similar logic as in the definition of ACR_K in the seasonal dimension. The design of the index will be illustrated using a simple example of a 10-team league with two teams participating in European tournaments.

Figure 5.2: Mobility Curve of DN_1 in a 20-team League



Apparently, the champion stands for the first level while the second ranking team stands for the second level. Although DN_1 effectively demonstrates the mobility in the first level, DN_2 alone cannot capture each of the levels, since it rates them equally. Thus, the development of an index which accounts for the relative importance of each level would be very beneficial for the measurement of competitive balance across seasons. An average index effectively captures the relative significance, as it adjusts for the relative mobility of each level. The resultant average index captures ranking mobility between the two levels, as it is presented in Table 5.2.

The leagues in *seasons A* and *B* display identical cumulative absolute ranking change for the 1st and 2nd team. However, the specific ranking position of the first two teams markedly differs from season *A* to season *B*. DN_1 and DN_2 effectively demonstrate the degree of mobility or dynamic domination by the champion and the top two teams respectively. However, DN_2 fails to account for the relative importance of the two ranking places, or else to capture the ranking mobility between the two teams. Arguably, *season B* is more balanced than *season A*, although this cannot be captured by DN_2. For that reason, the average of the two indices is employed for an enhanced quantification of competitive balance.

Table 5.2: Average of DN_1 & DN_2

Starting Season (*S*)	*Season A*	$\left\| r_{i,S} - r_{i,A} \right\|$	*Season B*	$\left\| r_{i,S} - r_{i,B} \right\|$
1	3		3	
2	4		4	
3	1	2	2	1
4	2	2	1	3
5	5		5	
6	6		6	
7	7		7	
8	8		8	
9	9		9	
10	10		10	
	DN_1:	0.777		0.666
	DN_2:	0.75		0.75
	Average (DN_1, DN_2):	0.763		0.708

In essence, the resultant average index captures both levels and rates them accordingly. This procedure can be generalised for any number of the top *K* positions as long as their value is unequally rated. Thus, the ADN_K is derived by adjusting for the relative significance of the top *K* positions. Following the procedure in equations (4.2), (4.4), and (4.6) along with the formula for DN_K in equation (5.2), ADN_K is given by:

$$ADN_K = \frac{\sum_{i=1}^{K} DN_i}{K} = 1 - \frac{2}{K}\left[\sum_{i=1}^{K} w_i r_i\right] \quad \text{for } K \leq N/2. \tag{5.4}$$

The range of ADN_K accords with the conventional zero to one. The lower bound holds both for absence of dynamic domination by the top *K* teams and perfect dynamic competition among the same teams. The lower bound is obtained in the case of maximum ranking mobility in the reverse order; that is, the top *K* teams inversely come from the bottom of the ladder of the previous season. As the index increases, the mobility of the top *K* teams decreases and, thus, they become more dynamically dominant. On the other hand, the upper bound stands for a dynamically completely dominated league by the top *K* teams and absence of dynamic competition among the same teams. The upper bound is obtained when there is no ranking mobility in the top *K* teams. Since the range of the component indices are insensitive to the values in

N and K as previously described, ADN_K also has a similar behaviour. The ADN_K is interpreted as[16]:

a) The degree of ranking mobility or dynamic domination by the top K teams.
b) The degree of ranking mobility or dynamic competition among the top K teams.

For the DN_K index, the maximum raking mobility does not necessarily require the reverse order among the top K teams. The qualities of ADN_K for K=5 in a 20-team league are depicted in the mobility curve in Figure 5.3. From this figure it is clear that ADN_5 depends on 5 points in the mobility curve. Consequently, ADN_K provides more information than DN_K. A limitation of ADN_K, which is justified by its design, is that it does not provide any information concerning the mobility of the N-K teams. The two distinguishing features of ADN_K, similarly to its corresponding ACR_K, are as follows:

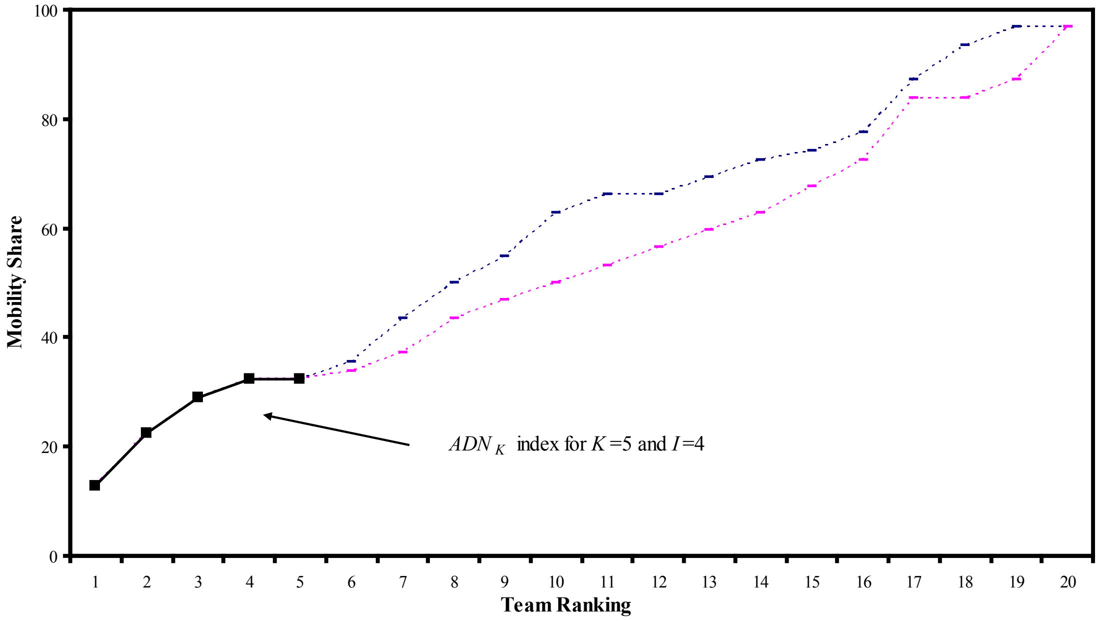
a) It can be decomposed into its K component indices; thus, the ingredient sources of dynamic domination can be determined.
b) It rates the top K ranking positions at a decreasing function of their ranking position according to the criteria set in Section 4.1. Actually, the weight w_i attached to the ith team, is identical to that derived from sequence (4.6) for the ACR_K index. Consequently, the discussion for the sensitivity of w_i to K, N, and ranking position i in ACR_K also holds for the ADN_K index. For clarification, the relative significance of the top places in ADN_K for K=8 is presented in Table 4.2 and illustrated in Figure 4.3.

5.1.4 Dynamic Index for Relegated Teams

As already discussed, the promotion-relegation rule is characteristic in European football structure. For this reason we introduce the *Dynamic Index for Relegated Teams* (DN^I) that captures the degree of dynamic weakness of the I relegated teams. According to Table 5.1, in which the league exhibits the maximum ranking mobility, the absolute ranking change at the bottom is similar to that at the top of the ladder.

[16] For the difference between ADN_K and DN_K see the relevant discussion for the ACR_K and NCR_K indices in Section 4.2.2.

Figure 5.3: Mobility Curve of ADN_K for K=5 in a 20-team League



As a result, $\max DN^I$ is given by:

$$\max DN^I = \sum_{i=N-I}^{N} \left| r_{i,t} - r_{i,t-1} \right| = \sum_{i=1}^{I} \left(N - (2i-1) \right) = I(N-I), \quad \text{for } I \leq N/2. \tag{5.5}$$

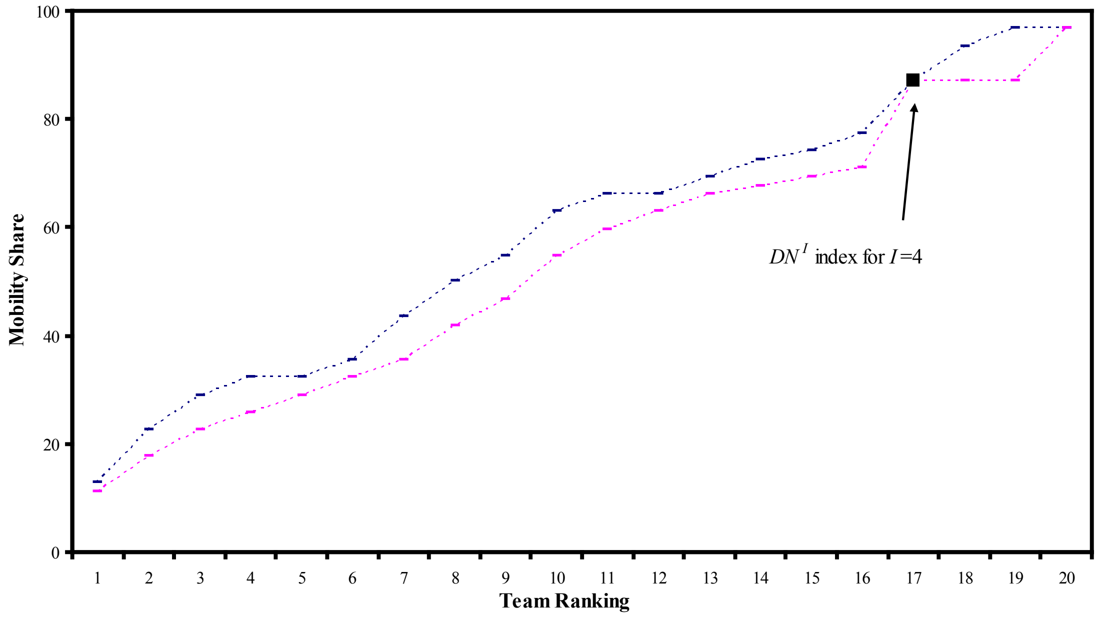
Therefore, the DN^I index is given by:

$$DN^I = 1 - \frac{\sum_{i=N-I+1}^{N} \left| r_{i,t} - r_{i,t-1} \right|}{I(N-I)} = 1 - \frac{\sum_{i=N-I+1}^{N} r_i}{I(N-I)}, \quad \text{for } I \leq N/2. \tag{5.6}$$

The range of DN^I is from zero to one. The former stands for the maximum ranking mobility while the latter stands for absence of ranking mobility. Similarly to the corresponding NCR^I in the seasonal dimension, the DN^I does not account for the ranking mobility among the I teams. Consequently, the reverse order is not required for the maximum ranking mobility of the I relegated teams. The interpretation of the index is fairly simple, as it is defined by the degree of ranking mobility or the degree of dynamic weakness of the I relegated teams or the degree of dynamic competition for relegation.

A major advantage of the index it that it provides a reliable estimation for the ranking mobility of the I relegated teams regardless of the variation in N and/or I. Hence, DN^I can be adjusted according to the specific promotion-relegation rule and can be used for an analysis of competitive balance across leagues and/or seasons with variant N. A limitation of the index is that it does not provide any information for the ranking mobility of each particular demoted team which is of limited importance for fans. Additionally, it ignores the mobility of the remaining teams. The properties of DN^I are shown in the mobility curve illustrated in Figure 5.4. Evidently, as is the case with DN_K, the DN^I index depends on only one point on the mobility curve.

Figure 5.4: Mobility Curve of DN^I for I=4 in a 20-team League



5.1.5 Special Dynamic Index

In this section, the *Special Dynamic Index* (SDN_K^I) is introduced in order to account for all three important levels in the multi-prized European football leagues. The process for the development of the index is similar to its equivalent SCR_K^I for the seasonal dimension. SDN_K^I can be considered as a custom-built index, which can be adapted according to variation in K and/or I. Additionally, it is a composite index, since a number of simpler indices are employed for its design. Based on the approach followed in equation (4.10) and the formulas for the ADN_K (5.4) and DN^I (5.6) indices, the function of SDN_K^I is given by:

$$SDN_K^I = \frac{\sum_{i=1}^{K} DN_i + DN^I}{K+1} = 1 - \frac{2}{K+1}\left[\sum_{i=1}^{K} w_i r_i + \sum_{i=N-I+1}^{N} w_I r_i\right], \qquad \textbf{(5.7)}$$

for $I \leq N/2$, $K \leq N/2$, $I+K<N$.

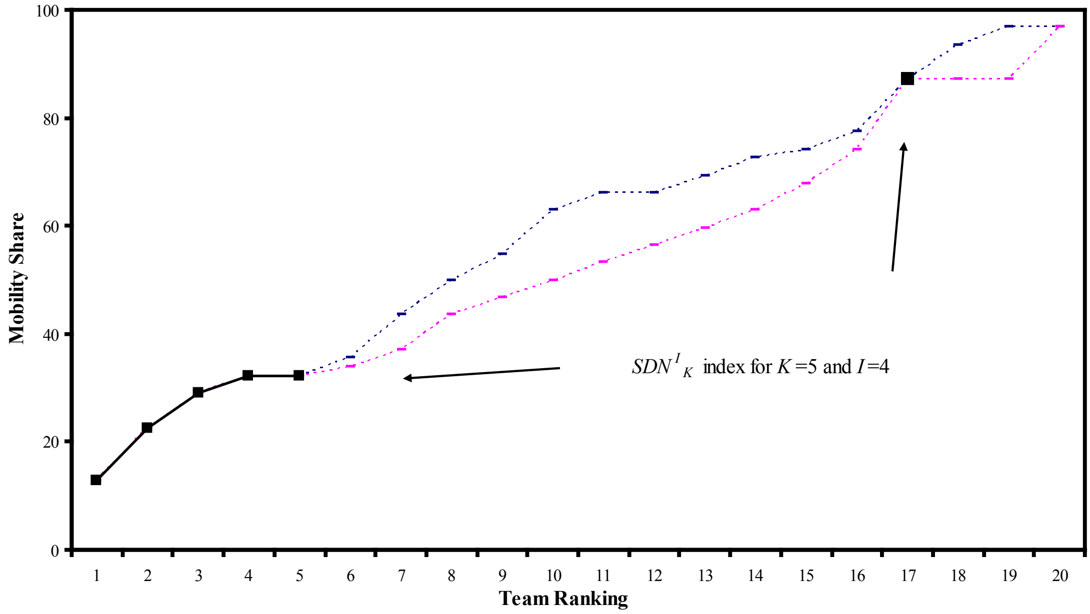
The zero value (lower bound) of SDN_K^I is reached for the maximum ranking mobility among the top K teams as well as for the maximum ranking mobility of both the top K and the bottom I teams. Essentially, the top K teams inversely come from the bottom K positions, whereas the I relegated teams come from the top I positions of the previous season. The value of one (upper bound) is reached when no ranking mobility is observed in both the top K and the bottom I positions. The range of SDN_K^I is insensitive to values of N, K, and I making comparisons between different seasons feasible. The interpretation of this composite index is specified by three different qualities:

a) The degree of ranking mobility or dynamic domination by the top K teams.
b) The degree of ranking mobility or dynamic competition among the top K teams.
c) The degree of ranking mobility or the degree of dynamic weakness of the I relegated teams or the degree of dynamic competition for relegation .

The properties of SDN_K^I for K=5 and I=4 in a 20-team league are depicted in the mobility curve of Figure 5.5. Apparently, SDN_K^I provides more information than the previously mentioned dynamic indices, since it depends on more points in the mobility curve. As its components, SDN_K^I, does not provide any information for the mobility of the teams ranked from K+1th to N-I-1th positions[17]. The innovative features of SCR_K^I also apply to SDN_K^I; for details see Section 4.2.4, p. 100.

[17] This could be a serious limitation only when the sum of K and I is substantially smaller than N. For a proper solution see Section 4.2.4.

Figure 5.5: Mobility Curve of SDN_K^I for K=5 and I=4 in a 20-team League



The calculation of SDN_K^I for K=8 and I=3 in ten simple steps is summarized in Table 5.3. In this example, SDN_8^3 for a 20-team league is interpreted as:

a) The degree of ranking mobility or dynamic domination by the top eight teams with respect to the remaining 12 teams.
b) The degree of ranking mobility or dynamic competition among the top eight teams.
c) The degree of ranking mobility or the degree of dynamic weakness of the three relegated teams with respect to the remaining 17 teams or the degree of dynamic competition for relegation.

SDN_8^3 can be decomposed into three ingredients levels as:

a) Level 1: Step 1
b) Levels 1 & 2: Average from step 1-8
c) Level 3: Step 9

Table 5.3: Algorithmic Steps for the Calculation of SDN_8^3

Steps	*Action*	*Equation*	*Description*
1	DN_1	$DN_1 = 1 - \frac{r_1}{20-1}$	**First Level** DN_1
2	DN_2	$DN_2 = 1 - \frac{r_1 + r_2}{2(20-2)}$	**First & Second Level** $ADN_8 = \frac{\sum_{i=1}^{8} DN_i}{8}$
3	DN_3	$DN_3 = 1 - \frac{r_1 + r_2 + r_3}{3(20-3)}$	
4	DN_4	$DN_4 = 1 - \frac{r_1 + r_2 + r_3 + r_4}{4(20-4)}$	
5	DN_5	$DN_5 = 1 - \frac{r_1 + r_2 + r_3 + r_4 + r_5}{5(20-5)}$	
6	DN_6	$DN_6 = 1 - \frac{r_1 + r_2 + r_3 + r_4 + r_5 + r_6}{6(20-6)}$	
7	DN_7	$DN_7 = 1 - \frac{r_1 + r_2 + r_3 + r_4 + r_5 + r_6 + r_7}{7(20-7)}$	
8	DN_8	$DN_8 = 1 - \frac{r_1 + r_2 + r_3 + r_4 + r_5 + r_6 + r_7 + r_8}{8(20-8)}$	
9	DN^3	$DN^3 = 1 - \frac{r_{18} + r_{19} + r_{20}}{3(20-3)}$	**Third Level** DN^I
10	SDN_8^3	$SDN_8^3 = \frac{\sum_{i=1}^{8} DN_i + DN^3}{8+1}$	**First**, **Second**, and **Third Levels** SDN_K^I

r_i stands for the absolute ranking difference (from season t-1 to season t) of the ith team.

5.2 Bi-dimensional Indices of Competitive Balance

In Section 4.2 and Section 5.1, a number of new indices were introduced for the seasonal dimension (which captures the degree of concentration or domination/weakness), and for the between-seasons dimension (which captures the degree of ranking mobility or dynamic domination/weakness), respectively. In what follows, we introduce bi-dimensional indices that capture both dimensions combining different aspects of competitive balance in a single index. Such indices provide information for the overall aspect of competitive balance, since they consolidate different qualities from two dimensional groups of indices.

Based on the analysis in the previous sections, the three levels of the European football league structure are taken into account in the development of specially designed single-dimensional indices. Although those indices measure different levels or dimensions, we can identify a number of common properties among them:

a) All indices have the same range, that is, the conventionally defined range from zero to one. Moreover, the range is well-documented, as it is insensitive to the variation in N, K, and/or I.
b) In general, the upper and lower bounds of the indices stand for the two polar cases in terms of competitive balance, that is, the perfectly balanced and the completely unbalanced league respectively.
c) The relative significance attached to ranking positions is identical for seasonal and between-seasons indices.

By virtue of these properties, a group of bi-dimensional *Dynamic Concentration* indices is introduced that captures levels both from the seasonal and the between-seasons dimension. Essentially, a *Dynamic Concentration* index employs the specific qualities of a *Normalised Concentration Ratio* (seasonal dimension) as well as a *Dynamic Index* (between-seasons dimension). A limitation of *Dynamic Concentration* indices is that they cannot indicate the specific dimensional source of competitive balance. However, as will be illustrated below, the development of the *Dynamic Concentration* indices is relatively simple; thus, they can be easily decomposed into their single-dimensional components, since it is assumed that the two dimensions are of equal importance.

5.2.1 Dynamic Concentration for the Champion

The *Dynamic Concentration for the Champion* (DC_1) captures the first level in two dimensions. More specifically, DC_1 nicely depicts the degree of the champion's domination both seasonally and dynamically. The calculation of DC_1 is derived by the average of its corresponding component (single dimensional) indices NCR_1 and DN_1. Following equations (4.1) and (5.3), the formula of DC_1 is given by:

$$DC_1 = \frac{NCR_1 + DN_1}{2} = \frac{P_1 - 2r_1}{4(N-1)}. \tag{5.8}$$

The lower bound of zero is obtained under the following two conditions:

a) Absence of domination where the champion collects 50% of the maximum attainable points, and consequently, all teams equally share the same number of points.

b) Maximum ranking mobility or absence of dynamic domination; the champion comes was promoted in the previous season.

On the other hand, the upper bound of one is obtained when there is:

a) Complete domination by the champion, who collects the maximum attainable number of points.

b) Absence of ranking mobility or a completely dynamically dominated by the champion league; i.e. the champion is the same for two consecutive seasons.

For its interpretation we must refer to the qualities of the component indices; thus, DC_1 is interpreted as the degree of dynamic concentration or bi-dimensional domination by the champion. In essence, DC_1 is a bi-dimensional index, which portrays the champion's overall behaviour in terms of competitive balance.

5.2.2 Adjusted Dynamic Concentration

The *Adjusted Dynamic Concentration* (ADC_K) captures the first two levels in both dimensions. In particular, ADC_K summarises the behaviour of the top K teams that qualify in any European tournament. Similarly to the DC_1, the calculation of the index is merely the average of the corresponding ACR_K and ADN_K indices. According to equations (4.2) and (5.4), the formula of the ADC_K is given by:

$$ADC_K = \frac{ACR_K + ADN_K}{2} = \frac{1}{2K}\left[w_i \sum_{i=1}^{K} (P_i - 2r_i) - C_K \right] + \frac{1}{2}, \quad \text{for } K \leq N/2. \tag{5.9}$$

The definition of ADC_K derives from the properties of its corresponding component indices. In particular, the lower bound of zero is obtained under the following two conditions:

a) Absence of domination where any of the top K teams collects 50% of the maximum attainable points. In such a case, the league is seasonally perfectly balanced, since all teams share points equally.

b) Absence of both dynamic domination by the top K teams and dynamic competition among the same teams where there is maximum ranking mobility -in the reverse order- by the top K teams. In such a case, the league is dynamically perfectly balanced, since the top K teams inversely come from the bottom of the ladder of the previous season.

On the other hand, the upper bound of one is obtained when:

a) There is complete domination by the top K teams and complete imbalance among the same teams.
   i. The top K teams collectively gather the maximum attainable number of points; that is, they always win against the remaining teams.
   ii. Within the group of K, any team always wins against any weaker and loses from any stronger.
b) There is complete dynamic domination by the top K teams and absence of dynamic competition among the same teams. This is obtained when the ranking position of the top K teams remains unchanged in two adjacent seasons.

Given that ADC_K refers to a large number of single-dimensional component indices, its interpretation is not simple and is given as follows:

a) The degree of concentration or domination by the top K teams.
b) The degree of competition among the top K teams.
c) The degree of ranking mobility or dynamic domination by the top K teams.
d) The degree of ranking mobility or dynamic competition among the top K teams.

In effect, ADC_K is a composite index, which can be decomposed into $2K$ simpler indices in both dimensions and interpreted as the degree of dynamic concentration of the top K teams. Essentially, the index concentrates on the bi-dimensional relative performance of the top K teams.

5.2.3 Dynamic Concentration for Relegated Teams

Since relegation is an important aspect of the European league structure, the *Dynamic Concentration for Relegated Teams* (DC^l) is introduced to capture the bi-dimensional performance of the I relegated teams. DC^I effectively depicts the behaviour of the last I teams, since it borrows its specific features from its component NCR^I and DN^I indices. Following the previous discussion and according to equations (4.9) and (5.6), the derived formula of DC^I is given by:

$$DC^I = \frac{NCR^I + DN^I}{2} = \frac{2N - I - 1}{2(N-I)} - \frac{\sum_{i=N-I+1}^{N}(P_i + 2r_i)}{4I(N-I)}, \quad \text{for } I \leq N/2. \tag{5.10}$$

The interpretation of the index's conventional range (0-1) refers to the qualities of its two component indices. In particular, the lower bound is obtained when every team collects 50% of the maximum attainable number of points and the I relegated teams come from the top I positions of the previous season. On the other hand, the upper bound is reached when the I teams collect the minimum number of points and they are promoted the previous season. The bi-dimensional DC^I index is interpreted as the degree of dynamic concentration of the I relegated teams. Alternatively, the index is interpreted as the bi-dimensional competition for relegation or the degree of bi-dimensional weakness of the I relegated teams.

5.2.4 Special Dynamic Concentration

Lastly, the *Special Dynamic Concentration* (SDC_K^I) is introduced, which is a comprehensive index, as it captures all three levels in both the seasonal and the between-seasons dimensions. More specifically, SDC_K^I reveals the bi-dimensional behaviour both of the top K and the bottom I teams. It is calculated by simply averaging the corresponding SCR_K^I and SDN_K^I indices and following equations (4.10) and (5.7), it is given by:

$$SDC_K^I = \frac{SCR_K^I + SDN_K^I}{2} \Leftrightarrow$$
$$SDC_K^I = \frac{1}{2(K+1)}\left(w_i \sum_{i=1}^{K}(P_i - 2r_i) - w_I \sum_{i=N-I+1}^{N}(P_i + 2r_i) - C_K + C_I \right) + \frac{1}{2}, \tag{5.11}$$

where $I \leq N/2$, $K \leq N/2$, $I+K<N$.

The lower bound of zero is the bi-dimensionally perfectly balanced state reached under the following conditions:

a) Every team in the league collects 50% of the maximum attainable points. As a result, there is absence of both domination by the top K teams and weakness of the I relegated teams. Essentially, this is the seasonally perfectly balanced state defined by the following three features:
    i. Absence of domination by the top K teams.
    ii. Perfect balance among the top K teams.
    iii. Absence of weakness of the I relegated teams, or else a perfectly balanced for relegation league.
b) There is maximum ranking mobility in both top K and bottom I teams. More specifically, the top K teams inversely come from the bottom of the ladder and the bottom I teams come from the top I positions of the previous season. This is the dynamically perfectly balanced state defined by the following three features:
    i. Absence of dynamic domination by the top K teams.
    ii. Perfect dynamic competition among the top K teams.
    iii. Absence of dynamic weakness of the I relegated teams, or else dynamically perfectly balanced for relegation league.

With reference to the upper bound of one, it refers to the bi-dimensionally completely unbalanced state obtained in the following cases:

a) Each of the top K teams gets the maximum attainable number of points, provided that any team always wins against any weaker and loses from any stronger. Additionally, the relegated I teams collectively gather the minimum number of points; that is, they only gather points from other relegated teams. This is the seasonally completely unbalanced state defined by the following three features:
    i. Complete domination by the top K teams.
    ii. Complete imbalance among the top K teams.
    iii. Maximum weakness of the I relegated teams, or else a completely unbalanced for relegation league.

b) There is absence of ranking mobility in the top K and bottom I teams. This is the dynamically completely unbalanced state defined by:
   i. Complete dynamic domination by the top K teams.
   ii. Absence of dynamic competition among the top K teams.
   iii. Maximum dynamic weakness of the I relegated teams, or else absence of dynamic competition for relegation.

The interpretation of SDC_K^I is not simple, since it holds for simpler indices from two dimensions and three levels. In particular the index can be interpreted as:

a) The degree of concentration or domination by the top K teams as well as the level of competition among the same teams.
b) The degree of dynamic domination by the top K teams as well as the degree of dynamic competition among the same teams.
c) The degree of bi-dimensional competition for relegation, or else the degree of bi-dimensional weakness of the I relegated teams.

Essentially, SDC_K^I is a comprehensive index, which focuses on the most important aspects of the three-level league structure; thus, it effectively provides an enhanced assessment of the overall competitive balance in the context of European football. Despite the seemingly complex formula given by equation (5.11), the SDC_K^I can be easily decomposed into its constituent elements providing a powerful tool for policy makers to further explore the ingredient sources of competitive balance. Therefore, the usefulness of this bi-dimensional index derives from its ability to effectively convey information from various aspects of competitive balance.

5.3 Conclusion

Following the procedure discussed in the previous chapter, this chapter also provides answer to the third issue of the thesis by creating additional specifically designed indices for a comprehensive analysis of competitive balance. In the context of multi-prized structure of European football, new indices for the between-seasons dimension as well as bi-dimensional indices are constructed.

For the design of the following new between-seasons indices, the new *Dynamic Index* (DN_K) is employed which accounts for the degree of ranking mobility of the top K teams.

i. The *Dynamic Index for the Champion* (DN_1), which captures the first level and is interpreted as the degree of the champion's ranking mobility or dynamic domination.
ii. The *Adjusted Dynamic Index* (ADN_K), which captures the first two levels and is interpreted as: a) the degree of ranking mobility or dynamic domination by the top K teams, and b) the degree of ranking mobility or dynamic competition among the top K teams.
iii. The *Dynamic Index for Relegated Teams* (DN^I), which captures the third level and is interpreted as the degree of ranking mobility of the relegated I teams.
iv. The *Special Dynamic Index* (SDN_K^I), which captures all three levels.

The approach followed also enables for the development of the so-called "*Dynamic Concentration*" bi-dimensional indices that capture both dimensions of competitive balance. It must be noted that the interpretation of the bi-dimensional indices is derived from that of their component indices:

i. The *Dynamic Concentration for the Champion* (DC_1), which captures the first level and is interpreted as the degree of dynamic concentration or bi-dimensional domination by the champion.
ii. The *Adjusted Dynamic Concentration* (ADC_K), which captures the first two levels and is interpreted as: a) the degree of concentration or domination by the top K teams, b) the degree of competition among the top K teams, c) the degree of ranking mobility or dynamic domination by the top K teams, and d) the degree of ranking mobility or dynamic competition among the top K teams.
iii. The *Dynamic Concentration for Relegated Teams* (DC^I), which captures the third level and is interpreted as the degree of dynamic concentration of the I relegated teams or the degree of bi-dimensional competition for relegation.

iv. The *Special Dynamic Concentration* (SDC_K^I), which captures all three levels.

The weighting pattern offered by all new indices meets the criteria set in Section 4.1. However, we should point out that our claim is not that this weighing pattern is the optimal one, but rather that it provides a simple and plausible benchmark for the study of competitive balance in European football. Following the definition and the discussion of their properties, we suggest to further explore and compare the behaviour of the existing, modifying, and new indices. In the course of the next chapter, a sensitivity analysis is attempted through the implementation of all indices in various hypothetical leagues in terms of their competitive balance level. What is interesting about the sensitivity analysis is that it can illustrate differences and similarities among indices as well as unveil the aspects of competitive balance they capture.

Overview Table with New Indices of Competitive Balance

The derived function and a short description of all competitive balance indices that were introduced in the present chapter are presented in Table 5.4. It must be pointed out that all modified and new indices introduced in Chapters 3, 4, and 5 as well as the appropriate existing indices that were presented in Chapter 2 can be applied for a cross examination of competitive balance in European football across countries and/or seasons.

Table 5.4: New Between-seasons and Bi-dimensional Indices of Competitive Balance

	Index	Function	Description
Between-seasons	*Dynamic Index*	$DN_K = 1 - \frac{\sum_{i=1}^{K} r_i}{K(N-K)}$	The modified DN_t^* index is adapted so as to account for the degree of ranking mobility of the top *K* teams.
	Dynamic Index for the Champion	$DN_1 = 1 - \frac{r_1}{(N-1)}$	DN_K for K=1: captures the first level (the degree of the champion's ranking mobility).
	Adjusted Dynamic Index	$ADN_K = \frac{\sum_{i=1}^{K} DN_i}{K} = 1 - \frac{2}{K}\left[\sum_{i=1}^{K} w_i r_i\right]$	Average of the first K DN_i indices: captures the first two levels (the degree of ranking mobility of the top *K* teams as well as the degree of ranking mobility among the same teams).
	Dynamic Index for Relegated Teams	$DN^I = 1 - \frac{\sum_{i=N-I+1}^{N} r_i}{I(N-I)}$	DN_K is adapted to capture the third level (ranking mobility of the *I* relegated teams).
	Special Dynamic Index	$SDN_K^I = \frac{\sum_{i=1}^{K} DN_i + DN^I}{K+1}$	The ADN_K and DN^I are averaged in a single index: captures all three levels.
Bi-dimensional	*Dynamic Concentration for the Champion*	$DC_1 = \frac{P_1 - 2r_1}{4(N-1)}$	Average of NCR_1 and DN_1: captures the first level in both the seasonal and the between-seasons dimensions.
	Adjusted Dynamic Concentration	$ADC_K = \frac{1}{2K}\left[w_i \sum_{i=1}^{K}(P_i - 2r_i) - C_K\right] + \frac{1}{2}$	Average of ACR_K and ADN_K: captures the first and the second level in both the seasonal and the between-seasons dimensions.
	Dynamic Concentration for Relegated Teams	$DC^I = \frac{2N-I-1}{2(N-I)} - \frac{\sum_{i=N-I+1}^{N}(P_i + 2r_i)}{4I(N-I)}$	Average of NCR^I and DN^I: captures the third level in both the seasonal and the between-seasons dimensions.
	Special Dynamic Concentration	$SDC_K^I = \frac{SCR_K^I + SDN_K^I}{2}$	Average of SCR_K^I and SDN_K^I : captures all the three levels in both the seasonal and the between-seasons dimensions.

Chapter 6. Sensitivity Analysis

In the previous chapters, the theoretical foundation and the features of an extensive number of competitive balance indices was presented and discussed. The aim of this chapter is to illustrate the properties of the indices presented in Chapters 2-5. An in-depth exploration of the behaviour of these indices is illustrated via sensitivity analysis in various hypothetical leagues. This approach is quite innovative, since it employs extreme and selected scenarios of competitive balance and, thus, can illustrate differences and similarities in the behaviour of different competitive balance indices. The sensitivity analysis also assesses the behaviour of the indices to the three important levels in the league structure.

A systematic classification of all indices according to dimension, status of origin, and type is presented in the overview Table 6.1, as follows:

a) The dimension of competitive balance the index refers to. Therefore, the indices are classified as:
    i. Seasonal indices measuring the relative quality or strength of teams into a particular season.
    ii. Between-seasons indices measuring the relative quality of teams across seasons.
    iii. Bi-dimensional indices that capture both dimensions of competitive balance.
b) The status of the origin of the index. Consequently, the indices can be classified as:
    i. Existing indices appropriate for the study of European football.
    ii. Modified indices derived of existing ones adjusted for a proper cross examination across countries and/or seasons.
    iii. New indices developed to account for the multi-levelled structure of European football.
c) The type of the index, which is determined by the number of points on which it depends on the concentration or mobility curve. Based on this

classification, there are two types of indices: partial and summary ones[18] (Kamerschen & Lam, 1975). The former stands for those that depend on one or a few points while the latter for those that depend on all points in the concentration or mobility curve. Consequently, a partial index provides information either for one or for a few teams, whereas a summary index provides information for all the teams that make up the league.

Table 6.1: Overview Table of Competitive Balance Indices

Index	***Dimension***	***Status of Origin***	***Type***
$NAMSI$	Seasonal	Existing*	Summary
HHI^*		Existing*	
$AGINI$		Existing*	
AH		Modified**	
nID		Modified**	
nCB_{qual}		Modified**	
S		Modified**	
NCR_1		new†	Partial
NCR_K		Modified**	
NCR^I		New†	
ACR_K		New†	
SCR_K^I		New†	
τ	Between-seasons	Modified**	Summary
r_s		Modified**	
DN_t^*		Modified**	
DN_1		New†	Partial
DN_K		New†	
DN^I		New†	
ADN_K		New†	
SDN_K^I		New†	
aG		Modified**	
DC_1	Bi-dimensional	New†	Partial
ADC_K		New†	
DC^I		New†	
SDC_K^I		New†	

*The origin, the derived function, the unit of measurement, and a short description of the existing indices are presented in Table 2.10 (p.52) and Table 2.14 (p.69).
**The action followed for the derived function of the modified indices is presented in Table 3.6 (p.85).
†A short description and the derived function of the new indices are presented in Table 4.6 (p.109) and Table 5.4 (p.130).

[18] Similarly, Marfels (1971) classifies indices into discrete and summary ones.

Following the general description of the sensitivity analysis, a detailed presentation of the various scenarios by dimension is introduced and the results derived from the indices implementation are discussed. The chapter concludes with an overview table and the main conclusions derived from the analysis.

6.1 The Process for the Sensitivity Analysis

The sensitivity analysis followed serves to explore the behaviour of the indices from an initial to a final hypothetical state. The behaviour of the indices is determined by the indices fluctuation or sensitivity in the path from the initial to the final state. As an initial state, the cases of either perfectly balanced or completely unbalanced league is selected. On the other hand, the selection of the final state is based on the specific interest of the league. In particular, a final state could be either the opposite extreme case or any of the three important levels in the European football league structure.

This process allows us to a priori specify the hypothetical state and examine the behaviour of the indices under this known state. We focus on the examination of the seasonal and the between-seasons indices, whereas bi-dimensional indices are excluded from this particular study. However, the interpretation of the specific features of bi-dimensional indices can be easily deducted from the behaviour of their corresponding single-dimensional components. For the analysis, a 10-team league is selected, in which the first three qualify for European tournaments while the last two are relegated to the immediately lower league. A league with a small number of teams is selected simply for the sake of simplicity. Such a small league can be found in Norway (seasons from 1963-1971) and in Sweden (seasons 1991 & 1992). The steps followed in the various scenarios are presented algorithmically on the Appendix at the end of the chapter.

6.2 Sensitivity Analysis for the Seasonal Dimension

The selected initial state in the seasonal dimension is the case of either a perfectly balanced league, which is obtained when teams equally share wins and/or points, or a completely unbalanced league, which is obtained when teams always win against any weaker teams and lose from any stronger ones. With reference to the final state, what is selected is the opposite extreme case of competitive balance or any of the three important levels in European football. Additionally, based on the assumption that teams at the top and the bottom of the ladder are more important for the fans, the behaviour of the indices is also investigated concerning changes at the middle of the ladder. For the analysis, given the characteristics of the chosen league, the partial indices included in the simulation are defined as follows[19]:

a) NCR_1, which captures first level.
b) NCR_3, which captures the domination by the top three teams.
c) ACR_3, which captures first & second level.
d) NCR^2, which captures third level.
e) SCR_3^2, which captures all three levels.

6.2.1 Sensitivity Analysis for Changes in the Value of Competitive Balance

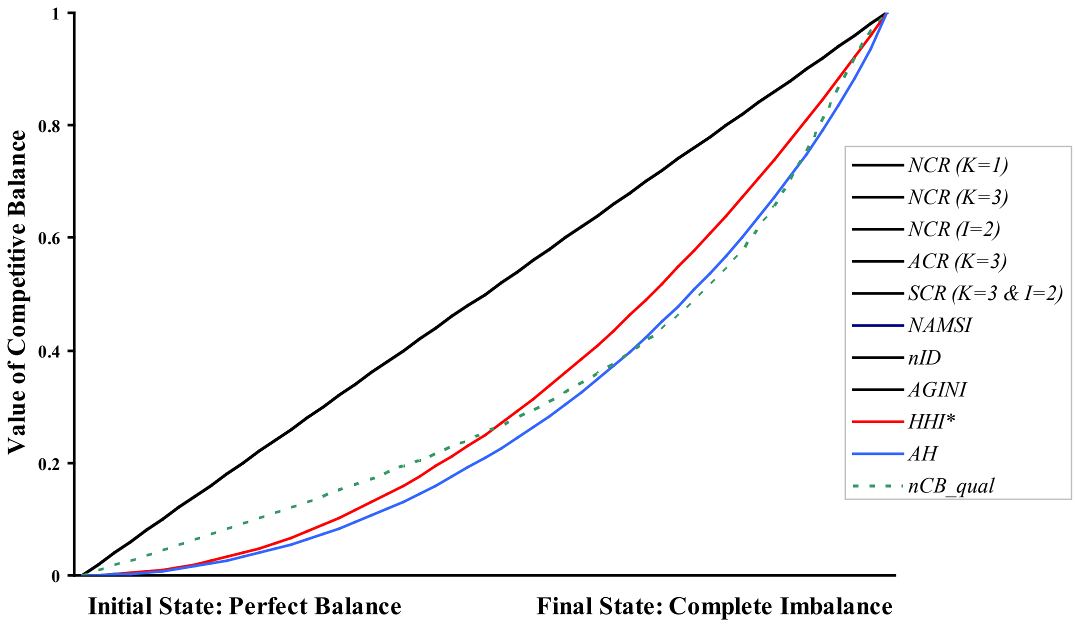
We can safely argue that an important aspect of the behaviour of the indices is their sensitivity to the relative value of a league's competitive balance. For this reason, we will study a hypothetical league, which gradually deviates from an initial perfectly balanced to a final completely unbalanced state. More specifically, differences and similarities will be designated based on fluctuation of the indices in their transition from one polar state to the other in terms of competitive balance value. Provided that initially there is an equal sharing of wins and/or points, teams at the upper half of the ladder progressively gather more wins and/or points, whereas teams at the bottom half of the ladder progressively lose equivalent number of wins and/or points. In the final state, the first team wins all games, the second team wins all games but those against the first and so on. The value of competitive balance indicated by the various indices in the course of the analysis is illustrated in Figure 6.1.

From this figure it can be confirmed that the two extreme cases of competitive balance are well defined for all indices. However, interesting observations can be drawn from the behaviour of the indices along the path from the initial to the final state. Based on their behaviour, indices may be distinguished into two groups. In

[19] The S index cannot be included, because it is not possible to calculate surprise points for the various scenarios.

particular, the summary indices *NAMSI*, *nID*, and *AGINI*, along with all partial indices are all highly sensitive to the value of competitive balance, which is indicated by the diagonal line.

Figure 6.1: Sensitivity to the Value of Competitive Balance



On the other hand, there is another group of indices (*HHI**, *AH* and nCB_{qual}) which are initially insensitive and, thus, understate competitive balance compared to the remaining indices. In particular, *AH* understates the value of competitive balance more than *HHI** while the behaviour of nCB_{qual} is more complicated. In effect, they all display the lowest relative values towards moderate intensity of competitive balance. Close to the final state, those three indices become hypersensitive at an increasing rate. This feature may be viewed as desirable, since our main concern is for an unbalanced league or for high values of competitive balance.

The behaviour of the indices can be explained by examining the weight attached to each team in the calculation of each index. In particular, for the first group of indices the weight is as follows:

a) *nID*: there is not attached any weight to the teams.
b) *AGINI*: the attached weight depends on the ranking of the teams.
c) Partial indices: the attached weight remains constant for the whole process.

d) *NAMSI*: the attached weight changes symmetrically for teams at the upper and bottom half of the ladder.

On the other hand, the behaviour of the second group of indices is attributed to their design. The common feature of those indices is that more weight is attached to the top ranking teams, which also changes in the course of the simulation. In fact, the weight gradually increases according to the level of team's performance. Based on the review in Chapter 2, *HHI** gives a quadratic weight, which is advantageous for the top teams, and, thus, when those teams gather many wins the index sharply increases. As far as *AH* and nCB_{qual} are concerned, the explanation for the former relates to its logarithmic base while for the latter to the non-linear weight derived from its quite complicated calculation[20].

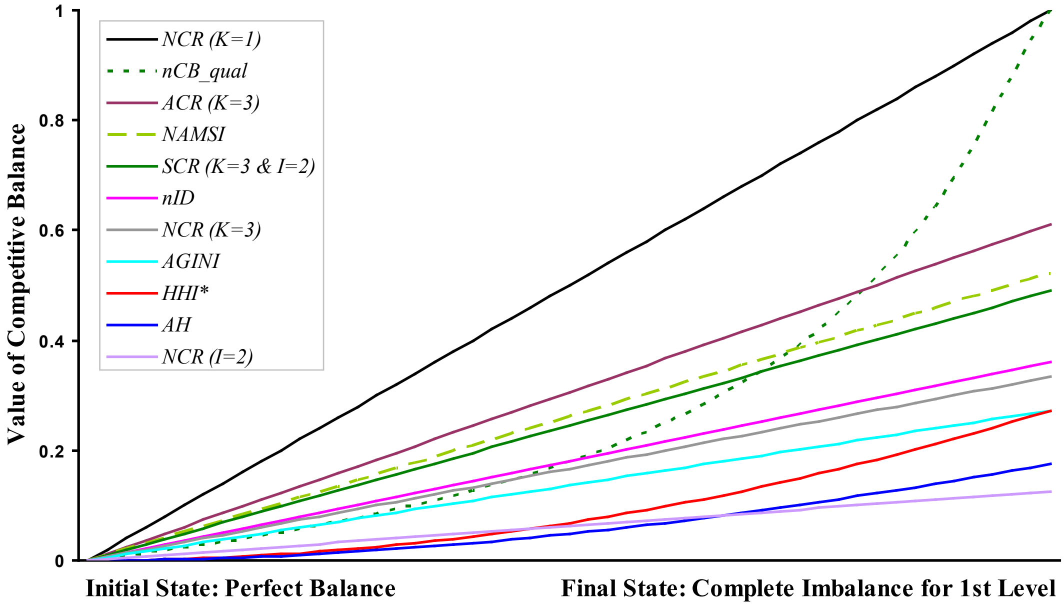
6.2.2 Sensitivity Analysis for Changes in the First Level

Another important aspect is the sensitivity of the indices in relation to the champion's domination or the competition for the first level in the league. In order to demonstrate this, we employed for our analysis a league in which the champion gradually deviates from an initial perfectly balanced state to a final state which is completely dominated by the champion. For clarification, initially all teams equally share wins and/or points, whereas in the final state the champion has only wins while the remaining teams share the remaining wins and/or points.

The fluctuation of the indices is illustrated in Figure 6.2. As it is expected, NCR_1 displays the greatest sensitivity to the champion's domination, given that it is especially designed for the first level. Interestingly enough, nCB_{qual} also finally reaches the highest sensitivity, although it exhibits insensitivity in the path from the initial to the final state. This conforms to the behaviour of nCB_{qual} in the previous analysis. As it is anticipated, ACR_3 is more sensitive than $NCR_{3,}$ since it weights the champion heavily while SCR_3^2 exhibits moderate sensitivity. With reference to the summary indices of dispersion, *NAMSI* and *nID* demonstrate moderate and low sensitivity respectively.

[20] Kwoka (1985), shows that the weights the *H* attaches to teams' winning share decrease as the winning share increases.

Figure 6.2: Sensitivity to the First Level



It is worth mentioning that *AGINI* and *HHI** reach the same height of sensitivity in the final state. The reason relates to the fact that, even though those two indices are seemingly quite different in design, they are reported to be correlated in the literature (Adelman, 1969; Kamerschen & Lam, 1975; Kendall & Stuart, 1963).

However, it must be noted that they follow a different increasing pattern; *HHI** follows a concave pattern whereas *AGINI* follows a linear trend, which is explained by the ranking weighting scheme attached to the winning percentage of the teams. *AH* demonstrates low sensitivity which, as expected, is also exhibited in a concave mode. Lastly, NCR^2 is the least sensitive index, given that it is especially developed to capture the degree of the teams' weakness at the bottom of the ladder. The corresponding values of competitive balance for all indices in the final state are presented in Table 6.2. Essentially, those values quantify the sensitivity of the indices to the first level or the champion's domination.

6.2.3 Sensitivity Analysis for Changes in the Second Level

In what follows, we will examine the sensitivity of the indices to the second level. More specifically, since there are three qualifying teams in European tournaments, the interest is in the behaviour of the indices to changes in the second level defined by the two following aspects:

Table 6.2: Sensitivity to the First Level

Index	*Sensitivity Value*
NCR_1	1.000
nCB_{qual}	1.000
ACR_3	0.611
$NAMSI$	0.522
SCR_3^2	0.489
nID	0.360
NCR_3	0.333
$AGINI$	0.273
HHI^*	0.273
AH	0.176
NCR^2	0.125

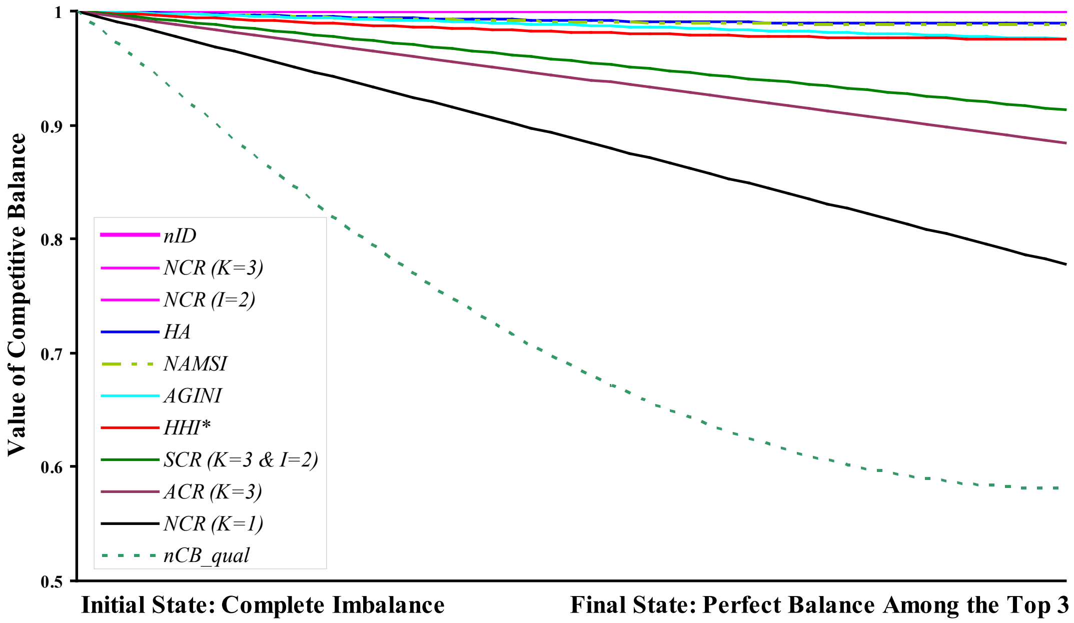
a) The domination by the top three teams.

b) The competition among the top three teams.

Essentially, the behaviour of the indices relating to the first aspect (the domination by the top three teams) is similar to that of the champion's domination (first level); thus, conclusions and observations in relation to that are comparable to those regarding the analysis in the previous analysis. With concern to the second aspect, we designed a hypothetical league, in which what changes is only the competitiveness among the top three teams. Initially, the league is in a completely unbalanced state. The top three teams gradually turn to perfect balance among them, that is, they equally share wins and/or points. It must be pointed out that in the course of this scenario the condition for the remaining teams remains unchanged.

The behaviour of the indices with regard to changes in the competitiveness among the top three teams is illustrated in Figure 6.3. It can be easily drawn that the summary nCB_{qual} index exhibits the highest sensitivity, even though that is at a decreasing rate. Similarly, the partial NCR_1 and ACR_3 indices exhibit moderate to high sensitivity, whereas the more sophisticated partial SCR_3^2 displays low to moderate sensitivity. The behaviour of those partial indices is explained by their design. As it is expected, the partial NCR^2 index shows no sensitivity, since it focuses only on the last two teams. In the same vein, NCR_3 is also insensitive, which is justified by its design that captures only the domination of the top three teams.

Figure 6.3: Sensitivity to the Competition among the Top Three Teams



All of the remaining summary indices display very low to zero sensitivity. In particular, *AGINI* and *HHI** display a similar low sensitivity in a slightly different path. Additionally, *NAMSI* and *AH* both demonstrate negligible levels of sensitivity. Lastly, *nID* shows zero sensitivity, which is a quite undesirable feature provided that the competition among the top three teams is important for the fans. The behaviour of *nID* is justifiable as it equally rates the teams' winning share. The sensitivity quantified by the respective value of competitive balance in the final state is presented in Table 6.3**.**

Table 6.3: Sensitivity to the Competition among the Top Three Teams

Index	*Sensitivity Value*
nCB_{qual}	0.419
NCR_1	0.222
ACR_3	0.116
SCR_3^2	0.087
HHI^*	0.024
AGINI	0.024
NAMSI	0.012
AH	0.011
nID	0
NCR_3	0
NCR^2	0

6.2.4 Sensitivity Analysis for Changes in the Third Level

Another important aspect of the indices is their ability to capture the third level or set of punishment. Due to the promotion-relegation rule, the last ranking teams are relegated to the immediate lower division. Consequently, what is of concern is the sensitivity of the indices to the third level, which is defined as the degree of weakness of the relegated teams. For that reason, the sensitivity analysis is designed as follows: the hypothetical league is initially in a perfectly balanced state, in which all teams equally share wins and/or points. Progressively, the two relegated teams lose their competitiveness, whereas the remaining teams continue sharing the remaining wins and/or points. In the final state, the relative weakness of the relegated teams reaches its maximum, that is, they gather wins and/or points only from the other relegated teams.

The fluctuation of the indices is illustrated in Figure 6.4. As is expected, the most sensitive index is NCR^2, which is especially designed to capture the third level or the weakness of the last two teams. Additionally, *NAMSI* and *nID* also demonstrate high sensitivity, which is explained by the nature of the indices which treat equally teams at the top and at the bottom of the ladder. *AH* is initially quite insensitive changing to highly-sensitive. Following a similar pattern, *HHI** presents low to moderate sensitivity in the path from the initial to the final state. Additionally, *AGINI* and SCR_4^2 display moderate sensitivity in a linear fashion. As it is expected, the partial indices NCR_1, NCR_3, and ACR_3, given that they focus on the top teams, they demonstrate very low sensitivity. Lastly, nCB_{qual} is the least sensitive index, which is in sharp contrast to its behaviour with regard to the domination by the top teams. The sensitivity of all indices to the third level is presented in Table 6.4.

6.2.5 Sensitivity Analysis for Changes in the Middle Ranking Places

In the context of European football, the interest mainly lies in the top places (first and second level) and the bottom places (third level). Therefore, it is reasonable to investigate the sensitivity of the indices to changes in the middle ranking positions. In that case, a hyper sensitivity is considered as undesirable. For the purposes of this analysis, we designed a hypothetical league which is initially in a completely unbalanced state.

Figure 6.4: Sensitivity to the Third Level

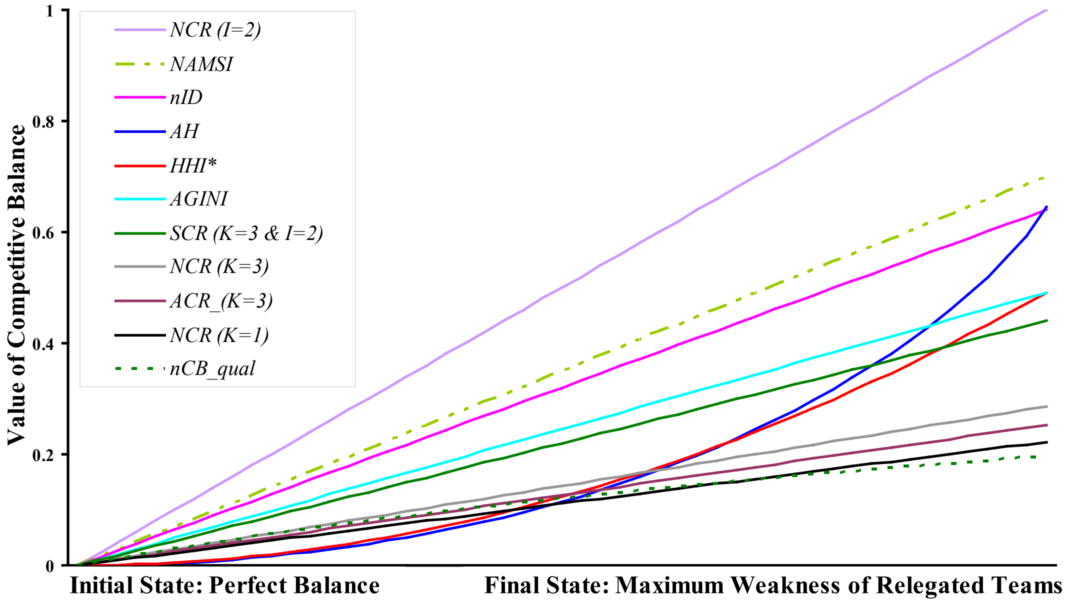


Table 6.4: Sensitivity to the Third Level

Index	*Sensitivity Value*
NCR^2	1.000
NAMSI	0.701
AH	0.644
nID	0.640
AGINI	0.491
*HHI**	0.491
SCR_3^2	0.439
NCR_3	0.286
ACR_3	0.260
NCR_1	0.222
nCB_{qual}	0.197

In this scenario, what changes is only the performance of the teams in the middle of the ladder (from fourth to eighth position). Actually, those teams gradually turn to a perfectly balanced state, that is, they equally share wins and/or points. The performance of teams at the top and the bottom of the ladder remains unchanged.

The fluctuation of the indices during the sensitivity analysis is illustrated in Figure 6.5. All partial indices are insensitive to changes in the middle. With reference to the summary indices, nCB_{qual} is the least sensitive. *NAMSI* also demonstrates very low sensitivity, which is justified since it is essentially an index of standard deviation and, therefore, focuses on teams at the top and the bottom of the ladder. Low sensitivity in a slightly variant fashion is also demonstrated by the *AH*, *HHI**, and *AGINI* indices. This behaviour is explained by the emphasis given to the top ranking places. Lastly, *nID* shows a hyper-sensitivity, which is a quite undesirable feature and is explained by the fact that the index weights all positions equally. The values of the indices in the final state are presented in Table 6.5.

Figure 6.5: Sensitivity to Changes in the Middle Ranking Places

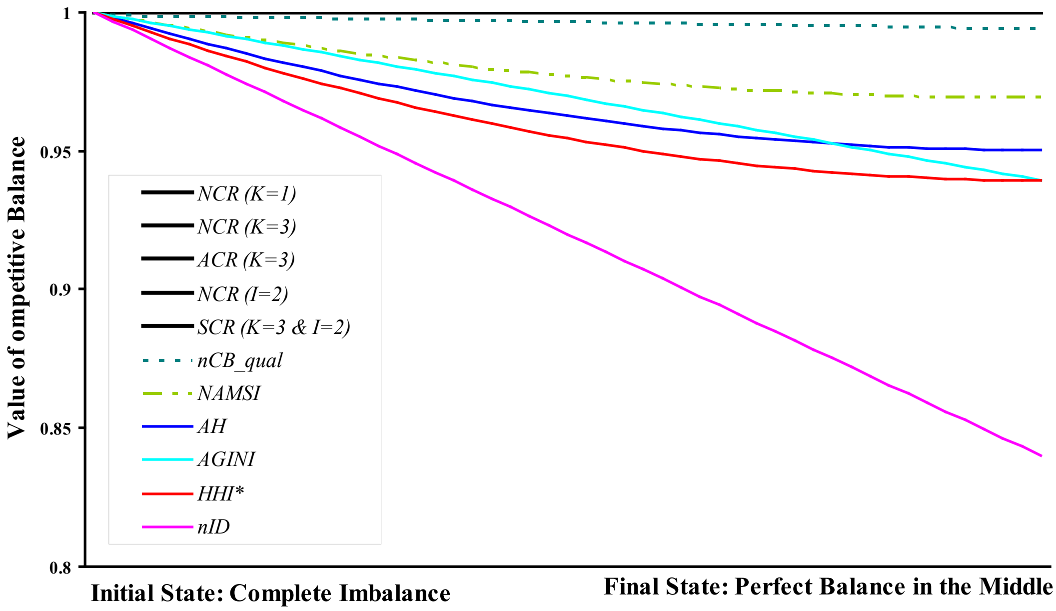


Table 6.5: Sensitivity to Changes in the Middle

Index	*Sensitivity Value*
nID	0.160
*HHI**	0.061
AGINI	0.061
AH	0.050
NAMSI	0.031
nCB_{qual}	0.006
NCR_1	0
NCR_3	0
NCR^2	0
ACR_3	0
SCR_3^2	0

6.3 Sensitivity Analysis for the Between-Seasons Dimension

Following the analysis for the seasonal dimension, we will discuss the process for the between-seasons dimension, which deals with the ranking mobility of teams across seasons. Either a completely unbalanced or a perfectly balanced league is selected as the initial state.

Regarding the sensitivity analysis, the interest primarily lies in the responsiveness of the indices to the first, second, and third levels respectively. The time frame is two adjacent seasons; consequently, aG index is excluded since for its study a large number of seasons is required. For the purposes of the analysis, given the structure of the chosen league, the included partial indices are the following:

a) DN_1 which captures first level.
b) DN_3 which captures the dynamic domination by the top three teams.
c) ADN_3 which captures first & second level.
d) DN^2 which captures third level.
e) SDN_3^2 which captures all three levels.

6.3.1 Sensitivity Analysis for Changes in the First Level

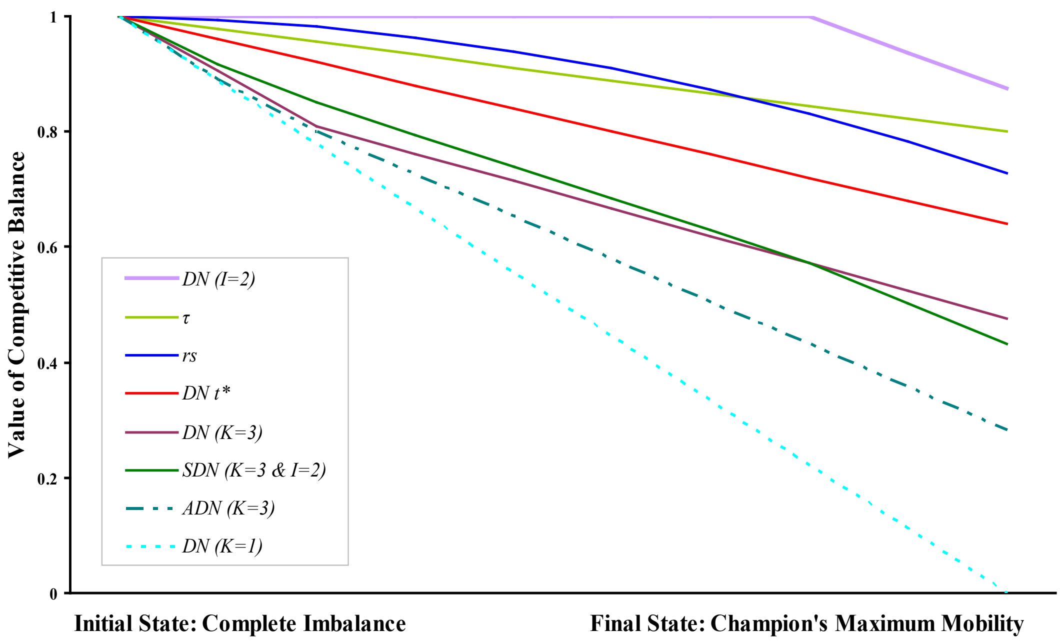
An important aspect of the behaviour of the indices is their sensitivity to the first level or the champion's mobility. For that reason, we have produced a scenario in which the champion progressively moves from the first (initial state) to the last ranking place (final state). The relative ranking position of the remaining teams does not change. Initially, the hypothetical league is in a completely unbalanced state, that is, ranking mobility is absent. In the final state, given that the champion moves to the last place, the second team moves to the first place, the third to the second place and so on. Essentially, during this particular sensitivity analysis, ranking mobility, which reaches its maximum, concerns only the champion. For clarification, the mobility of all teams is presented Table 6.6.

The behaviour of the indices from the initial to the final state is demonstrated in Figure 6.6. As it is expected, DN_1 is the most sensitive index, which confirms the fact that it effectively captures the champion's mobility. The partial indices ADN_3, DN_3, and SDN_3^2 all exhibit lower sensitivity given that they provide information from a larger number of teams. Additionally, DN^2 shows no sensitivity until the very last part of the hypothetical scenario, in which the top team moves to the last two ranking places.

Table 6.6: Ranking Mobility for the First Level

R	*Teams*	*Initial State*	*Final State*
1	A	**A**	B
2	B	B	C
3	C	C	D
4	D	D	E
5	E	E	F
6	F	F	G
7	G	G	H
8	H	H	I
9	I	I	J
10	J	J	**A**

Figure 6.6: Sensitivity to the First Level



On the other hand, it is interesting to examine the behaviour of the summary indices. More specifically, the r_s and τ indices display low sensitivity, whereas DN_t^* displays moderate sensitivity. This behaviour is explained by the fact that summary indices take into consideration the ranking mobility of all teams and not only that of the top team. Differences among summary indices are accounted for by their design emphasising the fluctuation in a concave fashion of the r_s index. The sensitivity to the first level for all the between-seasons indices is presented in Table 6.7.

Table 6.7: Sensitivity to the First Level

Index	*Sensitivity Value*
DN_1	1.000
ADN_3	0.716
SDN_3^2	0.568
DN_3	0.534
DN_t^*	0.360
r_s	0.278
τ	0.200
DN^2	0.125

6.3.2 Sensitivity Analysis for Changes in the Second Level

In view of the fact that the second level is also important for European football, the sensitivity of the indices to the mobility of the top K teams has also been investigated. As long as three teams qualify for European tournaments, the focus is on the sensitivity of the indices with regard to the following two aspects of the second level:

a) The ranking mobility or dynamic domination by the top three teams.
b) The ranking mobility or dynamic competition among the top three teams.

The behaviour of the indices for the first aspect is identical with the champion's domination; thus, conclusions are comparable to those regarding the analysis for the first level. With respect to the second aspect, we have produced a scenario in which there is ranking mobility only among the top three teams. Initially, the league is in a completely unbalanced state without any mobility. Progressively, the ranking changes only for the top three positions, so that the first team withdraws to the third position while the third team advances to the first one. Essentially, the simulation analysis is composed by three steps described in Table 6.8. In this scenario, the ranking for teams below the fourth place remains unchanged.

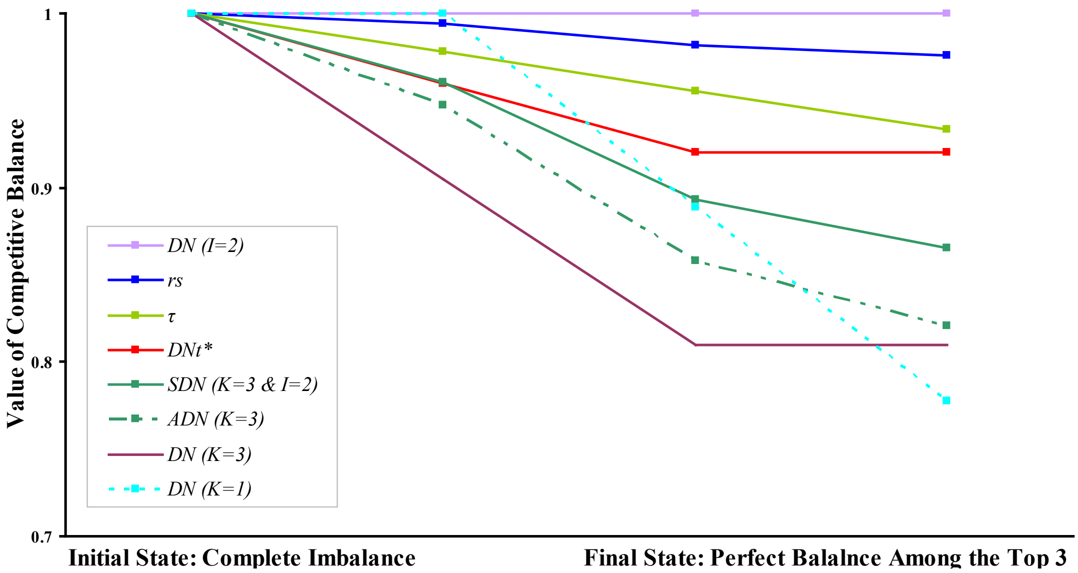
The fluctuation of the indices is illustrated in Figure 6.7. Regarding the summary indices, the least sensitive is r_s, the most sensitive is DN_t^*, and τ lies in the middle.

What is also observed is that DN_t^* remains unchanged during the third step. Similarly, the DN_1 and DN_3 indices also remain unchanged in the first and third step respectively. Essentially, this behaviour unveils a deficiency which refers to DN_t^* and the derived partial indices. That deficiency stems from the nature of those indices, that is, their calculation is based on the summation of an absolute ranking difference. However, this deficiency is restored by the utilisation of ADN_3 and SDN_3^2 whose sensitivity is exhibited throughout the different simulating steps, as a result of their more sophisticated design.

Table 6.8: Mobility of the Top Three Teams

R	*Teams*	*Initial State*	*First Step*	*Second Step*	*Final State*
1	A	**A**	**A**	**C**	**C**
2	B	**B**	**C**	**A**	**B**
3	C	**C**	**B**	**B**	**A**
4	D	D	D	D	D
5	E	E	E	E	E
6	F	F	F	F	F
7	G	G	G	G	G
8	H	H	H	H	H
9	I	I	I	I	I
10	J	J	J	J	J

Figure 6.7: Sensitivity to the Level of Ranking Mobility among the Top Three Teams



Moreover, the overall sensitivity of the partial indices is justified by their design. In particular, DN_1, DN_3, and ADN_3 are, in order of sensitivity, the most sensitive indices, whereas SDN_3^2 displays lower sensitivity, since it also captures the ranking mobility at the bottom of the ladder. Lastly, as it is expected, DN^2 is insensitive to the second level as it refers only to the ranking mobility of the relegated teams. The values of all indices in the current analysis are presented in Table 6.9.

Table 6.9: Sensitivity to the Ranking Mobility among the Top Three Teams

Index	*Sensitivity Value*
DN_1	0.222
DN_3	0.190
ADN_3	0.179
SDN_3^2	0.134
DN_t^*	0.080
τ	0.067
r_s	0.024
DN^2	0

6.3.3 Sensitivity Analysis for Changes in the Third Level

In what follows, we investigate the ability of the indices to capture the third level (relegated teams). As was already noted, due to the promotion-relegation rule, the mobility at the bottom of the ladder is also interesting and important for the fans. In order to capture the sensitivity of the indices to the third level, we have generated a series of hypothetical leagues where the promoted team gradually advances from the last (initial state) to the first place (final state)[21]. In this scenario, the relative ranking position of the remaining teams stays unchanged. Initially, the league is completely unbalanced without any mobility; thus, the promoted team returns to the lower division the following season. In the final state, given that the last team advances to the first place, the champion withdraws to the second place, the second team withdraws to the third place and so on. For illustration purposes, the ranking mobility of all teams is presented in Table 6.10.

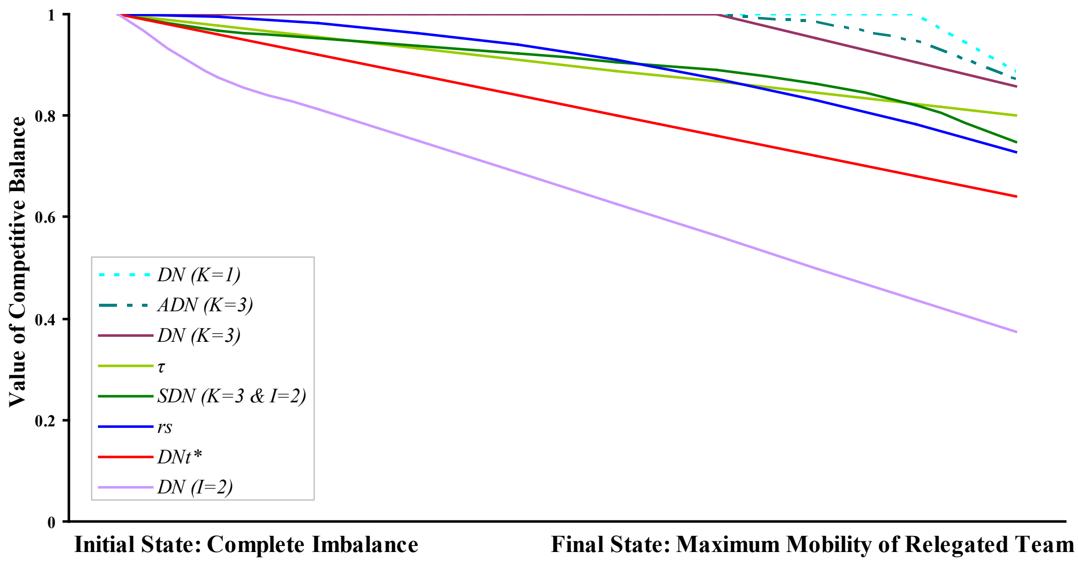
[21] According to the adopted compromise, the ranking position of the relegated teams is conveyed to the promoted ones. For the sake of simplicity only one promoted/relegated team is selected.

Table 6.10: Mobility of the Promoted/Relegated Team to the First Place

R	*Teams*	*Initial State*	*Final State*
1	A	**A**	J
2	B	B	**A**
3	C	C	B
4	D	D	C
5	E	E	D
6	F	F	E
7	G	G	F
8	H	H	G
9	I	I	H
10	J	J	I

The behaviour of the indices is depicted in Figure 6.8. As expected, DN^2 is the most sensitive index, since it captures the mobility of the relegated teams. On the contrary, the indices DN_1, ADN_3, and DN_3 demonstrate the lowest sensitivity. In effect, those indices are insensitive until the promoted team advances to the top places. As an exception to partial indices, SDN_3^2 presents moderate to low sensitivity. This attribute is justified by the ability of the index to capture the mobility both at the top and the bottom of the ladder.

Figure 6.8: Sensitivity to the Third Level



Interestingly enough, all summary indices (DN_t^*, r_s, τ) exhibit an identical behaviour to that of the first level sensitivity analysis, that is, when the champion progressively withdraws from the first to the last ranking place. This feature is explained by the fact that those indices equally rate all ranking positions. Consequently, DN_t^* displays moderate sensitivity, whereas the statistical indices r_s and τ display moderate to low sensitivity. For purposes of elucidation, the sensitivity of all indices in the final state of the current analysis is presented in Table 6.11.

Table 6.11: Sensitivity to the Third Level

Index	*Sensitivity Value*
DN^2	0.625
DN_t^*	0.360
r_s	0.273
SDN_3^2	0.251
τ	0.200
DN_3	0.143
ADN_3	0.126
DN_1	0.111

6.4 Conclusion

This chapter, which answers the fourth issue of the thesis, offered an innovative approach to an enhanced exploration of the main features of the indices by performing extensive sensitivity analyses over various hypothetical leagues with different states of competitive balance. For a reliable quantification, it is important to distinguish the aspects of competitive balance each index embodies. Based on the results of the different sensitivity analyses, the indices exhibit diverse behaviour, which illustrates the different aspects of competitive balance they capture. The main positive and negative features of the indices in the context of the European football league structure are presented in the overview Table 6.12. Most observations are justified by the design of each particular index, although the analysis unveils features that are not easily distinguishable.

More specifically, the behaviour of the summary indices could not be easily detected without the sensitivity analysis presented here. For instance, both the particular sensitivity of the nCB_{qual} index to the champion's domination and its unresponsiveness to the third level were not identifiable from its definition.

Similarly, what is interesting is the low sensitivity of HHI^*, *AGINI*, and *AH* both to the champion's domination and the competition among the top K teams. On the other hand, the behaviour of the partial indices is relatively straightforward. For instance, the high and low sensitivity of NCR_1 to the first and the third levels respectively is to be expected.

The fact that the comprehensive SCR_K^I and SDN_K^I have only a small number of negative features suggests that they may be the most suitable indices to measure the seasonal and the between-seasons dimension of competitive balance respectively. Given that the behaviour of the bi-dimensional indices is derived from their corresponding components (single-dimensional indices), what is also implied is that the bi-dimensional comprehensive SDC_K^I could be an optimal index for the study of competitive balance in European football. Therefore, the weighting pattern offered by the averaging approach followed for the design of SDC_K^I is suggested as a plausible benchmark for the study of competitive balance in European football.

After clarifying the key properties of the indices, what is recommended is their empirical investigation in European football. For this reason, in the next chapter, we will present an empirical study, which involves various European football leagues for an extensive period to further illustrate the behaviour of the indices by means of a cross examination across countries and/or seasons.

Table 6.12a: Main Features of the Seasonal Indices Based on the Sensitivity Analysis

	Index	Positive	Negative
Summary	*NAMSI*	‣ Moderate sensitivity to the champion's domination (Section 6.2.2). ‣ High sensitivity to the third level (Section 6.2.4). ‣ Very low sensitivity to changes in the middle ranking places (Section 6.2.5).	‣ Negligible sensitivity to the competition among the top *K* teams (Section 6.2.3).
	HHI^*	‣ Insensitive to low values of competitive balance (Section 6.2.1). ‣ Moderate-low sensitivity to the third level (Section 6.2.4). ‣ Low sensitivity to changes in the middle ranking places (Section 6.2.5).	‣ Low sensitivity to the champion's domination (Section 6.2.2). ‣ Low sensitivity to the competition among the top *K* teams (Section 6.2.3).
	AGINI	‣ Moderate sensitivity to the third level (Section 6.2.4). ‣ Low sensitivity to changes in the middle ranking places (Section 6.2.5).	‣ Low sensitivity to the champion's domination (Section 6.2.2). ‣ Low sensitivity to the competition among the top *K* teams (Section 6.2.3).
	AH	‣ Insensitive to low values of competitive balance (Section 6.2.1). ‣ High sensitivity to the third level (Section 6.2.4). ‣ Low sensitivity to changes in the middle ranking places (Section 6.2.5).	‣ Low sensitivity to the champion's domination (Section 6.2.2). ‣ Negligible sensitivity to the competition among the top *K* teams (Section 6.2.3).
	nID	‣ High sensitivity to the third level (Section 6.2.4).	‣ Low sensitivity to the champion's domination (Section 6.2.2). ‣ Insensitive to the competition among the top *K* teams (Section 6.2.3). ‣ Moderate-low sensitivity to the champion's domination (Section 6.2.2). ‣ Moderate sensitivity to changes in the middle ranking places (Section 6.2.5).
	nCB_{qual}	‣ Insensitive to low values of competitive balance (Section 6.2.1). ‣ Negligible sensitivity to changes in the middle ranking places (Section 6.2.5). ‣ High sensitivity to first & second level (Section 6.2.2 & Section 6.2.3).	‣ Low sensitivity to the third level (Section 6.2.4).
Partial	NCR_1	‣ Highest sensitivity to the champion's domination (Section 6.2.2). ‣ Moderate sensitivity to the competition among the top *K* teams (Section 6.2.3). ‣ Insensitive to changes in the middle ranking places (Section 6.2.5).	‣ Low sensitivity to the third level (Section 6.2.4).
	NCR_K	‣ Insensitive to changes in the middle ranking places (Section 6.2.5).	‣ Moderate-low sensitivity to the champion's domination (Section 6.2.2). ‣ Insensitive to the competition among the top *K* teams (Section 6.2.3). ‣ Low sensitivity to the third level (Section 6.2.4).
	NCR^I	‣ Highest sensitivity to the third level (Section 6.2.4). ‣ Insensitive to changes in the middle ranking places (Section 6.2.5).	‣ Low sensitivity to the champion's domination (Section 6.2.2). ‣ Insensitive to the competition among the top *K* teams (Section 6.2.3).
	ACR_K	‣ High sensitivity to the champion's domination (Section 6.2.2). ‣ Moderate sensitivity to the competition among the top *K* teams (Section 6.2.3). ‣ Insensitive to changes in the middle ranking places (Section 6.2.5).	‣ Low sensitivity to the third level (Section 6.2.4).
	SCR_K^I	‣ Moderate sensitivity to the champion's domination (Section 6.2.2). ‣ Moderate sensitivity to the third level (Section 6.2.4). ‣ Insensitive to the changes in the middle ranking places (Section 6.2.5).	‣ Low-moderate sensitivity to the competition among the top K teams (Section 6.2.3).

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

Table 6.12b: Main Features of the Between-seasons Indices Based on the Sensitivity Analysis

	Index	Positive	Negative
Summary	τ	‣ Moderate-low sensitivity to third level (Section 6.3.3).	‣ Low sensitivity to the champion's ranking mobility (Section 6.3.1). ‣ Very low sensitivity to the ranking mobility among the top K teams (Section 6.3.2).
	r_s	‣ Moderate-low sensitivity to third level (Section 6.3.3).	‣ Low sensitivity to the champion's ranking mobility (Section 6.3.1). ‣ Very low sensitivity to the ranking mobility among the top K teams (Section 6.3.2).
	DN_t^*	‣ Moderate sensitivity to the champion's ranking mobility. ‣ Moderate sensitivity to third level (Section 6.3.3).	‣ Low sensitivity to the ranking mobility among the top K teams (Section 6.3.2).
Partial	DN_1	‣ Highest sensitivity to the champion's ranking mobility (Section 6.3.1). ‣ Moderate sensitivity to the ranking mobility among the top K teams (Section 6.3.2).	‣ Very low-no sensitivity to third level (Section 6.3.3).
	DN_K	‣ Moderate sensitivity to the champion's ranking mobility (Section 6.3.1). ‣ Moderate-low sensitivity to the ranking mobility among the top K teams (Section 6.3.2).	‣ Very low-no sensitivity to third level (Section 6.3.3).
	DN^I	‣ Highest sensitivity to third level.	‣ Insensitive to first & second level (Section 6.3.1 and Section 6.3.2).
	ADN_K	‣ High sensitivity to the champion's ranking mobility (Section 6.3.1). ‣ Moderate-low sensitivity to the ranking mobility among the top K teams (Section 6.3.2).	‣ Very low-no sensitivity to third level (Section 6.3.3).
	SDN_K^I	‣ Moderate sensitivity to the champion's ranking mobility (Section 6.3.1). ‣ Moderate sensitivity to the ranking mobility among the top K teams (Section 6.3.2). ‣ Moderate-low sensitivity to third level (Section 6.3.3).	

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).
The properties of the bi-dimensional indices is derived from their corresponding single-dimensional components.

Appendix of Chapter 6

The scenarios followed for the sensitivity analysis are presented in algorithmic steps. For illustration purposes, there are 50 incremental steps implemented from the initial to the final state. It is selected a 10-team league in which the first three qualify for European tournaments while the last two are relegated to the immediate lower league.

Table 6.13: Algorithmic Steps for the Scenario in Section 6.2.1

Sensitivity Analysis for Changes in the Value of Competitive Balance		
Initial State	Perfect balance: all teams equally share the number of wins	Every team has 18 points
50 steps	Teams at the upper half progressively gather the required number of wins for the transition to complete imbalance. Similarly, teams on the bottom half lose the equivalent number of wins	In each incremental step, the first team gather (max – 18)/50=(36-18)/50=0.36 additional points, the second team (32-18)/50=0.28 and so on. The last and the second but the last teams lose 0.36 and 0.28 points respectively.
Final State	Complete Imbalance: The first team wins all games, the second team wins all games but those against the first and so on	The first team has 36 points, the second 32, the third 28, and so down to the last team with no points.

Table 6.14: Algorithmic Steps for the Scenario in Section 6.2.2

Sensitivity Analysis for Changes in the First Level		
Initial State	Perfect balance: all teams equally share the number of wins	Every team has 18 points
50 steps	The first team progressively gather the required number of wins for the transition to the complete domination. The remaining teams progressively lose their games against the champion.	In each incremental step, the first team gather (max – 18)/50=(36-18)/50=0.36 additional points. Given that they lose all games against the champion, each of the remaining teams lose 2/50=0.04 points.
Final State	Completely dominated by the champion league: The first team wins all games, the remaining teams share the remaining number of wins.	The first team has 36 points whereas each of the remaining teams has 16 points.

Table 6.15: Algorithmic Steps for the Scenario in Section 6.2.3

Sensitivity Analysis for Changes in the Second Level		
Initial State	Complete Imbalance: The first team wins all games, the second team wins all games but those against the first and so on.	The first team has 36 points, the second 32, the third 28, and so down to the last team with no points.
50 steps	The first team progressively lose the required number of wins for the transition to the perfect balance among the top three. Similarly, the third team progressively gather the equivalent number of wins. The number of wins for the second and all teams after the third place remains unchanged.	In each incremental step, the first team lose (max – 32)/50=(36-32)/50=0.08 points whereas the third team gather 0.08 additional points.
Final State	Perfect balance among the top three teams and complete imbalance after the third place.	Each of the first three teams has 32 points. The number of points for the remaining teams remains unchanged.

Table 6.16: Algorithmic Steps for the Scenario in Section 6.2.4

Sensitivity Analysis for Changes in the Third Level		
Initial State	Perfect balance: all teams equally share the number of wins.	Every team has 18 points
50 steps	The last two (relegated) teams progressively lose the required number of wins for the transition to the complete imbalance for relegation. The remaining teams progressively win all games against the two relegated teams.	In each incremental step, the last team lose (18-min)/50=18/50=0.36 points and the second but the last team lose (18- 4)/50=0.28 points. Given that they win all games against the relegated teams, each of the remaining teams gather (0.36 + 0.28)/8=0.08 additional points.
Final State	Complete imbalance for relegation and perfect balance among the remaining teams.	Each of the first eight teams has 22 points, the second but the last has 4 points, and the last team has no points.

Table 6.17: Algorithmic Steps for the Scenario in Section 6.2.5

Sensitivity Analysis for Changes in the Middle Ranking Places		
Initial State	Complete Imbalance: The first team wins all games, the second team wins all games but those against the first and so on.	The first team has 36 points, the second 32, the third 28, and so down to the last team with no points.
50 steps	The fourth and fifth teams progressively lose the required number of wins for the transition to the perfect balance among the teams in middle ranking places. Similarly, the sixth and seventh teams progressively gather the equivalent number of wins. The number of wins for the top and bottom three teams remains unchanged.	In each incremental step, the fourth team lose (max – 18)/50=(24-18)/50=0.12 points and the fifth teams lose (20-18)/50=0.04 points. Sixth, seventh, and eighth teams gather 0.04, 0.012, and 0.2 points respectively.
Final State	Complete imbalance for the top and bottom three teams and perfect balance among the teams in middle of the ladder.	The top three teams have 36, 32, and 28 points respectively. Each of the teams in the middle has 18 points. The last three teams have 8, 4, and 0 points respectively.

Chapter 7. Empirical Measurement of Competitive Balance in European Football

Following our discussion for the sensitivity analysis, we now proceed to an empirical investigation of eight European football leagues for the last 45-50 seasons. This study in combination with the sensitivity analysis provides a powerful guidance and standardization about the practical issues of the competitive balance indices. More specifically, the sensitivity analysis, using various hypothetical competitive balance scenarios, reveals interesting facts and properties about the main features of the related indices. The empirical investigation, using real data from various domestic leagues, may further elucidate the key points by exploring the value and the trend of the indices both in Europe and country-wise. There is a limited number of empirical studies of competitive balance across European football leagues (e.g., Goossens, 2006; Haan et al., 2002; Michie & Oughton, 2004, 2005a, 2005b), which renders the current analysis particularly useful.

The results of any empirical study are reinforced by the size of the sample. Since the objective is this study is the examination of competitive balance in European football, we have included cross sectional data from various football leagues over an extensive period of time. Consequently, using various statistical methods, the empirical investigation enables a comparison across countries and seasons while a special attention is given to Greece.

The presentation of the empirical results is organised in seven sub-sections. Subsequent to the discussion of data and measurement issues, the value and then the variability of competitive balance is investigated both in Europe and country-wise using various descriptive statistics and ranking results for all indices, which is followed by a cross examination of the three important levels in the multi-prized structure of European football. A trend and cluster analysis of the comprehensive indices that capture all levels may further elucidate the characteristics and the overall competitive balance in Europe. This is followed by a correlation analysis which explores similarities and differences among the indices. Lastly, the concluding remarks are presented in the final section of the present chapter.

7.1 Data and Measurement Issues

As presented in Table 7.1, the collected data concerns eight European countries[22].

Table 7.1: Dataset

Country	*Starting season*	*Ending season*	*Total seasons*
Belgium (BEL)	1966	2008	43
England (ENG)	1959	2008	50
France (FRA)	1959	2008	50
Germany (GER)	1963	2008	46
Greece (GRE)	1959	2008	50
Italy (ITA)	1959	2008	50
Norway (NOR)	1963	2008	46
Sweden (SWE)	1959	2008	50

Data selection was based on the following criteria[23]:

a) Availability of data for the fifty seasons. The starting season 1959 coincides with the establishment of the highest league in Greece[24].
b) Representation from southern (Greece and Italy), central (Belgium, France, and Germany) and northern Europe (England, Norway, and Sweden).
c) Representation from both the top five leagues (England, France, Germany, and Italy) and the group of smaller countries (Belgium, Greece, Norway, and Sweden) in terms of their total revenues based on the distinction suggested by Koning (2000), and Michie and Oughton (2004).

We calculated all indices in Table 6.1 on an annual basis using the final season results from the available data[25]. Regarding the partial indices, they are selected according to the particular interest in the domestic league. More specifically, the

[22] The name of the highest domestic league is not used, since it continually changes during the period investigated.
[23] Historical data sources of the championship results and final rankings by season from the highest league are presented in Table A.2 in the Appendix. Due to the promotion-relegation rule, the calculation of some indices also requires data from the immediately lower league. The relevant data sources are presented in Table A.3 in the Appendix.
[24] The first highest league was "A' Ethniki".
[25] Only the *S* index requires data collection at a game level. However, *S* cannot be calculated for England due to a difficulty collecting the relevant data.

number of teams in the second and the third level is determined by the specific domestic league format. In particular, the number of teams that qualify for any European tournament and are relegated to the lower division determines the number of teams for the second and third levels. It must be noted that the number both of the qualifying and the relegated teams greatly varies across countries and/or seasons. Therefore, the partial indices have been calculated with the appropriate N, K, and I for every season based on the data presented in Tables A.1, A.4 and A.5 and illustrated in Figures A.1, A2, and A3 in the Appendix.

Generally, the number of qualifying teams for European tournaments corresponds to the top ranking positions. However, there are cases in which lower ranking teams, even from a lower division (i.e. Lyn in Norway 1970), may qualify for European tournaments, especially for the Cup Winners Cup. For that reason, the number of qualifying teams (Table A.4 and Figure A.2 in the Appendix) is considered to be the extended number of qualifying teams. This is also justifiable from the fans' perspective, since their expectation is that the top teams participate in European tournaments. Similarly, the number of relegated teams is legitimately extended by those participating in play-off and/or play-out relegation games. For instance, in Germany from 1981 to 1990 the last two teams in the league were immediately relegated to the lower division. However, an additional team may be relegated, since the last but two teams in the league participate in a play-off tournament with teams from the lower division.

We could assume that the minimum number of qualifying teams is the top three. This is reasonable based on the assumption that even in the leagues with the smallest number of teams (i.e ten teams in Norway 1963-1971) fans are primarily interested at least in the top three teams. The number of qualifying teams was quite small in the early 1960's, since pan-European championships had just began to emerge. There are eleven cases in the dataset (all in the early 1960's), in which the number of teams qualifying for European tournaments is less than three. Similarly to the number of qualifying teams, the minimum number of relegated teams is based on the assumption that every team strives to avoid the undesirable last position, even when that does not entail demotion. There is one single case in season 1975 in Greece, in which no team was relegated. This was due to the increase in the number of teams that made up the highest league "A' Ethniki" the following season.

The period of five seasons is selected for the calculation of the *aG* index. This period is also used from UEFA for both country and team rankings (UEFA, 2012). Additionally, in the calculation only the immediate lower league is taken into consideration since teams from other divisions have negligible chances to seriously compete at the top level for a period of five subsequent seasons. The number of top teams under investigation depends on the total number of teams in the league. For leagues with a number of teams lower than 13 and higher than 17 the top 3 and 5 teams respectively are selected. On the other hand, for leagues with teams from 13-17 the top 4 teams are selected. The number of the teams for the second division per country and season are presented in Table A.6 in the Appendix.

7.2 The level of Competitive Balance in European Football

Our first task is the study of competitive balance in Europe by country, which is common practice in most of the existing empirical studies in football (Goossens, 2006; Groot, 2008; Michie & Oughton, 2004). Table 7.2 below, which presents the best and worst records for all indices along with their derived range, allows us to make some interesting observations. It must be noted that more descriptive statistics and a related graph with the mean values concerning all indices country-wise are presented in the Appendix from Table A.9 to Table A.16. From Table 7.2 it is obvious that most competitive leagues are attributed to Germany (1968) for the seasonal and Norway (1987) for the between-seasons indices whereas the least competitive to Greece (for several seasons). With the exception of *aG* in season 2008, the presence of England in the worst records column is due to equal values in multiple cases.

It is interesting to note that the range of DN_1 reaches its maximum attainability. In particular, the range of DN_1 equals unity, since the best and worst records are equal to the lower and upper bounds of the index respectively. The appearance of the upper bound (unity) for DN_1 in 124 out of a total 377 cases is justified, since it is reached when a single team wins the championship for two consecutive seasons. On the other hand, the lower bound (zero) DN_1 is achieved when the last promoted team wins the championship the following season, which is a quite infrequent incident[26].

Table 7.2: Best and Worst Records of the Indices

	Index	*Best* Country	*Best* Season	*Best* Value	*Worst* Country	*Worst* Season	*Worst* Value	*Range*
Seasonal	$NAMSI$	Germany	1968	0.195	Greece	2002	0.634	0.438
	HHI^*	Germany	1968	0.038	Greece	2002	0.401	0.363
	$AGINI$	Germany	1968	0.179	Greece	2002	0.621	0.442
	AH	Germany	1968	0.031	Norway	1965	0.380	0.349
	nID	Germany	1968	0.167	Greece	2002	0.633	0.466
	NCR_1	Sweden	1968	0.227	Greece	1999	0.824	0.596
	NCR_K	Germany	1968	0.181	Greece	1997	0.700	0.519
	NCR^I	Germany	1968	0.172	Sweden	1967	0.675	0.503
	$ANCR_K$	Germany	1968	0.229	Greece	1972	0.744	0.515
	SCR_K^I	Germany	1968	0.221	Greece	1972	0.699	0.478
	nCB_{qual}	France	1964	0.094	Greece	1999	0.539	0.446
	S	Germany	1968	0.179	Greece	2002	0.621	0.442
Between-seasons	τ	Norway	1987	0.348	Greece	1972	0.882	0.534
	r_s	Norway	1987	0.297	Greece	1972	0.954	0.656
	DN_t^*	Norway	1987	0.222	Greece	1972	0.815	0.593
	DN_1	England	1977	0.000	England	2008	1.000*	1.000
	DN_K	France	1977	0.344	Greece	2007	1.000	0.656
	DN^I	Norway	2004	0.212	England	1997	1.000*	0.788
	ADN_K	Norway	1987	0.204	Greece	2007	1.000	0.796
	SDN_K^I	Norway	1987	0.245	Greece	1960	0.972	0.726
	aG	France	1964	0.164	England	2008	0.925	0.762
Bi-dimensional	DC_1	Sweden	1968	0.114	Greece	1999	0.912	0.798
	DC^I	Norway	2004	0.265	Sweden	1967	0.838	0.572
	ADC_K	Sweden	1968	0.235	Greece	2000	0.838	0.602
	SDC_K^I	Norway	1987	0.269	Greece	1999	0.800	0.531

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).
*On this table appear the most recent of the multiple cases with the same value of unity.

[26] It should be reminded that the promoted teams are orderly assigned the ranking place of the relegated teams.

In fact, there are only two cases in which DN_1 takes the value of zero. More specifically, the first case concerns the remarkable for England 1977 season, during which Nottingham Forrest (the third out of three promoted teams) won the league while the second case concerns the 1968 season for Sweden, during which Osters IF (the second out of two promoted teams) also won the championship title. In reality, for the entire investigated period, nine cases are reported in which a promoted team becomes the champion as is presented in Table 7.3.

Table 7.3: From Promotion to the Championship Title

Country	*Season*	*Team*	*Rank in the lower division*	*Number of Promoted teams*	*Total Number of teams*	DN_1
England	1977	Nottingham	3rd	3	22	*0.000
Sweden	1968	Osters IF	2nd	2	12	*0.000
England	1961	Ipswich	1st	2	22	0.047
France	1977	Monaco	2nd	3	20	**0.053
France	1963	St. Etienne	1st	3	18	0.059
Norway	1987	Moss	1st	2	12	0.091
Sweden	1961	IF Elfsborg	1st	2	12	0.091
Norway	1967	Rosenborg	1st	2	10	0.111
Germany	1997	FC Kaiserslautern	1st	3	18	0.118

*In Sweden 1968 the number of promoted teams was two and Osters IF was assigned to the very last position since it was the second promoted team in season 1967. In the same way, in England 1977 the number of promoted teams was three and Nottingham Forrest was assigned to the very last position since it was the third promoted team in season 1976.

**The DN_1 value is not zero for France because three teams were promoted in 1977.

Furthermore, there are nine cases that DN^I reaches its upper bound, which is defined as the minimum ranking mobility of relegated teams or absence of dynamic competition for relegation. In that case, promoted teams are immediately relegated to the following season exactly in the same ranking order. Also DN_K and ADN_K indices reach their upper bound in season 2007 in Greece, during which the ranking position of the top qualifying teams remains unchanged from the previous season. In seasons 2006 and 2007 there are four teams that qualify for European championship in Greece. The ranking order in both seasons is: 1) Olympiakos, 2) AEK Athens, 3) Panathinaikos, 4) Aris.

7.3 Variability of the Indices

Generally, the range of the indices is considerably large, which is indicative of a great variability in the competitive balance value. This variability is mainly derived from three important sources:

a) The variation of competitive balance across countries.
b) The variation of competitive balance within countries: this concerns the different aspects of competitive balance the indices possess.
c) The variation of competitive balance across seasons.

7.3.1 Variability of the Indices across Countries

To further explore the variability across countries, the mean values of each index per country are investigated, as is presented in Table 7.4. The variability of the indices across countries indicates that domestic championships are quite dissimilar in terms of competitive balance. Moreover, across European countries, the largest and smallest mean differences- are observed for the aG and DC^I indices respectively. The former is an indication of a variant behaviour of teams at the top while the latter is an indication of a similar behaviour of teams at the bottom of the ladder. The above statement is further reinforced by the relatively small mean difference in the DC^I as compared to the DC_1 and ADC_K indices. This statement is also supported by the relevant *SD*. It is important to further emphasise the larger variability among partial indices in the between-seasons than in the seasonal dimension. The latter may be an indication of closer championships within the season than across seasons. Lastly, it seems to be the case that Greece is the least competitive country, since it displays the highest values in almost every index.

In essence, using raw numbers, it is difficult to further distinguish the best and the worst countries in the dataset. For that reason, the ranking of countries by index, from the most to the least competitive, is presented in Table 7.5. Additionally, the frequency of ranking scores by country is presented in Table 7.6 and graphically illustrated in Figure 7.1. It can be verified that Greece is ranked last in almost every index while Belgium is ranked second but the last. Additionally, for the seasonal dimension the best country is France followed by Germany and England.

Table 7.4: Mean Values of the Indices Country-wise

	Index	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*	*Range*	*SD**
Seasonal	$NAMSI$	0.453	0.378	0.344	0.378	0.496	0.423	0.421	0.414	*0.152*	*0.048*
	HHI^{*}	0.208	0.148	0.121	0.147	0.252	0.181	0.183	0.177	*0.131*	*0.041*
	$AGINI$	0.436	0.362	0.329	0.364	0.470	0.405	0.404	0.398	*0.141*	*0.045*
	AH	0.172	0.124	0.102	0.124	0.210	0.152	0.158	0.153	*0.108*	*0.033*
	nID	0.428	0.350	0.315	0.352	0.461	0.397	0.395	0.386	*0.146*	*0.046*
	NCR_1	0.568	0.487	0.445	0.456	0.614	0.516	0.460	0.442	*0.172*	*0.063*
	NCR_K	0.472	0.384	0.350	0.367	0.548	0.412	0.399	0.392	*0.198*	*0.065*
	NCR^I	0.437	0.364	0.337	0.371	0.431	0.386	0.409	0.424	*0.100*	*0.036*
	ACR_K	0.517	0.430	0.390	0.403	0.582	0.457	0.424	0.413	*0.192*	*0.066*
	SCR_K^I	0.503	0.419	0.382	0.399	0.551	0.447	0.421	0.416	*0.169*	*0.057*
	nCB_{qual}	0.246	0.184	0.159	0.179	0.294	0.215	0.208	0.198	*0.135*	*0.043*
	S	0.436	**	0.328	0.363	0.469	0.404	0.403	0.396	*0.141*	*0.046*
Between-seasons	τ	0.722	0.687	0.661	0.700	0.780	0.732	0.642	0.673	*0.138*	*0.044*
	r_s	0.800	0.756	0.726	0.771	0.864	0.814	0.693	0.730	*0.171*	*0.055*
	DN_t^{*}	0.602	0.567	0.532	0.574	0.679	0.614	0.500	0.539	*0.179*	*0.056*
	DN_1	0.895	0.850	0.837	0.823	0.931	0.878	0.818	0.732	*0.199*	*0.060*
	DN_K	0.798	0.717	0.695	0.691	0.855	0.733	0.644	0.644	*0.211*	*0.073*
	DN^I	0.749	0.725	0.713	0.744	0.769	0.740	0.668	0.734	*0.101*	*0.030*
	ADN_K	0.851	0.793	0.760	0.750	0.892	0.810	0.708	0.687	*0.205*	*0.069*
	SDN_K^I	0.833	0.783	0.751	0.749	0.868	0.800	0.700	0.699	*0.169*	*0.060*
	aG	0.588	0.568	0.486	0.597	0.778	0.652	0.456	0.518	*0.322*	*0.102*
Bi-dimensional	DC_1	0.732	0.671	0.640	0.639	0.772	0.696	0.641	0.587	*0.185*	*0.059*
	DC^I	0.594	0.546	0.524	0.558	0.599	0.564	0.539	0.577	*0.075*	*0.026*
	ADC_K	0.684	0.613	0.574	0.576	0.736	0.633	0.567	0.549	*0.187*	*0.065*
	SDC_K^I	0.668	0.602	0.565	0.574	0.709	0.623	0.561	0.556	*0.153*	*0.056*
	Range	*0.723*	*0.726*	*0.735*	*0.699*	*0.721*	*0.726*	*0.660*	*0.581*		
	*SD**	*0.200*	*0.209*	*0.208*	*0.203*	*0.205*	*0.205*	*0.170*	*0.171*		

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

**SD* refers to the entire data set while *Range* refers to the mean values by country.

**The *S* index was not calculated for England.

On the other hand, Norway and Sweden are the best countries in the between-seasons dimension. Bi-dimensionally, Sweden and Norway are the best countries followed by Germany. It can also be drawn that England, France, and Germany perform relatively better in the seasonal than in the between-seasons dimension in terms of competitive balance. On the contrary, Norway and Sweden are ranked higher in the between-season than in the seasonal dimension. The remaining three countries, that is, Italy, Belgium, and Greece, are ranked in that particular order the last three positions in both dimensions.

Table 7.5: Ranking of Countries by Index

	Index	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
Seasonal	*NAMSI*	7	3	1	2	8	6	5	4
	HHI^*	7	3	1	2	8	5	6	4
	AGINI	7	2	1	3	8	6	5	4
	AH	7	2	1	3	8	4	6	5
	nID	7	2	1	3	8	6	5	4
	NCR_1	7	5	2	3	8	6	4	1
	NCR_K	7	3	1	2	8	6	5	4
	NCR^I	8	2	1	3	7	4	5	6
	ACR_K	7	5	1	2	8	6	4	3
	SCR_K^I	7	4	1	2	8	6	5	3
	nCB_{qual}	7	3	1	2	8	6	5	4
	S	7	2	1	3	8	6	5	4
Between-seasons	τ	6	4	2	5	8	7	1	3
	r_s	6	4	2	5	8	7	1	3
	DN_t^*	6	4	2	5	8	7	1	3
	DN_1	7	5	4	3	8	6	2	1
	DN_K	7	5	4	3	8	6	2	1
	DN^I	7	3	2	6	8	5	1	4
	ADN_K	7	5	4	3	8	6	2	1
	SDN_K^I	7	5	4	3	8	6	2	1
	aG	5	4	2	6	8	7	1	3
Bi-dimensional	DC_1	7	5	3	2	8	6	4	1
	DC^I	7	5	3	4	8	6	2	1
	ADC_K	7	3	1	4	8	5	2	6
	SDC_K^I	7	5	3	4	8	6	2	1

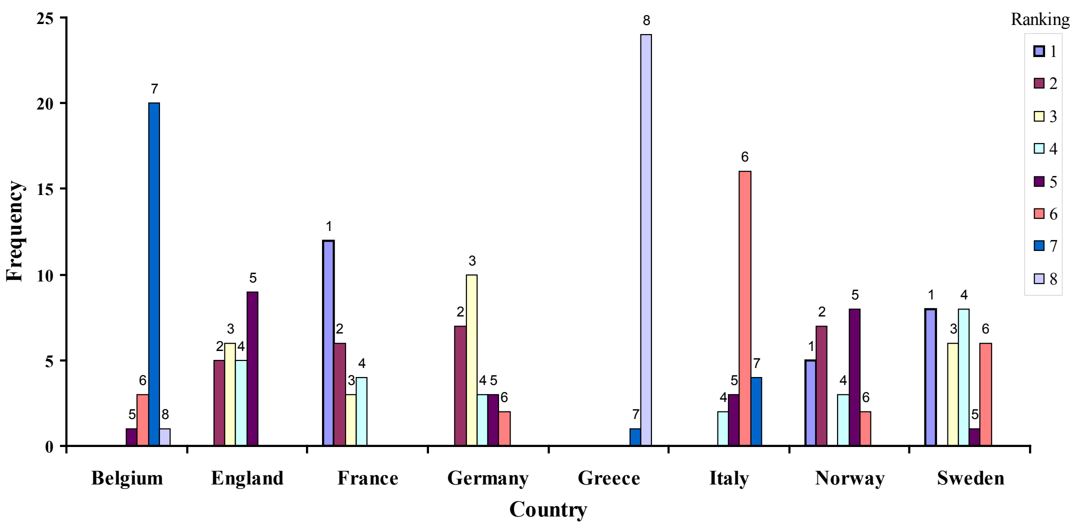
An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

A closer observation of the seasonal ranking results reveals that Sweden performs much better when it is measured using NCR_1 as compared to NCR^I. The latter may be an indication of a better competition for the championship title than for the relegation. A mirror image holds for England in which competition for relegation looks more promising than that for the championship title. Regarding the between-seasons ranking results, Norway performs by far better as compared to the other countries. At this point, it is important to note the similarities that hold between Germany and Sweden with respect to the DN^I and aG indices. More specifically, the lower relative performance of DN^I is suggestive of lower ranking mobility or dynamic competition for relegation rather than for the top ranking places. On the other hand, the lower performance of aG is indicative of a lower mobility at the top ranking places for the period of five seasons rather than for two consecutive seasons.

Table 7.6: Frequency of Ranking Scores by Country

Ranking	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
1st			12				5	8
2nd		5	6	7			7	
3rd		6	3	10				6
4th		5	4	3		2	3	8
5th	1	9		3		3	8	1
6th	3			2		16	2	6
7th	20				1	4		
8th	1				24			

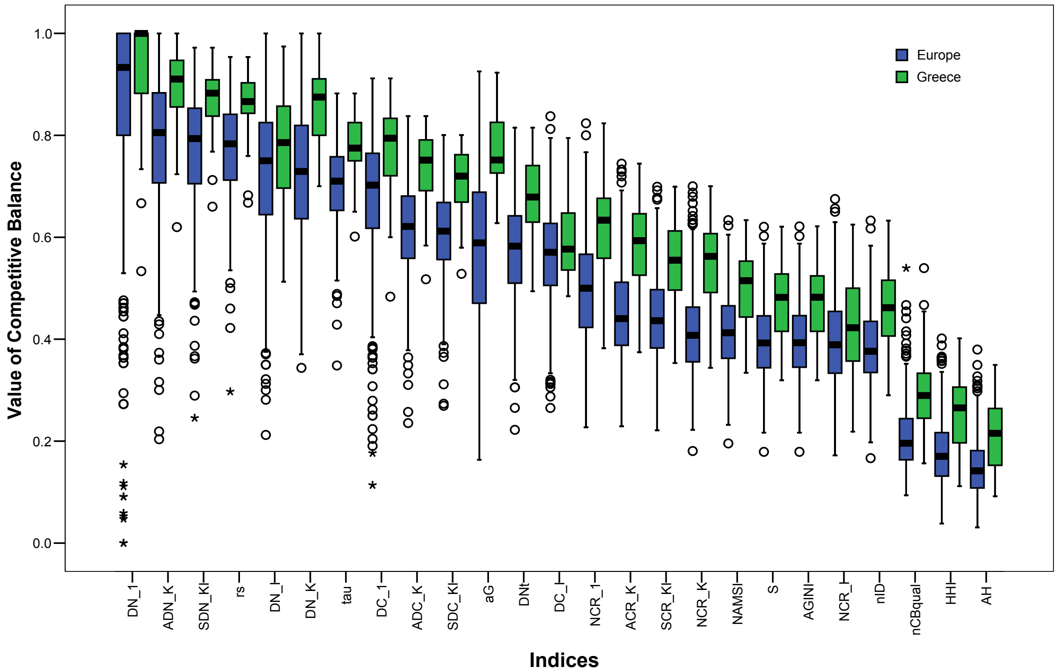
Figure 7.1: Frequency of Ranking Scores by Country



7.3.2 Variability of the Indices within Countries

Returning to Table 7.4, we observe that variability of the indices is greater within rather than across countries, since both the range and the *SD* are higher vertically than horizontally. This is reasonable since, as was shown in the sensitivity analysis, indices capture different aspects of competitive balance. To effectively illustrate this variability, the study of the indices in Europe is employed. Based on the median value in Europe, the indices are orderly depicted and a comparison is attempted with Greece in the box-plot presented in Figure 7.2. For a further analysis, all descriptive statistics of the indices in Europe (Table A.17) and box-plots per country (Figures A.4-A.11) are presented in the Appendix.

Figure 7.2: Box-plot of the Indices in Europe; Comparison with Greece



An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

The highly skewed distribution of DN_1 is explained by the already noticed large number of cases reaching the upper bound of the index. Moreover, DN_1 displays many outliers and the most extreme values which are explained by Table 7.3. As a result, the bi-dimensional DC_1 also displays a rather large number of outliers and extreme values. The range of the median values among indices in Europe is 0.784, which is quite large given the feasible range of all indices from zero to unity. In particular, DN_1 displays the highest while *AH* displays the lowest median value. In particular, DN_1 is very close to its upper bound (0.933) suggesting that the relative mobility of the champion from season to season is very small in European football.

Therefore, what causes concern is the champion's dynamic domination or the tendency to remain in the first place for two adjacent seasons. By contrast, following sensitivity analysis, the low values of AH (0.142) implies acceptable values of the overall seasonal concentration. Generally, what is derived from the previous graph is that the seasonal indices display lower values than the between-seasons indices while bi-dimensional indices stand in between.

In particular, the seasonal dimension does not seem to present an issue for European football, since it reaches tolerable values of competitive balance (values lower than 0.5). On the other hand, what is a cause for concern is the between-seasons dimension, in that it reaches values close to complete imbalance (values higher than 0.5 and close to unity). It must be noted that the champion's seasonal domination, which is best captured by NCR_1, is much lower (0.5) than the champion's dynamic domination (DN_1=0.933). Therefore, it may be stated that, in contrast to the dynamic, seasonal domination by the champion does not present an issue for the European football since it shows medium values.

Similar conclusions may be drawn from the ranking mobility and the seasonal weakness of the relegated teams, which are best captured by the DN^I and the NCR^I indices respectively. In particular, DN^I exhibits much higher values than NCR^I; thus, the dynamic weakness or tendency of the promoted teams to be relegated the following season causes more concern than their seasonal weakness. Therefore, the comparison between the two dimensions indicates competitive championships in the course of a particular season but absence of dynamic competition or ranking mobility from season to season in European football.

It may also be drawn from Figure 7.2 that partial indices have higher values than the summary indices in both dimensions. In reality, this phenomenon is noticeable only in the partial indices that capture teams at the top. The partial indices for relegated teams are very close to the summary ones. Therefore, it may be inferred that competition in the middle is higher than in the top and comparable with that in the bottom ranking places. This signifies that the promotion-relegation rule greatly contributes to a more competitive championship and, thus, proves to be a useful mechanism in European football. On the other hand, the higher the ranking position, the more noticeable the predominance becomes. For illustration, NCR_1, DN_1, and DC_1 are ranked first among the seasonal, between-seasons, and bi-dimensional partial indices respectively. This is indicative of less competition for the first as compared to the remaining ranking positions, which may be interpreted as the champion's negative contribution to a balanced league. Additionally, ACR_K and ADN_K display higher values than their corresponding NCR_K and DN_K indices. This signifies lower competition among the top K teams than domination by the same teams. Therefore, it may be inferred that also the competition among the top K teams negatively contributes to a balanced league.

Lastly, some interesting remarks may also be drawn for the summary indices. More specifically, nCB_{qual}, HHI^*, and AH display considerably lower values than the remaining summary seasonal indices. This verifies mediocre values of seasonal competitive balance which are considered acceptable to European football. Additionally, the value of the between-seasons summary indices (r_s, τ, and DN_t^*) may be explained by their sensitivity to the first level. In particular, the higher value of r_s confirms high values of the champion's dynamic domination. It is important to note at this point that the last two statements confirm the conclusions drawn from the sensitivity analysis.

In the box-plot in Figure 7.2, as is expected, in every index Greece displays values higher than in Europe. Actually, most of the median values in Greece are even higher than third quartile in Europe, and therefore, Greek championships are much less competitive than the remaining ones in the dataset. Interestingly enough, the median value for DN_1 in Greece reaches the upper bound of unity which is interpreted as extreme values of the champion's dynamic domination. On the other hand, Greece displays median values very close to European median only for the indices that capture the performance of the relegated teams. This indicates that the promotion-relegation rule is quite effective for the enhancement of competitive balance in Greece. Furthermore, this also confirms the findings for a similar behaviour of relegated teams at European level.

7.3.3 Variability across Seasons

With reference to the variability across seasons, it is instructive to study the behaviour of the indices for the entire period in every country. More specifically, a decade ranking is investigated, which indicates the best and the worst periods in terms of competitive balance. Additionally, a Moving Average (*MA*) for five years time series is examined, which further illustrates the fluctuation and compares the behaviour of the indices country-wise. The study focuses on Greece while the analysis for the remaining European countries is presented in Appendix B.

The ranking of decades in Greece, from the most to the least competitive, is presented in Table 7.7. The relevant ranking frequency results from Table 7.8 and Figure 7.3 clearly demonstrate that 1979-1988 is the most competitive decade in Greece. Concerning that decade, the only exception is the lower ranking of the DN^I and aG indices. The former signifies a tendency of lower ranking teams to be relegated while the latter signifies a relatively unchanged identity of the top ranking teams across seasons.

On the other hand, the least competitive decade is the recent 1999-2008 decade. An exception to this decade is the high ranking performance of DN^I which may be interpreted as a higher probability for teams close to the top to be relegated the following season. It can also be inferred from the decade ranking that competitive balance in Greece does not follow a linear pattern. The fact that the best ranking decade is in the middle of the investigated period implies a quadratic trend.

The trend pattern and fluctuation of the indices is effectively depicted by the $MA(5)$ time series, which is illustrated in Graphs 1-5 in Figure 7.4. In Graph 1 an almost identical pattern is noted among summary seasonal indices, which is an indication of strong correlation. It is also observed that those indices formulate two distinct groups. In particular, the indices *NAMSI*, *AGINI*, *nID*, and *S* form the group with the higher level, whereas the indices *HHI**, *AH*, and nCB_{qual} form the group with the lower level. A justification for the latter may be provided by the design of the indices and signifies medium levels of seasonal competitive balance.

Table 7.7: Decade Ranking for All Indices in Greece

	Index	*1959-1968*	*1969-1978*	*1979-1988*	*1989-1998*	*1999-2008*
Seasonal	*NAMSI*	2	4	1	3	5
	HHI^*	2	4	1	3	5
	AGINI	2	4	1	3	5
	AH	2	4	1	3	5
	nID	2	4	1	3	5
	NCR_1	3	4	1	2	5
	NCR_K	4	5	1	2	3
	NCR^I	2	4	1	3	5
	ACR_K	4	3	1	2	5
	SCR_K^I	3	4	1	2	5
	nCB_{qual}	3	4	1	2	5
	S	2	4	1	3	5
Between-seasons	τ	5	3	1	2	4
	r_s	5	3	2	1	4
	DN_t^*	5	2	1	3	4
	DN_1	3	2	1	4	5
	DN_K	5	2	1	3	4
	DN^I	5	3	4	1	2
	ADN_K	5	2	1	3	4
	SDN_K^I	5	2	1	3	4
	aG	3	2	4	1	5
Bi-dimensional	DC_1	4	2	1	5	3
	DC^I	3	4	1	2	5
	ADC_K	5	2	1	3	4
	SDC_K^I	4	2	1	3	5

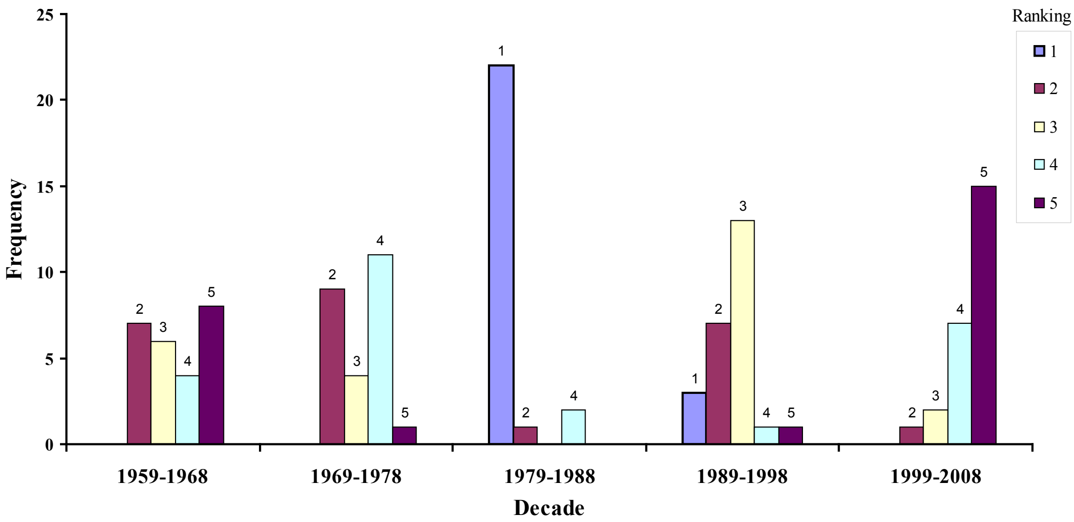
An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

Remarkably, the values of the *AGINI* and *S* indices are strikingly similar, although they are very different in nature, since their percentage difference is only 0.25% for the entire dataset. Consequently, given this similarity with *AGINI*, the inability to calculate the *S* index for England is not considered to be important. Therefore, to clarify the reason for that similarity further research is required in the structural design of the indices.

Table 7.8: Frequency of Ranking Scores of the Indices by Decade in Greece

Ranking	*1959-1968*	*1969-1978*	*1979-1988*	*1989-1998*	*1999-2008*
1st			22	3	
2nd	7	9	1	7	1
3rd	6	4		13	2
4th	4	11	2	1	7
5th	8	1		1	15

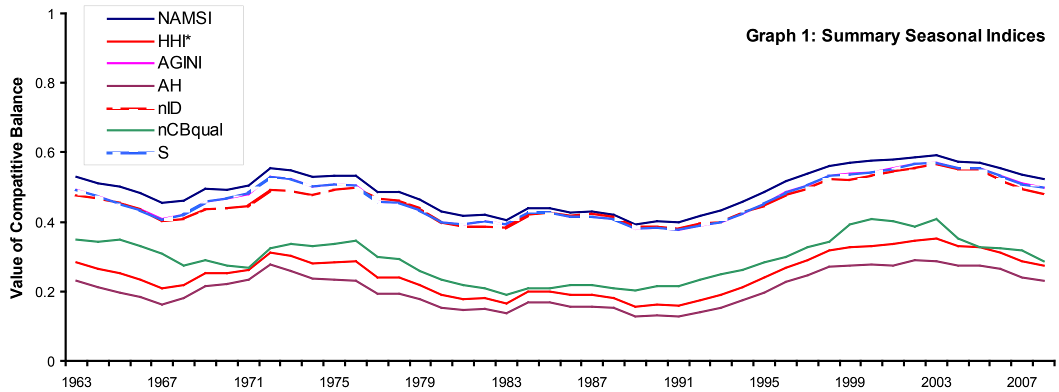
Figure 7.3: Frequency of Ranking Scores of the Indices by Decade in Greece

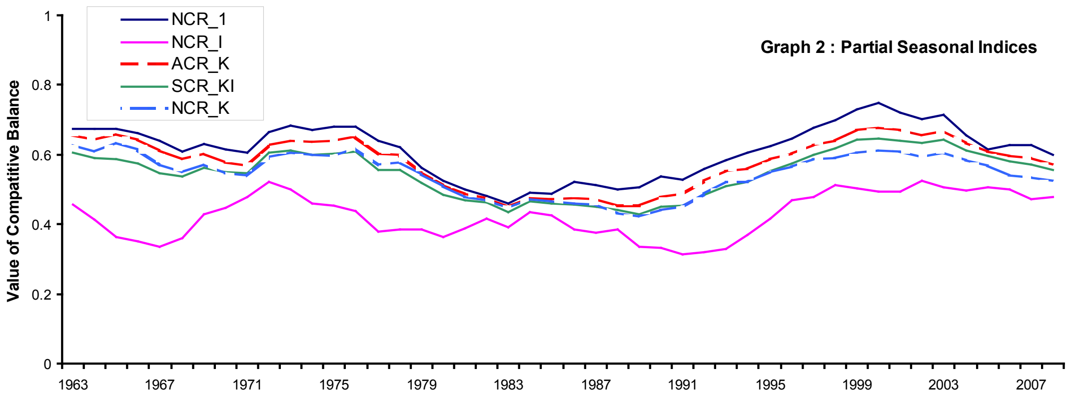


In Graph 2 a considerable difference is observed between the values of NCR_1 and NCR^I indices. This is a strong indication for a greater competition for the relegation places than for the champion. In Graph 3, the extremely high values of partial between-seasons indices is illustrated, which is indicative of a considerably unbalanced league across seasons. In that graph, the large gap between the DN_1 and DN^I indices should also be emphasised. Based on the properties of those indices, it may be drawn that there is a greater diversity in the identity of the relegated teams as compared to that of the champion across seasons. Alternatively, the promotion-relegation rule contributes more than the champion to a dynamically balanced championship.

The high value of summary between-seasons indices in Graph 4 may be interpreted as low degree of overall ranking mobility across seasons. Additionally, those indices also exhibit an identical trend pattern, which implies strong correlation. The fact that r_s display the highest values may be explained by the champion's extreme dynamic domination, which is more noticeable in Graph 5 that refers to the bi-dimensional indices. From this graph what can be verified is more competition in the bottom than in the top ranking places. It is worth mentioning that most indices display lower values during the middle of 1980's, which verifies that that decade was the most competitive in Greece. The trend pattern of the indices in the time series presentation intensifies the evidence for the previously implied quadratic trend.

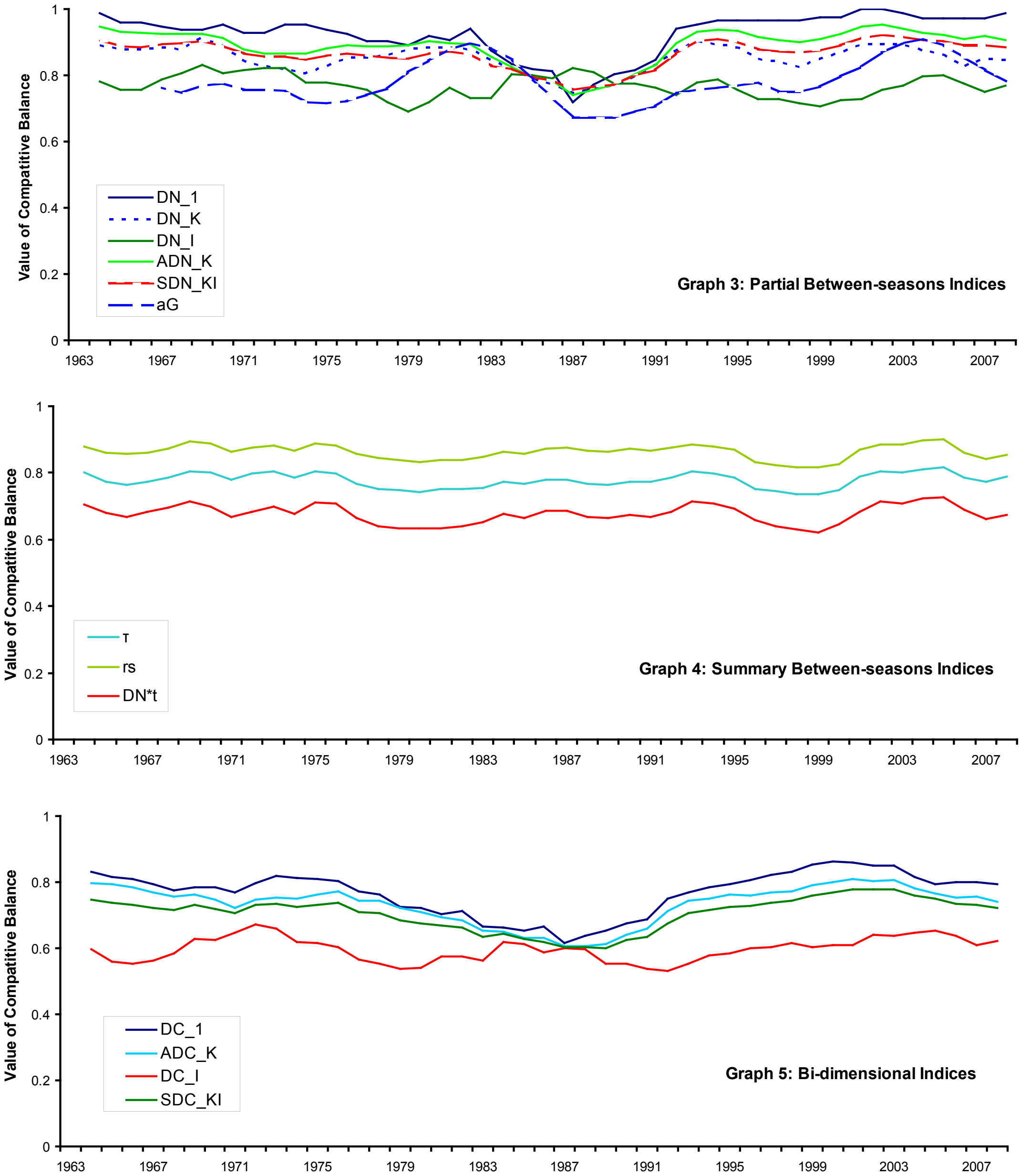
Figure 7.4a: *MA*(5) for All Indices in Greece





An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

Figure 7.4b: *MA*(5) for All Indices in Greece



An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

7.4 A Cross Examination of the Three Levels in European Football

To further explore competitive balance in European football, a cross examination of the three important levels is attempted. More specifically, we investigate the behaviour of three-levelled indices for multi-prized structured leagues across countries and seasons using 10-season averages.

7.4.1 First Level

The first level is captured by the bi-dimensional DC_1 index, which is simply the average of the seasonal NCR_1 and between-seasons DN_1 indices. The mean value of those indices by decade average for every country is presented in Table 7.9. As was expected, NCR_1 displays lower values than DN_1 in every decade for all countries. This indicates a persistently more dynamic than a seasonal domination by the champion.

Table 7.9: Dynamic Concentration for the Champion (DC_1) by Decade Average

Decade	*Index*	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
1959-1968	NCR_1:	0.533	0.433	0.428	0.390	0.642	0.518	0.435	0.464
	DN_1:	0.933	0.693	0.774	0.586	0.958	0.861	0.533	0.556
	$\boldsymbol{DC_1}$:	**0.733**	**0.563**	**0.601**	**0.488**	**0.800**	**0.689**	**0.484**	**0.510**
1969-1978	NCR_1:	0.506	0.460	0.457	0.456	0.652	0.490	0.454	0.467
	DN_1:	0.897	0.757	0.826	0.900	0.928	0.887	0.856	0.732
	$\boldsymbol{DC_1}$:	**0.702**	**0.608**	**0.642**	**0.678**	**0.790**	**0.688**	**0.655**	**0.599**
1979-1988	NCR_1:	0.574	0.447	0.458	0.485	0.480	0.477	0.409	0.462
	DN_1:	0.882	0.883	0.816	0.918	0.824	0.823	0.691	0.782
	$\boldsymbol{DC_1}$:	**0.728**	**0.665**	**0.637**	**0.701**	**0.652**	**0.650**	**0.550**	**0.622**
1989-1998	NCR_1:	0.603	0.483	0.457	0.434	0.641	0.503	0.540	0.408
	DN_1:	0.906	0.934	0.859	0.738	0.959	0.882	0.936	0.804
	$\boldsymbol{DC_1}$:	**0.754**	**0.708**	**0.658**	**0.586**	**0.800**	**0.693**	**0.738**	**0.606**
1999-2008	NCR_1:	0.600	0.613	0.427	0.488	0.657	0.589	0.454	0.408
	DN_1:	0.888	0.968	0.907	0.853	0.987	0.937	0.931	0.770
	$\boldsymbol{DC_1}$:	**0.744**	**0.791**	**0.667**	**0.671**	**0.822**	**0.763**	**0.692**	**0.589**

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

It must be noted that Greece exhibits the highest values for both the NCR_1 and the DN_1 indices. For instance, the value of DN_1 in the most recent decade is very close to complete imbalance (0.987). An improvement in the middle of the 1980's may be interpreted as a greater competition for the championship title in Greece. During that period, we should also point out the lower performance of the traditionally strong teams in addition to the championship title for the first time by the teams PAOK and

Larissa. Traditionally, the strongest teams in Greece are considered Olympiakos, Panathinaikos, and AEK Athens.

On the other hand, the most competitive country in the first level is Sweden, although an increase is observed in the last decade, which is mainly derived from the gradual increase in DN_1 since the corresponding NCR_1 decreases. This signifies an increase in the champion's dynamic domination in contrast to a lower seasonal domination. Alternatively, despite the greater seasonal competition, the stronger team finally wins the championship title.

In England, there is a remarkable deterioration of competitive balance across decades. It is notable that during the most recent decade competition for the first level reaches values close to complete imbalance, which may be explained by the considerably high values in the champion's domination both for the seasonal and the between-seasons dimensions. During that decade, six out of ten champions won the title with more than ten-point difference while Manchester United won six out of ten championships.

In Norway, there is a worsening in DN_1 in the last two decades due to dynamic domination by Rosenborg which won the title for thirteen consecutive seasons (from 1992 to 2004). During the last decade, the champion's dynamic concentration (DC_1) in France, Germany, and Norway follow Sweden's best performance with medium to high values. On the other hand, England, Italy, and Belgium follow the poor performance of Greece with high to very high values in the DC_1 index.

7.4.2 First & Second Level

In what follows, we investigate the first two levels captured by the bi-dimensional ADC_K index and its components ACR_K and ADN_K indices. The mean value by decade average for every country is presented in Table 7.10. Similarly to the first level, the seasonal dimension displays considerably lower values than the between-seasons dimension. This may be interpreted as more dynamic than a seasonal domination by the top K teams. However, the value of ADC_K is lower than that of $DC_{1,}$ which indicates a greater competition for the top K rather than for the first place.

Table 7.10: Advanced Dynamic Concentration (*ADC_K*) by Decade Average

Decade	*Index*	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
1959-1968	*ACR_K*:	0.481	0.400	0.378	0.333	0.620	0.462	0.420	0.444
	ADN_K:	0.826	0.715	0.759	0.614	0.938	0.814	0.587	0.547
	***ADC_K*:**	**0.653**	**0.558**	**0.568**	**0.473**	**0.779**	**0.638**	**0.503**	**0.496**
1969-1978	*ACR_K*:	0.474	0.402	0.392	0.397	0.620	0.452	0.432	0.409
	ADN_K:	0.870	0.751	0.734	0.769	0.878	0.793	0.687	0.726
	***ADC_K*:**	**0.672**	**0.577**	**0.563**	**0.583**	**0.749**	**0.622**	**0.560**	**0.567**
1979-1988	*ACR_K*:	0.519	0.399	0.419	0.444	0.452	0.424	0.383	0.428
	ADN_K:	0.831	0.800	0.765	0.838	0.805	0.796	0.652	0.725
	***ADC_K*:**	**0.675**	**0.600**	**0.592**	**0.641**	**0.629**	**0.610**	**0.517**	**0.576**
1989-1998	*ACR_K*:	0.533	0.429	0.399	0.382	0.597	0.436	0.475	0.382
	ADN_K:	0.826	0.798	0.808	0.687	0.917	0.809	0.800	0.710
	***ADC_K*:**	**0.680**	**0.613**	**0.603**	**0.534**	**0.757**	**0.622**	**0.638**	**0.546**
1999-2008	*ACR_K*:	0.551	0.519	0.364	0.430	0.621	0.513	0.407	0.403
	ADN_K:	0.882	0.894	0.733	0.775	0.925	0.839	0.754	0.712
	***ADC_K*:**	**0.716**	**0.707**	**0.549**	**0.603**	**0.773**	**0.676**	**0.580**	**0.557**

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

Greece displays the highest value in every decade except for the third one, which confirms the improvement of competitive balance during the middle of the 1980's. The relevant pattern in England suggests a considerable deterioration during the last decade. France along with the Scandinavian countries and Germany, are the most competitive countries at least during the last decade. On the other hand, Belgium and Italy display similarly high values of imbalance as those noticed for Greece.

7.4.3 Third Level

The third level is captured by the bi-dimensional DC^I index and its component NCR^I and DN^I indices. The mean values are presented by decade average for every country in Table 7.11. As is expected, the seasonal dimension displays considerably lower values that the between-seasons dimension, which may be interpreted as more dynamic than seasonal weakness of the relegated teams.

Table 7.11: Dynamic Concentration for Relegated Teams (DC^I) by Decade Average

Decade	*Index*	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
1959-1968	NCR^I	0.393	0.353	0.335	0.359	0.408	0.375	0.417	0.515
	DN^I:	0.661	0.681	0.644	0.735	0.793	0.705	0.625	0.767
	$\boldsymbol{DC^I}$**:**	**0.527**	**0.517**	**0.489**	**0.547**	**0.601**	**0.540**	**0.521**	**0.641**
1969-1978	NCR^I	0.433	0.369	0.342	0.377	0.443	0.369	0.475	0.413
	DN^I:	0.689	0.695	0.651	0.736	0.769	0.772	0.625	0.778
	$\boldsymbol{DC^I}$**:**	**0.561**	**0.532**	**0.496**	**0.557**	**0.606**	**0.571**	**0.550**	**0.596**
1979-1988	NCR^I	0.419	0.346	0.354	0.383	0.389	0.354	0.363	0.394
	DN^I:	0.813	0.688	0.778	0.764	0.769	0.738	0.696	0.684
	$\boldsymbol{DC^I}$**:**	**0.616**	**0.517**	**0.566**	**0.574**	**0.579**	**0.546**	**0.530**	**0.539**
1989-1998	NCR^I	0.450	0.334	0.334	0.351	0.421	0.428	0.407	0.384
	DN^I:	0.694	0.776	0.755	0.755	0.747	0.802	0.653	0.693
	$\boldsymbol{DC^I}$**:**	**0.572**	**0.555**	**0.545**	**0.553**	**0.584**	**0.615**	**0.530**	**0.538**
1999-2008	NCR^I	0.460	0.420	0.323	0.381	0.491	0.406	0.386	0.413
	DN^I:	0.819	0.782	0.730	0.724	0.769	0.682	0.721	0.749
	$\boldsymbol{DC^I}$**:**	**0.640**	**0.601**	**0.527**	**0.553**	**0.630**	**0.544**	**0.553**	**0.581**

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

Nevertheless, the total level of DC^I is much lower than for the other two levels, which indicates a greater competition at the bottom than at the top of the ladder. Moreover, less variation is observed among countries, since values range between 0.5 and 0.6. An exemption to the latter is the high value in Sweden (0.641) and in Belgium (0.640) of the first and the last decades respectively.

England displays its highest value during the most recent decade, which further strengthens the findings that it is the least competitive decade. The fact that Greece exhibits medium values may be interpreted as a greater contribution of the promotion-relegation rule to an enhanced competitive balance in that country. On the other hand, the same rule is less effective in countries with lower values in the first two levels, such as France, Germany, and the Scandinavian countries.

7.5 Analysis of Comprehensive Indices & Overall Competitive Balance

The task of investigating the behaviour of comprehensive indices is particularly interesting, since they capture all three levels. Firstly, the trend analysis is employed in order to study the fluctuation of seasonal SCR_K^I as contrasted with the between-seasons SDN_K^I index. Secondly, important observations for the overall competitive balance both in Europe and country-wise can be drawn from the more sophisticated SDC_K^I index, which captures all three levels for both dimensions. Lastly, the cluster analysis, using the SDC_K^I index, enables us to determine whether European countries in our dataset form distinctive groups in terms of competitive balance status.

7.5.1 Trend Analysis

Trend analysis is a helpful tool for the study of the fluctuation of competitive balance across seasons. Before doing that, however, the unit root tests of the Augmented Dickey-Fuller (*ADF*) (Dickey & Fuller, 1979) and Philips-Perron (*PP*) (Phillips & Perron, 1988) are employed for the nonstationarity issue of the time series. In Table 7.12 the relevant unit root test results are reported. All cases provide support for a rejection of the unit root hypothesis for all time series except for the *ADF* test on SCR_K^I in Greece.

At this point, considering all series to be stationary, we can proceed to the testing of a deterministic trend. The trend analysis for every country is tested via Ordinary Least Squares (*OLS*) and the results are presented in Table 7.13. For interpretation issues, the analysis in this empirical research is limited to a linear, quadratic, and cubic trend effects. No significant trend was found for any country and dimension. Due to data volatility, smoothed time series via *MA*(5) is selected to better illustrate the fluctuation of competitive balance in Figure 7.5. In this figure the trend line is depicted only when it is found to be significant. Essentially, the evolution of the seasonal dimension is contrasted with the between-seasons dimension for every country. As was expected, the between-seasons SDN_K^I fluctuates in a considerably higher level than the seasonal SDC_K^I.

Table 7.12: Statistic Values for *ADF* and *PP* Unit Root Tests for Comprehensive SCR_K^I and SDN_K^I Indices

Country	*Index*	*ADF* $(p)^a$ Constant	*ADF* $(p)^a$ Constant & Trend	*PP* $(l)^b$ Constant	*PP* $(l)^b$ Constant & Trend
Belgium	SCR_K^I	-2.947** (1)	-6.831*** (0)	-5.920*** (3)	-6.821*** (2)
	SDN_K^I	-6.218*** (0)	-6.369*** (0)	-6.225*** (1)	-6.370*** (1)
England	SCR_K^I	-4.815*** (0)	-5.983*** (0)	-5.089*** (4)	-6.124*** (3)
	SDN_K^I	-3.126** (1)	-8.079*** (0)	-5.652*** (3)	-8.006*** (2)
France	SCR_K^I	-5.766*** (0)	-5.671*** (0)	-5.752*** (2)	-5.653*** (2)
	SDN_K^I	-5.680*** (0)	-5.639*** (0)	-5.573*** (5)	-5.526*** (5)
Germany	SCR_K^I	-6.973*** (0)	-7.381*** (0)	-6.994*** (2)	-7.364*** (1)
	SDN_K^I	-5.474*** (0)	-5.405*** (0)	-5.492*** (3)	-5.427*** (3)
Greece	SCR_K^I	-1.725 (2)	-1.767 (2)	-4.565*** (5)	-4.523*** (5)
	SDN_K^I	-4.416*** (0)	-4.395*** (0)	-4.370*** (1)	-4.344*** (1)
Italy	SCR_K^I	-6.250*** (0)	-6.741*** (0)	-6.379*** (3)	-6.794*** (3)
	SDN_K^I	-7.577*** (0)	-7.572*** (0)	-7.590*** (1)	-7.605*** (2)
Norway	SCR_K^I	-5.131*** (0)	-5.077*** (0)	-5.083*** (4)	-5.028* (4)
	SDN_K^I	-5.475*** (0)	-6.109*** (0)	-5.457*** (1)	-6.138*** (2)
Sweden	SCR_K^I	-6.142*** (0)	-6.361*** (0)	-6.627*** (1)	-6.352*** (1)
	SDN_K^I	-6.626*** (0)	-6.770*** (0)	-6.617*** (2)	-6.766*** (3)

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

[a] *p* = Stands for the number of lags which is determined using the Schwartz Information Criterion.

[b] *l* = Stands for the Bandwidth which is determined by the Newey-West (1994) Bandwidth using Bartlett kernel.

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

Critical values are based on tables presented by MacKinnon (1991, 1996).

After close observation of trend results, we should highlight the strong upward linear trend in England in both dimensions. To put this in perspective, the total increase for the entire period rises up to 36% and 30% for the seasonal and the between-seasons dimensions respectively. That may be interpreted as a serious deterioration of competitive balance in England in the course of seasons.

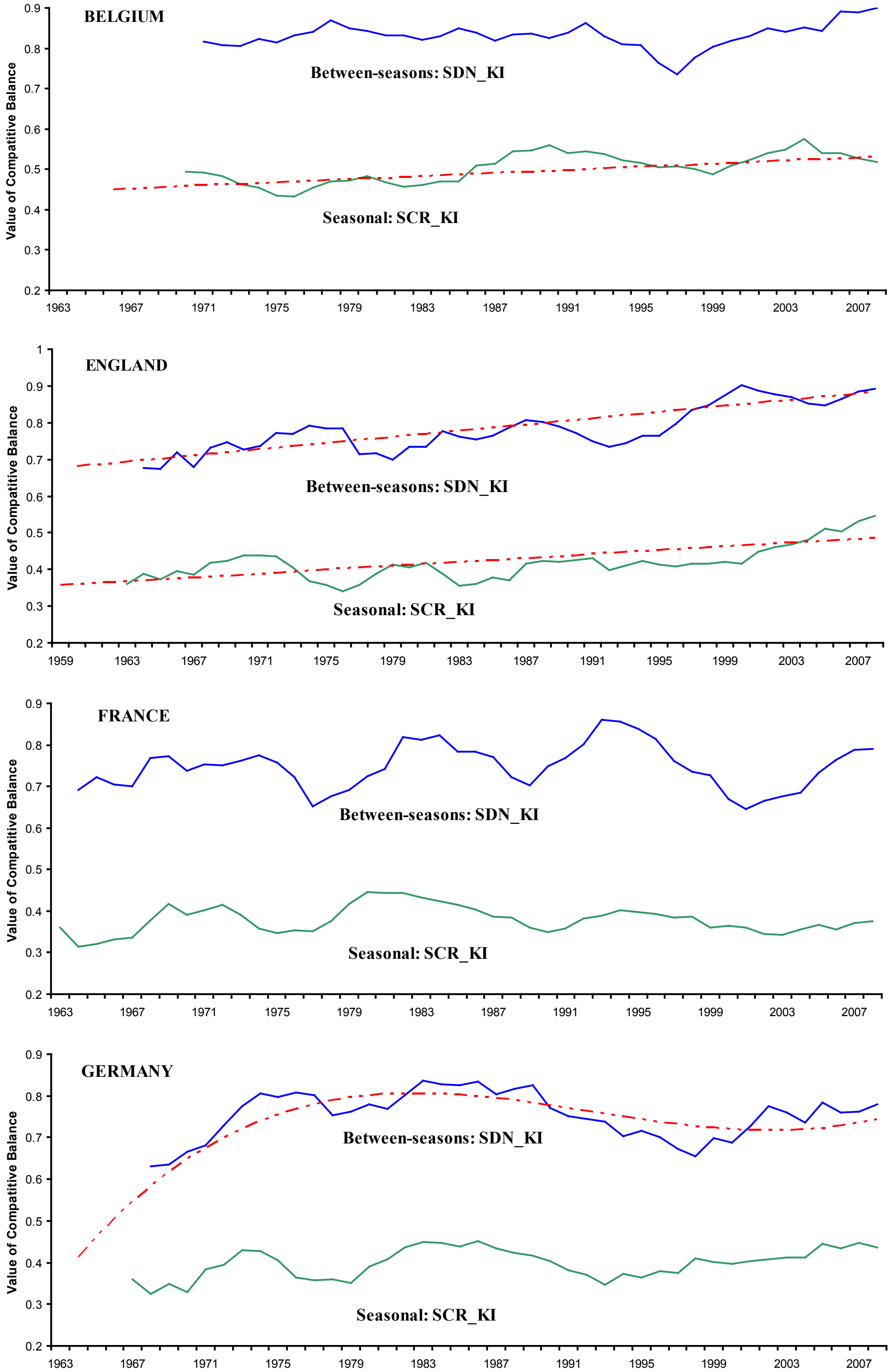
Table 7.13: Coefficients of the Trend Regression Model for SCR_K^I and SDN_K^I Indices per Country

Country	*Index*	C	T	T^2	T^3
Belgium	SCR_K^I	0.445*** (0.021)	0.0019*** (0.0007)		
	SDN_K^I	0.807*** (0.028)	0.0009 (0.0009)		
England	SCR_K^I	0.355*** (0.018)	0.0027*** (0.0006)		
	SDN_K^I	0.677*** (0.028)	0.0042*** (0.008)		
France	SCR_K^I	0.385*** (0.018)	-0.0001 (-0.0006)		
	SDN_K^I	0.740*** (0.035)	0.0004 (0.0012)		
Germany	SCR_K^I	0.366*** (0.022)	0.0012 (0.0007)		
	SDN_K^I	0.359*** (0.108)	0.0547*** (0.015)	-0.0021*** (-0.0006)	0.0001*** (0.000)
Greece	SCR_K^I	0.626*** (0.032)	-0.0099*** (0.003)	0.0002*** (0.000)	
	SDN_K^I	0.931*** (0.025)	-0.0076*** (-0.002)	0.0002*** (0.000)	
Italy	SCR_K^I	0.471*** (0.019)	-0.0049*** (0.002)	0.0001*** (0.000)	
	SDN_K^I	0.792*** (0.181)	0.0003 (0.0007)		
Norway	SCR_K^I	0.421*** (0.025)	-0.0001 (0.0008)		
	SDN_K^I	0.616*** (0.041)	0.0031** (0.0013)		
Sweden	SCR_K^I	0.448*** (0.019)	-0.0013* (0.0007)		
	SDN_K^I	0.657*** (0.037)	0.0016 (0.0013)		

SCR_K^I and SDN_K^I indices capture all three important levels for multi-prized European football leagues for the seasonal and between-seasons dimension of competitive balance respectively.
The numbers in parentheses are standard errors; In cases with no significant trend, coefficients are presented only for linear trend *T*; *C* is the constant of the regression.
*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

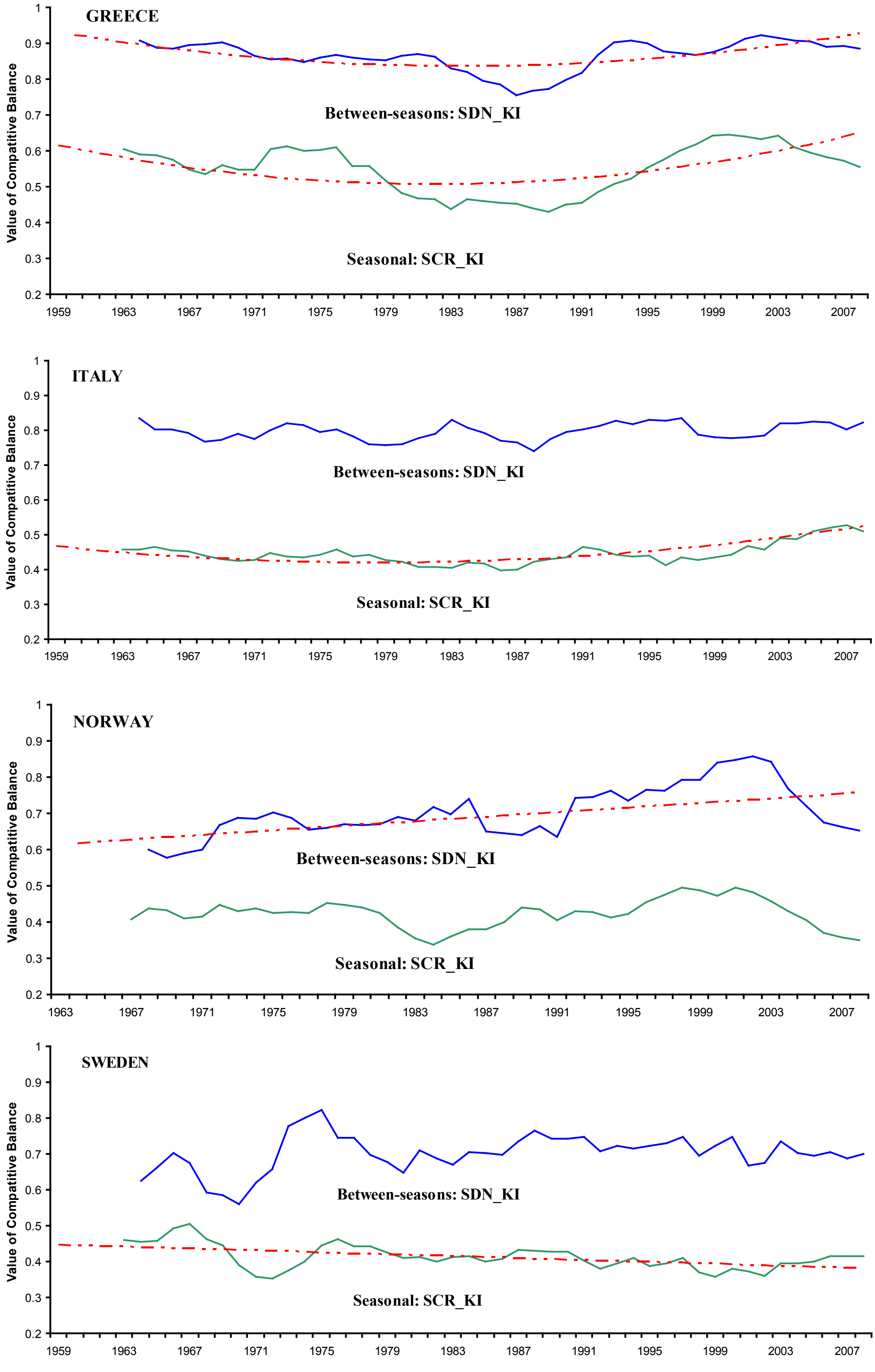
Competitive balance in Greece, which is at considerably high values, exhibits a significant trend in both dimensions. In particular, the trend pattern is quadratic and is minimised in the middle of the 1980's. Therefore, competitive balance in Greece is improving at a decreasing rate until the middle of the 1980's and it is worsening at an increasing rate soon afterwards.

Figure 7.5a: *MA*(5) Time Series and Trend in European Countries



SCR_K^I and SDN_K^I capture all three important levels for multi-prized European football leagues for the seasonal and between-seasons dimension of competitive balance respectively.

Figure 7.5b: *MA*(5) Time Series and Trend in European Countries



SCR_K^I and SDN_K^I capture all three important levels for multi-prized European football leagues for the seasonal and between-seasons dimension of competitive balance respectively.

More specifically, competitive balance is improving until the middle of the 1980's up to 17% and 9% and is declining afterwards as much as 27% and 10% for the seasonal and between-seasons dimensions respectively.

Regarding Belgium, a significant upward linear trend is established only for the seasonal dimension. In particular, seasonal competitive balance is worsening in Belgium up to 17% for the entire period. With regard to the between-seasons dimension, an abrupt drop is noticed from 1992 to 2002 and a return to the original levels soon afterwards. What this indicates is an increase in the teams' ranking mobility during that period. For instance in season 1993, the new promoted teams of Seraing R.S.C. and Oostende KV finish in the third and seventh position respectively while the 7^{th} ranked Waregem SV is relegated to the lower division. Similarly, the new promoted teams of Eendracht Aalst (1994-95) and Moeskroen R. (1996-97) finish in the fourth and third positions respectively. Based on the relevant $MA(5)$ time series, which is presented in Figure B.1 in the Appendix, there is no drop only for the DN_1 index. This may be interpreted as an increased ranking mobility in the league while the champion's identity remains unchanged.

Italy displays a quadratic trend in the seasonal dimension which is improving at the decreasing rate of 9% until the end of the 1970's but is worsening afterwards at the increased rate of 24%.

Germany demonstrates a significant trend in the between-seasons dimension which follows a cubic pattern and is worsening as much as 8% for the investigated period. With reference to the between-seasons dimension, there is a large drop in the end of the 1990's, which may be explained by a sharp increase in the teams' ranking mobility across seasons. For illustration, Bayer 04 Leverkusen moved from the 14^{th} to the 2^{nd} position in season 1996-97 while the newly promoted FC Kaiserslautern won the championship title in season 1997-98.

Regarding Norway, it exhibits a linear upward between-seasons trend, which may be interpreted as a deterioration of competitive balance as much as 22% for the entire period. It must be noted that the strong upward movement ends with a sudden drop around 2004. Part of the worsening in the between-seasons dimension may be derived from the dynamic domination by Rosenborg, which won the championship title for thirteen consecutive seasons (1992 to 2004). The downward direction around 2004 is firstly underlined by the second position of Velerenga (12th in 2003) and secondly by the play-off games for relegation of Bodø/Glimt (2nd in 2003) and the relegation of Stabæk (3rd in 2003). Additionally, in season 2005 Rosenborg lost the championship (7th place) while the new promoted team Start advanced to the second position.

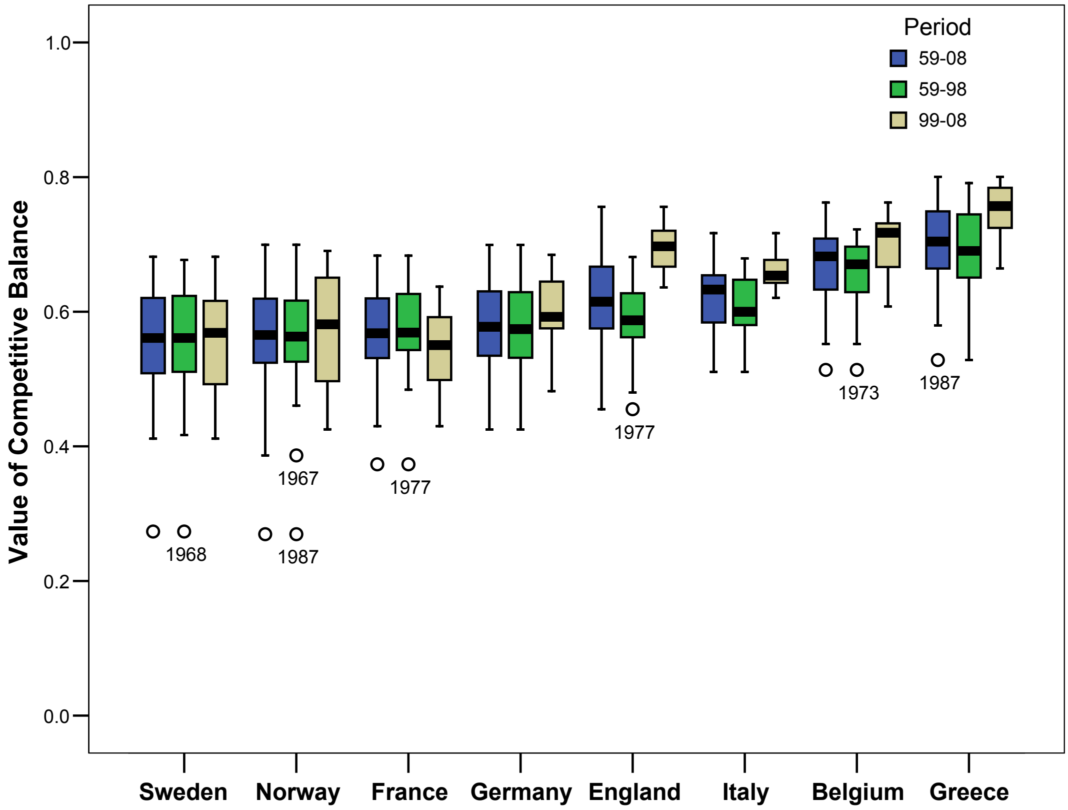
It is notable that Sweden is the only country which demonstrates a significant downward seasonal trend; thus, this case requires more attention. This unique trend in our sample is interpreted as an improvement in seasonal competitive balance which approximates 14% for the entire investigated period. On the other hand, the between-seasons dimension remains quite stable. Therefore, despite the greater seasonal competition, the identity of teams both at the top and at the bottom of the ladder shows a tendency to remain unchanged. This indicates long term dynamic domination by the top teams and weakness of the relegated teams respectively. Alternatively, regardless of the championship uncertainty, the strongest team finally prevails.

Lastly, competitive balance in France, which is the most competitive country, remains roughly stable since there is no significant trend in any dimension. In particular, the seasonal dimension is always at considerably low values, whereas the between-seasons competitive balance presents a cyclical pattern.

7.5.2 Overall Competitive Balance

From the trend analysis it can be deducted that, during the last decade competitiveness is reduced in most countries. This can be confirmed by the examination of SDC_K^I which captures all levels in both dimensions and provides an enhanced estimation of the overall competitive balance. The box-plot in Figure 7.6 illustrates the distribution of the index by country. More specifically, based on the median value of SDC_K^I for the entire investigated period (1959-2008), the eight countries are orderly depicted and a comparison is attempted with the last decade.

Figure 7.6: Competitive Balance in European Countries Using SDC_K^I: A comparison with the Last Decade



Differences among countries have been tested if they statistically significant. Both test for normality and homogeneity of variances have been rejected based on the results presented in Table 7.14. Therefore, the non-parametric test of equality of medians Kruskal Wallis has been used for the analysis. Based on the results presented in Table 7.15, the differences in median values among countries are statistically significant even at level of significance α=1%.

Based on box-plot in Figure 7.6, the most competitive country for the entire period is Sweden, closely followed by Norway, France, and Germany. The median values in those countries are close to 0.55, which may be considered to be acceptable or tolerable values of competitive balance. On the other hand, Greece is the least competitive country, with a value over 0.75, and is closely followed by Belgium. England and Italy stand in between the two extremes with values slightly higher than 0.6.

Table 7.14: Results from Diagnostic Tests of Normality and Homogeneity of Variances for SDC_K^I in European Countries

	Test	*Statistic*	*Degrees of freedom*	*p-value*
Tests of Normality	Kolmogorov-Smirnov	0.052	377	0.016
	Shapiro-Wilk	0.971	377	0.000
Test of Homogeneity of Variances	Levene	1.796	7 and 369	0.087

Table 7.15: Results from Kruskal-Wallis **Test for SDC_K^I in European Countries**

	Test	*Statistic*	*Degrees of freedom*	*p-value*
Non-parametric test of equality of medians	Kruskal-Wallis	141.300	7	0.000

However, it is quite interesting to examine the development of competitive balance during the last decade. Recently, France has become the most competitive country, as competitive balance has greatly improved by reaching the lowest values. In effect, during the last decade, France makes an exception, since the other countries exhibit values higher than their average.

Unambiguously, competitive balance has recently worsened in European countries. That is exemplified by England which reaches high values of competitive balance that approach the value of 0.7. It must be noted that the worsening of competitive balance during the last decade is more notable for countries with already high values of competitive balance. Therefore, the gap among the most and the least competitive countries is becoming larger.

7.5.3 Cluster Analysis

Based on the SDC_K^I results, the clustering analysis is employed to investigate the existence of distinct groups that exist among countries in the dataset in terms of their competitive balance status. Clustering, which is a common technique for statistical data analysis, assigns a set of observations (e.g. by country) into clusters so that, in effect, observations in the same cluster are in many ways similar (Everitt, 1993). We use the squared Euclidean which is the most common distance measure published in the relevant literature (Girish & Stewart, 1983).

The cluster Ward's method is employed which is distinct from all other methods in that it follows the approach of the analysis of variance to evaluate the distances between clusters (Ward, 1963). In short, this method attempts to minimise the sum of squares of any two (hypothetical) clusters that can be formed at each step (Everitt, Landau, & Leese, 2001).

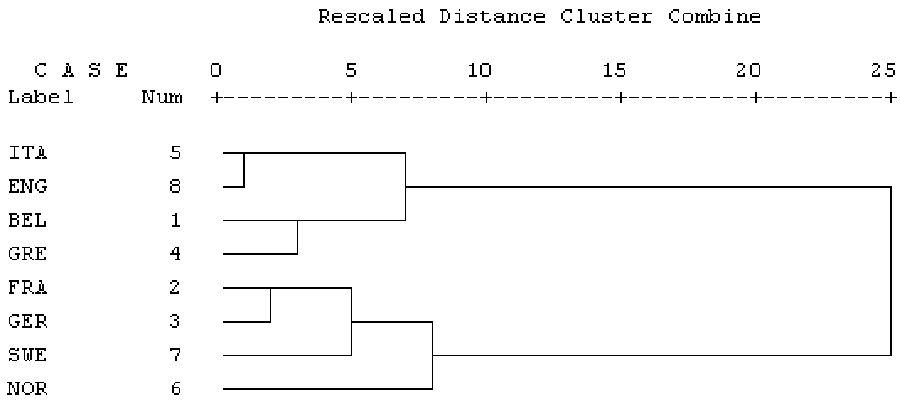
Regardless of the chosen linkage method, two distinct groups of countries are identified using hierarchical clustering. Using the between-groups linkage only, Belgium and Greece form a distinct group from the other countries. Following the Ward's method, the hierarchical cluster analysis of countries is shown in a dendrogram, which shows the followed steps graphically, as is presented in Figure 7.7. For instance, in the first step, England and Italy form initially a distinct group, which is joined by Belgium and Greece at a later step. In the final step, two distinct groups are identified as follows:

Group 1: Italy, England, Greece, and Belgium

Group 2: France, Germany, Sweden, and Norway

The first group is the least competitive, whereas the second group is the most competitive based on the SDC_K^I index results. This classification is supported by the height of competitive balance in European countries. Even if the sample is very small for a clustering analysis, what may be drawn is that the eight chosen countries are very different to form only one group; that is, the value of competitive balance in European countries is neither the same nor does it evolve equally. Similar conclusions have been derived by Goossens (2006), who also recognises two similar groups using a different dataset. A clustering analysis by dimension and index or even for all indices could also provide interesting results, yet it is beyond the scope of the present study.

Figure 7.7: Dendrogram based on the SDC_K^I Index in Hierarchical Cluster Analysis Using Ward's Method



7.6 Correlation Analysis

The next step of the empirical investigation is the correlation analysis between indices. The purpose of this method is to further elucidate similarities and differences among indices and to explore the suggestions derived from the sensitivity analysis. Using Pearson's *r* statistical method, the correlation is investigated by type and dimension followed by a cross dimensional examination of the indices. Bi-dimensional indices are not included in this analysis, since conclusions may be derived from their single-dimensional components.

7.6.1 Correlation of Seasonal Indices

Correlations between seasonal indices are all significant at α=1% significant level, as is indicated in the correlation matrix presented in Table 7.16. As was anticipated from the application results, there is high correlation among all summary seasonal indices. More specifically, the highest correlation (0.998) is observed between the *AGINI* and *S* indices, which may be justified by their negligible percentage difference, as was noted in Section 7.3.3. Furthermore, *NAMSI* displays the highest correlation with the other summary indices, which verifies the suggestion made by Utt and Fort (2002, p. 373) that it is a "*tried and true*" measure of seasonal competitive balance. More specifically, *NAMSI* exhibits the highest correlation with *HHI** (0.992) and *AGINI* (0.991) and the lowest correlation with nCB_{qual} (0.840).

What is more, its strong correlation with the S index (0.988) confirms the relevant findings from Groot (2008). On the other hand, nCB_{qual} displays the lowest correlation with the other summary seasonal indices. This seems to justify the different behaviour encountered in the sensitivity analysis, given that nCB_{qual} captures slightly different components of competitive balance that are mainly determined by its high sensitivity to the first two levels.

The correlation among partial seasonal indices is determined by their design. For instance, $NCR_{1,}$ which captures the champion's domination, is strongly correlated with ACR_K (0.905) that attaches more weight to the first of the top K teams. On the contrary, NCR_1 is weakly correlated with NCR^I (0.371) that is specially designed to account for the weakness of the relegated teams.

Regarding the relationship among seasonal indices by type, the correlation is mainly determined by the specific features of the indices. As is expected, the correlation is higher the more information the partial indices provide, that is, the more points they depend on the concentration curve. Thus, summary indices are generally mostly correlated with SCR_K^I and least of all with NCR_1. Yet, there are some exceptions to this rule. For instance, AH is correlated more with NCR^I than with $NCR_{K,}$ even though the latter provides more information, since K is larger than I. This may be justified by the sensitivity of AH to the weakness of the relegated teams, as was shown in the sensitivity analysis in the previous chapter. On the other hand, the correlation of nCB_{qual} with NCR^I (0.468) is weaker than that with NCR_K (0.847). In reality, nCB_{qual} exhibits the strongest correlation with all partial seasonal indices except NCR^I. Most notably, its strong correlation with NCR_1 (0.908) underlines the great sensitivity of nCB_{qual} to the first level. This also confirms the suggestion made above concerning its different behaviour from the other summary indices. As was identified in the sensitivity analysis, nCB_{qual} is hyper-sensitive to the first two and insensitive to the third level. Lastly, it is important to also point out the nearly identical correlations that the $AGINI$ and the S indices display towards all partial summary indices.

Table 7.16: Correlation Matrix of the Seasonal Indices

	Summary Indices							Partial Indices				
	NAMSI	*HHI**	*AGINI*	*AH*	*nID*	nCB_{qual}	*S*	NCR_1	NCR_K	NCR^I	ACR_K	SCR_K^I
NAMSI	1	0.992^+	0.991^+	0.978^+	0.958^+	0.840^+	0.988^+	0.704^+	0.894^+	0.811^+	0.857^+	0.924^+
HHI^*		1	0.983^+	0.989^+	0.951^+	0.844^+	0.981^+	0.693^+	0.890^+	0.804^+	0.850^+	0.916^+
AGINI			1	0.972^+	0.972^+	0.794^+	0.998^+	0.655^+	0.877^+	0.834^+	0.820^+	0.895^+
AH				1	0.933^+	0.774^+	0.970^+	0.622^+	0.840^+	0.854^+	0.781^+	0.865^+
nID					1	0.751^+	0.969^+	0.589^+	0.867^+	0.756^+	0.779^+	0.845^+
nCB_{qual}						1	0.781^+	0.908^+	0.847^+	0.468^+	0.941^+	0.933^+
S							1	0.647^+	0.877^+	0.831^+	0.814^+	0.892^+
NCR_1								1	0.736^+	0.371^+	0.905^+	0.879^+
NCR_K									1	0.575^+	0.940^+	0.941^+
NCR^I										1	0.492^+	0.634^+
ACR_K											1	0.984^+
SCR_K^I												1

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).
$^+$Significant at α=1%.

7.6.2 Correlation of the Between-seasons Indices

In what follows, we present the relationship among the between-seasons indices. In general, what is observed is that the correlation among the between-seasons indices is lower than that among seasonal indices, as is depicted in the correlation matrix in Table 7.17. This may be explained by the greater variability of the between-seasons indices, as was shown in previous sections. Furthermore, there are cases with either considerably weak or even insignificant correlation. More specifically, the correlation of DN^I with the DN_K (0.153) and the ADN_K (0.087) indices is quite weak while that with DN_1 was not found to be significant. This may be justified by the different qualities those indices possess: DN^I captures the mobility of teams at the bottom, whereas the other three indices capture the mobility of teams at the top of the ladder. We may interpret this finding by arguing that hardly ever do the *I* relegated teams come from the top *K* positions[27]. Alternatively, the ranking mobility of the top *K* teams, and especially of the champion, is virtually independent of the ranking

[27] As an exception, the best value of the DN^I index is for Norway in season 2004. In particular, the teams Bodo/Glimt, Stabæk, and Songal finish in the last three positions (12th, 13th, and 14th) while they come from the 2nd, 3rd, and 8th positions respectively in season 2003. The last two teams have been relegated, whereas Bodo/Glimt survive in play-off games. Additionally, the best value of the DN^1 index is also for Norway in season 1969, in which the last team (12th), Lyn, was the champion for the previous season (1968). The ten best records for the DN^I and the DN^1 indices are presented in Table A.18 in the Appendix.

mobility of the relegated ones. This is equivalent to the scarceness of cases when promoted teams become champions the following season (see Table 7.3). A similar interpretation may be drawn from the weak correlation aG exhibits with the DN^I (0.177) and the DN_1 (0.196) indices respectively. The former signifies that ranking mobility at the top is practically independent of the mobility at the bottom of the ladder while the latter may be interpreted by the fact that the champion's mobility is independent of the mobility of the remaining top teams. It must be noted that the champion's mobility is lower than that of the remaining top teams.

As is expected, there is very strong correlation among the summary between-seasons indices. In particular, r_s display the highest correlation with the other two indices. The correlation among the between-seasons indices by type is determined by the amount of information is provided by the partial ones. It should be noted that DN_t^* is more correlated with all partial indices than the other two summary indices. This signifies that DN_t^* is more sensitive to the three important levels than τ and r_s, as was indicated in the sensitivity analysis in the previous chapter.

Table 7.17: Correlation Matrix of the Between-seasons Indices

	Summary Indices			*Partial Indices*					
	τ	r_s	DN_t^*	DN_1	DN_K	DN^I	ADN_K	SDN_K^I	aG
τ	1	0.966^+	0.790^+	0.279^+	0.592^+	0.474^+	0.545^+	0.632^+	0.421^+
r_s		1	0.866^+	0.300^+	0.663^+	0.525^+	0.597^+	0.692^+	0.481^+
DN_t^*			1	0.323^+	0.708^+	0.532^+	0.611^+	0.709^+	0.529^+
DN_1				1	0.441^+	-0.013	0.790^+	0.747^+	0.196^+
DN_K					1	0.153^+	0.834^+	0.826^+	0.504^+
DN^I						1	0.087^*	0.315^+	0.177^+
ADN_K							1	0.970^+	0.449^+
SDN_K^I								1	0.467^+
aG									1

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).
*Significant at α=10%; $^+$significant at α=1%.

7.6.3 Cross-dimensional Correlation

We finally examine the correlation among seasonal and between-seasons indices, as is presented in Table 7.18. It may be easily inferred that cross-dimensional correlation is much lower than the correlation within dimensions, in that they capture different factors of competitive balance. An interesting fact is the correlation of the summary between-seasons indices with the seasonal ones. More specifically, DN_t^* displays the highest correlation followed by r_s and τ respectively. We should also underline that the correlation of DN^I with the nCB_{qual} and the NCR_1 indices was not found to be significant at conventional levels of significance α. Moreover, DN^I exhibits the weakest correlation with all seasonal indices, which may be an indication that it captures quite different aspects of competitive balance. A similar conclusion may be inferred for the NCR^I index, which is weakly correlated with all the between-seasons indices.

Table 7.18: Correlations among Seasonal and Between-seasons Indices

	Between-seasons								
Seasonal	τ	r_s	DN_t^*	DN_1	DN_K	DN^I	ADN_K	SDN_K^I	aG
$NAMSI$	0.250^+	0.289^+	0.399^+	0.232^+	0.318^+	0.185^+	0.335^+	0.371^+	0.376^+
HHI^*	0.243^+	0.278^+	0.393^+	0.225^+	0.315^+	0.181^+	0.328^+	0.363^+	0.380^+
$AGINI$	0.262^+	0.302^+	0.410^+	0.219^+	0.308^+	0.205^+	0.319^+	0.360^+	0.364^+
AH	0.220^+	0.250^+	0.360^+	0.194^+	0.269^+	0.190^+	0.280^+	0.320^+	0.349^+
nID	0.254^+	0.299^+	0.409^+	0.186^+	0.301^+	0.207^+	0.296^+	0.339^+	0.368^+
nCB_{qual}	0.218^+	0.254^+	0.365^+	0.286^+	0.373^+	0.082	0.405^+	0.410^+	0.386^+
S	0.412^+	0.387^+	0.403^+	0.225^+	0.314^+	0.208^+	0.323^+	0.366^+	0.347^+
NCR_1	0.287^+	0.318^+	0.371^+	0.351^+	0.407^+	0.079	0.476^+	0.477^+	0.349^+
NCR_K	0.305^+	0.351^+	0.440^+	0.259^+	0.467^+	0.150^+	0.431^+	0.445^+	0.413^+
NCR^I	0.153^+	0.167^+	0.238^+	0.095^*	0.097^*	0.242^+	0.112^{**}	0.171^+	0.166^+
ACR_K	0.317^+	0.355^+	0.432^+	0.320^+	0.476^+	0.113^{**}	0.489^+	0.495^+	0.418^+
SCR_K^I	0.314^+	0.350^+	0.432^+	0.304^+	0.438^+	0.151^+	0.457^+	0.476^+	0.406^+

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).
*Significant at α=10%; **significant at α=5%; $^+$significant at α=1%.

Interesting observations may also be derived by examining the comparison between those indices that are specially designed for teams at the top and the bottom of the ladder in both dimensions; that is, the comparison of NCR_1 with DN_1, the comparison of NCR_K with DN_K, and the comparison of NCR^I with DN^I. As is expected, the strongest correlation is between the indices for the top K teams (0.467), since those indices provide more information (K is larger than I). However, the correlation between the indices for the champion (NCR_1 & DN_1, 0.351) is stronger than that for the relegated teams (NCR^I & DN^I, 0.248), although I is larger than 1. Therefore, it may be inferred that the ranking in the previous season determines the success for the championship title rather than the relegation to a lower division. Alternatively, a large number of teams are candidates for relegation but only a few are contestants for the championship title. A tempting exercise for the indices would be to compare the correlations country-wise and to conduct factor or principal components analysis in European and country level; however, this is beyond the scope of the present study.

7.7 Conclusion

The empirical investigation, which employs data from eight European football leagues for the last 45-50 seasons, further elucidates the similarities and differences among indices. By employing various statistical methods we uncover different patterns of behaviour among indices, and thus, we answer the fifth issue of the thesis. As was specified in the theoretical foundation presented in Chapters 2-5, and confirmed by the sensitivity analysis in Chapter 6, the indices capture different components of competitive balance. Consequently, part of this diversity derives from the design of the indices; thus, for a suitable interpretation of the empirical results, what is required is to clearly define the aspect of competitive balance the index refers to.

Based on the empirical results, it may be drawn the following key points for European football:

- There is more competition for the seasonal than for the between-seasons dimension.
- There is more competition for the bottom than for the top ranking places.
- Competitive balance greatly varies among European countries.
- There is a worsening of competitive balance especially during the last decade in the dataset.
- Correlation analysis intensifies conclusions derived from sensitivity analysis.

More specifically, seasonal competitive balance in Europe is not a significant issue since it reaches tolerable values. However, the fact that the value of the between-seasons competitive balance is closer to complete imbalance is of particular concern. This may be interpreted as low ranking mobility across seasons. Regardless of the uncertainty during the season, the stronger team finally prevails.

From the findings, it may also be derived that the competition in the middle is higher than in the top *K*, and also comparable with that in the low *I* ranking places. Remarkably enough, championship competition reaches values close to complete imbalance. Essentially, the higher the ranking position, the lower the competition. This confirms the effectiveness of the promotion-relegation rule in promoting competitive balance in Europe. Therefore, if we ignore this mechanism, competitive balance is considerably more inferior than it appears.

The level of competitive balance differs greatly among European countries. Sweden is the most competitive country followed by Norway, France and Germany. The ranking continues with England and Italy while Belgium and Greece are the least competitive countries. Actually, the last four countries in terms of their competitive balance status form the worst of the two distinct groups that were identified by the cluster analysis. The trend behaviour of competitive balance also varies among countries. However, it may be drawn from the trend analysis that competitive balance worsens through seasons. An exception to that is Sweden which displays an improvement in the seasonal dimension. It is important to emphasise that the worsening of competitive balance is more notable during the last decade, and that is more prominent in England. This is in sharp contrast with the late improvement observed in France, which is already in acceptable values of competitive balance.

Interesting facts may also be derived from the correlation analysis which verified by the sensitivity analysis' results. It must be pointed out that the conventional *NAMSI* is an important index while nCB_{qual} captures quite different components of competitive balance from the other summary seasonal indices. Regarding the partial indices, the correlation is mainly determined by their design. The correlation among seasonal is higher than that among between-seasons indices. As is expected, correlation across dimensions is quite low, since they refer to different factors of competitive balance. The correlation analysis also verified the empirical result that it is rarely a case that one of the top *K* teams is relegated or one of the promoted teams becomes the champion in the following season. The interpretation may be that the ranking in the previous season determines the success for the championship title rather than relegation. Alternatively, a large number of teams are candidates for relegation in contrast to a small number of teams that are candidates for the championship title.

Our suggestion is to thoroughly examine all indices based on the *Uncertainty of Outcome Hypothesis* (*UOH*) (Fort & Maxcy, 2003; Zimbalist, 2002; Zimbalist, 2003). A proper econometric study is likely to reveal which indices, by type and dimension, mostly affect the demand for football games or for associated products in European football. Therefore, we assume that both the significance and the effect on the demand for football products will determine the usefulness of the each index from the fans' perspective.

Chapter 8. Testing for the Significance of Competitive Balance Indices in European Football

The analysis of Chapter 7 shows that competitive balance indices exhibit strikingly different behaviour both across countries and over time. Following the discussion closing the previous chapter, we may assume that this is mainly because they capture different aspects of competitive balance, which was also confirmed by the implemented sensitivity analysis. However, the analysis so far has not identified an optimal index for competitive balance in European football (and by no means this was not the purpose); therefore, it is difficult to make conclusive remarks for the degree of competitive balance. Here, the main objective is to determine the relative significance of all indices and to identify the best or optimal one for the study of competitive balance in European football. In that context, it may be possible to derive key assumptions concerning the relative importance of different aspects of competitive balance depending on the specific features of the optimal index.

Fans expect a certain degree of uncertainty in the outcome of games and seasons. This principle is of the utmost importance, since it implies that if fans were not responsive to competitive balance, its study would certainly be of no purpose. The importance of competitive balance derives from the assumption that the uncertainty of outcome instigates fans interest, thus, leading to an increased demand for attending sporting events (El-Hodiri & Quirk, 1971; Rottenberg, 1956). Consequently, given the fans' responsiveness, both revenues and economic viability of a sports league are affected by the degree of competitive balance. Thus, the focus of an economic analysis of competitive balance should be its effect on the fans' behaviour. As is pointed out by Zimbalist (2003), the fans' sensitivity should be used as a filter among potential indices. Consequently, any index which better captures fans' interest will be the best candidate.

The main study of the effect of competitive balance on the fans' behaviour is the longstanding "*Uncertainty of Outcome Hypothesis*" (UOH, Fort & Maxcy, 2003). *UOH* is also referred to as the empirical test of Neale's (1964) *League Standing*

Effect of competitive balance on attendance (Humphreys, 2002). Essentially, *UOH* analyses the relationship between competitive balance and fans' interest which is exhibited by their demand for league games. It should be pointed out that there is a number of alternative ways according to which the fans' demand for league games is manifested, based on which we can measure their behaviour. The most important are:

a) Attending games at the stadium (live).
b) Following games by means of electronic (TV, radio, internet, mobile) and printed (newspapers, related articles, books) media.
c) Buying products associated with a game, a team or a league (memorabilia, merchandise, gambling).

In the present study we focus on the attendance at league games, which is the most conventional measure for the fans' behaviour. According to the most complete reviews for demand in professional team sports (Borland & MacDonald, 2003; Villar & Guerrero, 2003), most econometric studies model attendance (Villar & Guerrero, 2009). The main objective of this chapter is to examine the relative significance of all indices that are appropriate for the study of competitive balance in European football, which was presented in the previous chapters. For that reason, *UOH* is employed to determine the relative significance of the indices from the fans' perspective in a context in which this area of research is relatively underdeveloped (Borland & MacDonald, 2003). Furthermore, the investigation across leagues or countries which is proposed for our study has received limited research attention, since only the studies of Lee, (2004) and Schmidt and Berri, (2001) are found in the literature, however, none of them concerns competitive balance in European football.

Testing the significance of a great number of existing, modified and new indices that capture various aspects of competitive balance is quite innovative, since the common practice is to employ a maximum of four indices; Lee and Fort (2008) employ four indices (or factors) whereas Humphreys (2002) and Lee (2004) employ three. The extensive number of indices used in our study can be considered advantageous in developing a comprehensive empirical representation of competitive balance as a potential determinant of demand. A properly designed econometric study may reveal which index is best or optimal for the complex structure of European football. Additionally, based on the features of the indices, interesting observations may be drawn for the aspect of competitive balance that mostly affects the fans' behaviour. Given that competitive balance is one of the key issues that ensure the long term success of the industry (Michie & Oughton, 2004), any conclusions that will be derived from such analysis should be of crucial importance for key policy-makers whose aim is to sustain the viability of European football.

The structure of this chapter is based on six sections on a number of themes related to the econometric analysis presented here. Section 8.1 discusses issues related to the nature of the data and the variables included in the model. The methodology and the construction of the econometric model in Section 8.3, follows the non-stationarity issue in Section 8.2. The empirical results are presented in Section 8.4 and discussed in Section 8.5. Lastly, Section 8.6 offers a summary of the conclusive remarks.

8.1 Variables & Data

The nature of the dataset is annual since competitive balance indices are calculated on an annual (or seasonal) basis. The size of the dataset is the unbalanced panel data used for the indices in Table 7.1 (p.157). The number of cross units n (European countries or domestic leagues) is eight while the number of years T (or seasons) ranges from 43 to 50. The variables included in the analysis are the following:

Dependent or response variable:

- $\ln ATT$: Attendance at football games (log scaled)

Independent or explanatory variables:

- $\ln CB$: Index of competitive balance (log scaled)
- $\ln POP$: National population (log scaled)
- $\ln RGNI$: Real per capita gross national disposable income (log scaled)
- $\ln Un$: Unemployment rate (log scaled)
- $d97$: Dummy variable for the period after season 1997
- t & t^2: Linear and quadratic trend

Given that a suitable form is important to the analysis (Villar & Guerrero, 2009), the natural logarithm of all indices (except from *d97* and *t*) is employed for an easier and economically important elasticity interpretation. This form also allows for non-linear (exponential) relationship of the explanatory with the response variable.

Annual attendance (ln*ATT*) is employed as the appropriate dependant variable in the demand function for attendance[28]. In particular, annual attendance per game is used account for differences in the number of teams across countries and seasons.

According to *UOH*, the main explanatory variable in this demand function for attendance is the index of competitive balance (ln*CB*). Consequently, all indices analysed in the previous chapters (see Table 6.1, p.132) are tested for their effectiveness to capture the fans' behaviour based on their effect on attendance. A negative sign in the coefficient is expected, since the value of the indices ranges from zero (perfect balance) to one (complete imbalance). The more balanced the league, the larger the attendance at the stadium.

The selection of determinants of attendance, other than the competitive balance indices, is based on the standard consumer-theory model. It is assumed that the fan-consumer's choice of attending a football game is only part of the consumption bundle to maximise utility which is subject to a budget constraint. The final decision to attend a football game or not clearly depends on the opportunity cost against other choices of goods and services. The application of the consumer-theory model recommends five categories of determinants of the demand for attendance at sporting events (Borland & MacDonald, 2003). The nature of the data prevents us from including any variable relating to the three categories of consumer preferences, quality of viewing, and supply capacity. Having already included competitive balance indices that capture the characteristics of sporting contests, the focus is to include the appropriate economic variables as is common practice in related studies across leagues.

Unfortunately, data on the important economic factor price is unavailable for such a large data panel. Price is the opportunity cost of attending a game (the total cost of

[28] The sources of attendance concerning the various European domestic leagues are presented in Table A.7 in the Appendix.

attendance, including travelling cost and time, parking, other expenses at the stadium) which is expected to negatively affect attendance (Borland & MacDonald, 2003).

However, another important economic factor is the size of the potential market, which is considered as an important explanatory variable for the demand in sports. Given the difficulty of defining potential market, market size is used as a proxy for its measurement. In particular, the total population of the metropolitan or the city is used in a number of related demand studies (Donihue, Findlay, & Newberry, 2007; Jennett, 1984; Rivers & DeSchriver, 2002; Wilson & Sim, 1995). In our case, the national population (ln*POP*) is employed as a proxy, given that in the present study leagues represent countries[29]. It is expected that the potential market expressed by the national population is to be positively related with attendance.

Fans' buying power also constitutes an important economic factor, provided that attendance at football games is a normal good. In order to capture that factor, the gross national disposable income per capita (*GNI*) is employed, which is the most typical way to evaluate the income variable (Villar & Guerrero, 2009) while some studies use alternative approaches instead of income. For instance, Bird (1982) uses real consumption spending, Schollaert and Smith (1987) use household income while Simmons (1996) uses regional real earnings. The selected *GNI* may better account for the fans' buying power instead of the gross domestic product per capita, which is suggested by Lee (2004). In particular, the real per capita *GNI* (ln*RGNI*) is used, which is the deflated per capita *GNI*, since it is divided by the consumer price index (*CPI*). All else being equal, what is expected is that ln*RGNI* will positively affect attendance.

The macroeconomic factor of unemployment rate (ln*Un*) could also affect attendance and is thus, included in the demand function. Borland and MacDonald (2003) suggest that attendance at sporting events may constitute a social outlet for unemployed persons. Moreover, in periods of high unemployment, football games

[29] The sources for the national population and the other economic variables are presented in Table A.8 in the Appendix.

may become more popular to help people manage personal disappointment (Borland & Lye, 1992; Dobson & Goddard, 1996). Consequently, other things being equal, the higher the ln*Un*, the higher the attendance is expected. However, as noted by Villar and Guerrero (2009), the most common effect of unemployment on attendance is found to be negative, although the significance of the coefficients is still low.

For the construction of the demand function, a dummy variable for the period after season 1997 (*d*97) is also included to account for two important structural changes to European football; that is, the famous 'Bosman' case and the Champion's League reform. The choice of season 1997 allows for these structural changes to have an effect in European football.

There may also be other factors that affect demand for attendance at football games that change systematically over the seasons. Therefore, for a more reliable interpretation of the effect of the variables on attendance, the time trend is eliminated by including a linear (t) and a quadratic trend (t^2) variable in the demand function.

8.2 The Non-stationarity Issue

The analysis of panel data has, until very recently, ignored the crucial non-stationarity issue. This was mainly due to the fact that panels were usually micro, that is, with a large n (cross section units) but a small T (length of time series). In essence, working with panels, multiple time series add considerably more information to the model; in that way, the spurious significance is avoided (Phillips & Moon, 1999, 2000). However, with the growing involvement of macro panels, where a large cross-sectional dimension is examined over a lengthy time series, the non-stationarity issue has started to emerge in panel data as well.

The nature of the dataset in the present study (small n and large T) stresses the adoption of panel unit root tests to avoid spurious regression issues, as described by Granger and Newbold (1974). The appropriate unit root test for unbalanced panel data is the model proposed by Maddala and Wu (1999); see e.g., Asteriou and Hall (2007). Essentially, this is an *ADF-Fisher* test, which is an alternative approach to panel unit root tests that allow for individual unit root processes. In effect, this test utilises Fisher's (1932) results to derive the combined *p*-values from individual unit root tests. Following the previous analysis, before testing the model under *UOH*, the *ADF-Fisher* panel unit root test is employed for the non-stationarity time series issue for all endogenous and exogenous variables, which were discussed in the previous section. The results of the *ADF-Fisher* panel unit root test, which is implemented with both constant and constant with trend term, are presented in Table 8.1 and in Table 8.2 for the indices and for the economic variables respectively.

The incorporated lag length, which is reported in parentheses, is derived from the lag structure, which is determined by minimisation of the Schwartz Information Criterion (*SIC*). As was expected, all indices are stationary since competitive balance must be a self-correcting mechanism if the *UOH* is true. Based on the *ADF-Fisher* panel unit root test results, the panel unit root null hypothesis is rejected even at α= 1% significance level for all competitive balance indices. The alternative hypothesis in this test is that there are some cross sections without unit root.

From Table 8.2, it is evident that the ln*ATT* variable is non-stationary in both versions of the *ADF-Fisher* panel unit root test, since the test fails to reject the panel unit root null hypothesis. However, the stationarity of the other variables is not equally apparent. More specifically, ln*POP* is considered as non-stationary only when the constant is included in the test, whereas it is considered as stationary when trend is added in the test as the unit root hypothesis is significantly rejected.

Regarding ln*RGNI*, the unit root hypothesis is rejected in both versions of the *ADF-Fisher* panel unit root test, although it barely reaches the lowest critical levels when trend is added to the test. Consequently, the ln*RGNI* series can be considered as stationarity with caution. With reference to ln*Un*, the unit root hypothesis is rejected in the version of the test, in which only the constant is included. Given the low power of the panel unit root tests for small *n*, both alternatives, that is, stationarity and non-stationarity for ln*POP*, ln*RGNI*, and ln*Un* should be tested for the right specification of the model.

Table 8.1: Statistic Values for *ADF-Fisher* Panel Unit Root Tests for Indices

	χ^2 *based ADF-Fisher* test	
Index	Constant	Constant & Trend
ln*NAMSI*	160.983^{***} (0-2)	164.850^{***} (0-3)
ln*HHI**	161.003^{***} (0-2)	164.863^{***} (0-3)
ln*AGINI*	164.989^{***} (0-3)	177.342^{***} (0-3)
ln*AH*	167.227^{***} (0-3)	174.327^{***} (0-3)
ln*nID*	169.747^{***} (0-3)	164.589^{***} (0-3)
$\ln nCB_{qual}$	145.977^{***} (0-2)	139.670^{***} (0-2)
ln*S*	165.398^{***} (0-3)	176.550^{***} (0-3)
$\ln NCR_1$	162.334^{***} (0)	155.147^{***} (0)
$\ln NCR_K$	169.407^{***} (0-1)	152.605^{***} (0-1)
$\ln NCR_I$	226.574^{***} (0)	228.513^{***} (0)
$\ln ACR_K$	148.715^{***} (0-1)	153.031^{***}(0-1)
$\ln SCR_K^I$	151.028^{***} (0-2)	159.479^{***} (0-2)
$\ln\tau$	178.090^{***} (0-1)	167.694^{***} (0)
$\ln r_s$	164.563^{***} (0-1)	153.405^{***} (0)
$\ln DN_t^*$	187.698^{***} (0)	166.708^{***} (0)
$\ln DN_1$	211.623^{***} (0)	185.327^{***} (0)
$\ln DN_K$	190.659^{***} (0-1)	166.962^{***} (0-1)
$\ln DN^I$	182.457^{***} (0-1)	158.941^{***} (0-1)
$\ln ADN_K$	162.532^{***} (0-1)	179.489^{***} (0)
$\ln SDN_K^I$	174.142^{***} (0-1)	172.446^{***} (0-1)
ln*aG*	47.943^{***} (0-2)	34.226^{***} (0-2)
$\ln DC_1$	177.212^{***} (0-1)	167.576^{***} (0-1)
$\ln DC^I$	199.336^{***} (0)	172.903^{***} (0)
$\ln ADC_K$	140.485^{***} (0-1)	171.852^{***} (0-1)
$\ln SDC_K^I$	133.947^{***} (0-1)	156.940^{***} (0-1)

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).
The lag length (numbers in parenthesis) is determined by using the Schwartz Information Criterion (*SIC*).
*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

Provided that the dependent variable (ln*ATT*) and some of the independent variables are non-stationary, there is danger of spurious economic relationships, thus rendering the output of the results also spurious (Phillips, 1986; Sims, Stock, & Watson, 1990). The differentiation of the non-stationary series is one of the methods to solve spuriousness. However, using differences of the data series (first order or even second order) we lose information on levels, and economic theory is essentially based on levels.

Table 8.2: Statistic Values for *ADF-Fisher* Panel Unit Root Tests for Economic Variables

	χ^2 *based ADF-Fisher* test	
Variable	Constant	Constant & Trend
ln*ATT*	12.687 (0-2)	8.332 (0-2)
ln*POP*	14.574 (0-9)	30.193*** (0-7)
ln*RGNI*	33.254*** (0-5)	24.172* (0-7)
ln*Un*	28.757** (0-7)	14.630 (0-7)

A description of the variables is presented in Section 8.1 (p.198).
The lag length (numbers in parenthesis) is determined using the Schwartz Information Criterion (*SIC*).
*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

Additionally, the interpretation of the results becomes quite problematic since it cancels out any meaning of elasticity. For that reason, in order to avoid possible spuriousness, what is followed as an alternative solution is the autoregressive distributed lag relation (*ADL*) (Banerjee, Dolado, Galbraith, & Hendry, 1993; Hendry & Doornik, 2009; Hendry & Nielsen, 2007). In such a relation, the regressors include lagged values of the dependent variable and current and lagged values of the explanatory variables. Essentially, following the solution of adding lags, all non-stationary variables in the model may be transformed into stationary ones. This transformation allows a reliable estimation of the standard errors. Additionally, by including lags of an explanatory variable, its effect on attendance is distributed over the years.

8.3 Methodology and Econometric Model

The most commonly used techniques followed for the analysis of panel data are the fixed and the random effect models (Baltagi, 2005; Hsiao, 2003). Generally, those approaches are appropriate in the context of a wide and short panel; that is, the number of cross-sectional units n is large and the number of time periods T is small. In our case, however, the characteristics of the dataset are entirely different, since it is a long and narrow panel data; that is, it has a small number of cross sections (n is 8 countries) over large time series observations (T is around 50 seasons).

That type of panel data requires a different approach to econometric analysis (Kennedy, 2008). In particular, Greene (2008) offers a number of different approaches according to which models can be estimated in the context of long and narrow panels. For such a panel data, it is possible to estimate a separate equation for each cross-sectional unit; that is, a different equation for every European country or domestic league. Therefore, the estimation task is to find the proper method to improve estimation of those equations by estimating them together since the interest is in the interpretation of the results at European level.

Following the suggestion proposed by Kennedy (2008), the eight equations (one for each country) are pooled together so as to improve efficiency. Such a pooled analysis with more temporal than cross-sectional units is also called "temporal dominant" (Stimson, 1985). Estimating several equations together improves efficiency only if there are some restrictions on parameters, which means that there exists a connection among those equations (Hill, Griffiths, & Lim, 2008). Based on the previous discussion, the general econometric model for the applied demand function for attendance takes the form:

$$\begin{aligned} A(L)\ln ATT_{it} &= C_i + B_1(L)\ln CB_{it} + B_2(L)\ln POP_{it} + B_3(L)\ln RGNI_{it} + B_4(L)\ln UN_{it} \\ &\quad + B_5 d97_t + \sum_{g=1}^{m} B_{5+g} t^g + \varepsilon_{it}, \qquad \varepsilon_{it} \sim \text{iid } N(0, \sigma_i^2), \end{aligned} \tag{8.1}$$

where C_i is the constant of the model, i stands for the country, t stands for the year, m stands for the degree of the trend variable, and ε is the error of the model, which is presumed to be white noise. L in model (8.1) denotes the lag operator while the lag polynomials for the series are defined as:

$$\begin{aligned} A(L) &= 1 - \alpha_1 L - \alpha_2 L^2 - \dots - \alpha_p L^p \\ B_1(L) &= \beta_{1,0} + \beta_{1,1} L + \beta_{1,2} L^2 + \dots + \beta_{1,q1} L^{q1} \\ B_2(L) &= \beta_{2,0} + \beta_{2,1} L + \beta_{2,2} L^2 + \dots + \beta_{2,q2} L^{q2} \\ B_3(L) &= \beta_{3,0} + \beta_{3,1} L + \beta_{3,2} L^2 + \dots + \beta_{3,q3} L^{q3} \\ B_4(L) &= \beta_{4,0} + \beta_{4,1} L + \beta_{4,2} L^2 + \dots + \beta_{4,q4} L^{q4} \end{aligned} \tag{8.2}$$

The variation of the constant term C_i in (8.1) allows for countries' heterogeneity and stands for the ith country-specific effect, which suggests that the overall ability to attract the fans differs among countries when all other variables are the same. The country specific effect is mostly influenced by market and football factors, which may be viewed as social factors related to football popularity, fans' loyalty, domestic league marketing and management effectiveness, as well as stadium infrastructure.

In model (8.1) all explanatory variables are assumed to have the same effect on attendance in all European domestic football leagues. This constraint enables to estimate the relative importance of the indices of competitive balance based on *UOH* at European level. The effect of the indices could vary among countries; however, our focus is on the interpretation of the results at European level. Similarly, with respect to the remaining explanatory variables, it is assumed that their effect on attendance is the same among countries, since Europe is a quite homogenous continent. Based on the imposed constraint, the magnitude and, more importantly, the sign of the explanatory variables effect enable us to determine the correct specification of the model. It may be admitted that those restrictions on parameters can create some bias; however, the efficiency created from pooling more than offset this (Baltagi, Griffin, & Xiong, 2000), which is also supported by Attanasio, Picci, and Scorpu (2000).

An additional restriction on model (8.1) is that the effect of the explanatory variables remains constant over time. As will be explained later, the focus is on the long-run or constant effect of variables on attendance; thus, such an assumption is desirable.

8.3.1 The *ADL* Scheme

The general scheme of our model is $ADL(p,q_1,q_2,q_3,q_4)$, whereas the order of the lag polynomials will be determined by the lag significance. However, a central question in our analysis is how to implement model (8.1) regarding the order of the lag polynomials. For the lag specification, the general to simple approach is followed, as suggested by Johnston and DiNardo (1997) for *ADL* schemes. This approach is essentially the procedure followed by Hendry and Ericsson (1991), which is thoroughly discussed by Ericsson, Campos, and Tran (1990) and Gilbert (1986).

With annual data, a usual initial general model used in relevant studies includes lags up to second order. This is a standard procedure to conserve degrees of freedom for models involving a large number of parameters with annual data (Catao & Terrones, 2001). Although the reported results refer to an initial *ADL* scheme of second order, an *ADL* scheme of third order is also tested with almost identical results. Therefore, the series of lag polynomials for the variables in our model in (8.1) is given by:

$$
\begin{aligned}
A(L)\ln ATT_{it} &= \ln ATT_{it} - \alpha_1 \ln ATT_{i,t-1} - \alpha_2 \ln ATT_{i,t-2} \\
B_1(L)\ln CB_{it} &= \beta_{1,0} \ln CB_{it} + \beta_{1,1} \ln CB_{i,t-1} + \beta_{1,2} \ln CB_{i,t-2} \\
B_2(L)\ln POP_{it} &= \beta_{2,0} \ln POP_{it} + \beta_{2,1} \ln POP_{i,t-1} + \beta_{2,2} \ln POP_{i,t-2} \\
B_3(L)\ln RGNI_{it} &= \beta_{3,0} \ln RGNI_{it} + \beta_{3,1} \ln RGNI_{i,t-1} + \beta_{3,2} \ln RGNI_{i,t-2} \\
B_4(L)\ln UN_{it} &= \beta_{4,0} \ln UN_{it} + \beta_{4,1} \ln UN_{i,t-1} + \beta_{4,2} \ln UN_{i,t-2}
\end{aligned}
\tag{8.3}
$$

The reduction of possibly redundant lags and/or variables in (8.1) is validated by the *Wald* test, which has the properties of the usual *t* and *F* tests. The conventional inference procedure is based on the move of the Schwarz Information Criterion and adjusted R^2.

In such a model, the current value of the response variable depends on the current and the previous values of the explanatory variables and on the error term ε. Alternatively, the general relation shows that the current values of the explanatory variables has an effect on the current and future values of the response variable. This implies a set of dynamic responses of the response variable to any given change in the explanatory variable (Johnston & DiNardo, 1997). The main interest in the current study is to determine the long-run response, although immediate, short-run, and medium-run responses could also be estimated.

8.3.2 The Long-run Impact and the Reparameterised *ADL* Scheme

In an *ADL* scheme, the long-run impact of any regressor in attendance is given by summing up all partial responses. Given that most of the variables are in logarithmic form, the static equilibrium equation implies a constant elasticity equilibrium relation (Johnston & DiNardo, 1997). For illustration, we consider the following simple *ADL* scheme:

$$
\begin{aligned}
A(L)y_t &= m + B(L)x_t + \varepsilon_t \\
y_t - \alpha_1 y_{t-1} &= m + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t \\
y_t &= m + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t .
\end{aligned}
\tag{8.4}
$$

This is an $ADL(1,1)$ scheme with one lag for both the dependent and the single explanatory variable. From (8.4), we get a series of equations:

$$
\begin{aligned}
y_t &= m + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t \\
y_{t+1} &= m + \alpha_1 y_t + \beta_0 x_{t+1} + \beta_1 x_t + \varepsilon_{t+1} \\
y_{t+2} &= m + \alpha_1 y_{t+1} + \beta_0 x_{t+2} + \beta_1 x_{t+1} + \varepsilon_{t+2} \\
y_{t+3} &= m + \alpha_1 y_{t+2} + \beta_0 x_{t+3} + \beta_1 x_{t+2} + \varepsilon_{t+3} \\
&\dots
\end{aligned}
\tag{8.5}
$$

The partial derivatives from series (8.5) are given by:

$$
\begin{aligned}
&\frac{\partial y_t}{\partial x_t} = \beta_0 \\
&\frac{\partial y_{t+1}}{\partial x_t} = \frac{\partial y_t}{\partial x_{t-1}} = \alpha_1 \frac{\partial y_t}{\partial x_t} + \beta_1 = \alpha_1 \beta_0 + \beta_1 \\
&\frac{\partial y_{t+2}}{\partial x_t} = \frac{\partial y_t}{\partial x_{t-2}} = \alpha_1 \frac{\partial y_{t+1}}{\partial x_t} = \alpha_1 (\alpha_1 \beta_0 + \beta_1) \\
&\frac{\partial y_{t+3}}{\partial x_t} = \frac{\partial y_t}{\partial x_{t-3}} = \alpha_1 \frac{\partial y_{t+2}}{\partial x_t} = \alpha_1^2 (\alpha_1 \beta_0 + \beta_1) \\
&\dots
\end{aligned}
\tag{8.6}
$$

The long-run effect γ of a unit change in x_t on y_t is the sum of all partial derivatives:

$$
\begin{aligned}
\gamma &= \frac{\partial y_t}{\partial x_t} + \frac{\partial y_t}{\partial x_{t-1}} + \frac{\partial y_t}{\partial x_{t-2}} + \frac{\partial y_t}{\partial x_{t-3}} + \dots = \frac{\partial y_t}{\partial x_t} + \frac{\partial y_{t+1}}{\partial x_t} + \frac{\partial y_{t+2}}{\partial x_t} + \frac{\partial y_{t+3}}{\partial x_t} + \dots \\
&= \beta_0 + (\alpha_1 \beta_0 + \beta_1) + \alpha_1 (\alpha_1 \beta_0 + \beta_1) + \alpha_1^2 (\alpha_1 \beta_0 + \beta_1) + \dots \\
&= \beta_0 (1 + \alpha_1 + \alpha_1^2 + \alpha_1^3 + \dots) + \beta_1 (1 + \alpha_1 + \alpha_1^2 + \alpha_1^3 + \dots) \\
&= \frac{\beta_o + \beta_1}{1 - \alpha_1} = \frac{B(1)}{A(1)}, \qquad \text{due to stationarity, } |\alpha_1| < 1,
\end{aligned}
\tag{8.7}
$$

where $B(1)$ equals the sum of $\beta_0+\beta_1$, and $A(1)$ equals 1-α_1. If we consider y_t and x_t in logarithmic form, γ is the constant elasticity. For a second order like our *ADL* scheme, following (8.1), (8.3), and (8.7), the constant elasticity γ_1 of lnCB_{it} on lnAtt_{it} is given by:

$$\gamma_1 = \frac{\beta_{1,0}+\beta_{1,1}+\beta_{1,2}}{1-\alpha_1-\alpha_2} = \frac{B_1(1)}{A(1)}, \qquad \text{due to stationarity, } |\alpha_1+\alpha_2|<1. \qquad \textbf{(8.8)}$$

The relation in (8.1) and (8.4) is only in terms of the levels of the variables. However, the properties of *ADL* relations can better be revealed through reparameterisation of the original equation in both levels and first differences (Hendry & Nielsen, 2007; Johnston & DiNardo, 1997). By switching to the reparemeterised *ADL* scheme, a substantial reduction is enabled in the collinearity of the regressors, which leads to smaller standard errors of the new parameters. Coefficient estimates may be affected by the correlation between the *RGNI* variable with the other determinants of attendance of *POP* and *Un* respectively (Borland & MacDonald, 2003). It must be noted that the estimated standard error of the regression, the log-likelihood values, the Durbin-Watson statistic, and the information criteria do not change (Johnston & DiNardo, 1997). Through the estimation and testing of the sums $A(1)$ and $B(1)$ in equations (8.7) and (8.8), the existence of the relevant cointegrating relation can be directly examined. Moreover, the reparemeterised *ADL* scheme also facilitates the identification of possible simplifications of the relationship between variables.

In our model, the reparameterisation of (8.2) and (8.3) in terms of both levels and first differences (innovations) for the second order lags of attendance is given by:

$$\begin{aligned} A(L) &= 1-\alpha_1 L-\alpha_2 L^2 \\ &= A(1)L+(1-L)(1+\theta_1 L) \\ A(L)\ln ATT_{it} &= \Delta \ln ATT_{it} + A(1)\ln ATT_{i,t-1} + \theta_1 \Delta \ln ATT_{i,t-1}, \end{aligned} \qquad \textbf{(8.9)}$$

where Δ is the first difference (innovation) operator, θ_1 is the coefficient of the lagged first difference. $A(1)$ is the denominator of equation (8.8) and equals 1-α_1-α_2.

For clarification, $\Delta \ln ATT_{i,t-1}$ equals $\ln ATT_{i,t-1}$-$\ln ATT_{i,t-2}$. Following a similar procedure, the reparemeterisation for $B_1(L)\ln CB_{i,t}$ or for any other explanatory variable in (8.3) is given by:

$$\begin{aligned} B_1(L) &= \beta_{1,0} + \beta_{1,1}L + \beta_{1,2}L^2 \\ B_1(L) &= B_1(1)L + (1-L)(\delta_{1,0} + \delta_{1,1}L) \\ B_1(L)\ln CB_{it} &= B_1(1)\ln CB_{i,t-1} + \delta_{1,0}\Delta \ln CB_{it} + \delta_{1,1}\Delta \ln CB_{i,t-1}, \end{aligned} \tag{8.10}$$

where δ is the coefficient of the first difference, $B_1(1)$ is the nominator of equation (8.8) and is equal to the sum of $\beta_{1,0}$+ $\beta_{1,1}$+$\beta_{1,2}$ coefficients. The long-run elasticity interpretation, given by (8.8) is unchanged and is derived by minimising the first differences of $\ln ATT$ and $\ln CB$ in equations (8.9) and (8.10) respectively.

Following the previous analysis for the reparemeterisation in model (8.1), the full specification of the new model is given by:

$$\begin{aligned} \Delta \ln ATT_{it} = C_i &+ B_1(1)\ln CB_{i,t-1} + \delta_{1,0}\Delta \ln CB_{it} + \delta_{1,1}\Delta \ln CB_{i,t-1} \\ &+ B_2(1)\ln POP_{i,t-1} + \delta_{2,0}\Delta \ln POP_{it} + \delta_{2,1}\Delta \ln POP_{i,t-1} \\ &+ B_3(1)\ln RGNI_{i,t-1} + \delta_{3,0}\Delta \ln RGNI_{it} + \delta_{3,1}\Delta \ln RGNI_{i,t-1} \\ &+ B_4(1)\ln UN_{i,t-1} + \delta_{4,0}\Delta \ln UN_{it} + \delta_{4,1}\Delta \ln UN_{i,t-1} \\ &- A(1)\ln ATT_{i,t-1} - \theta_1 \Delta \ln ATT_{i,t-1} \\ &+ B_5 d97_t + \sum_{g=1}^{m} B_{5+g}t^g + \varepsilon_{it}, \end{aligned} \tag{8.11}$$

After estimating the reparameterized model (8.11), the static equilibrium is given by putting all innovations to zero.

8.3.3 *OLS* and Assumptions Violation

Before testing the above model we should discuss, an important methodological issue. The estimation of pooled data via *OLS* tends to generate serious complications (Hicks, 1994). For *OLS* to be optimal, it is important that errors have the usual properties of i.i.d.; that is, they are homoscedastic and independent of each other. However, the estimation of pooled data using *OLS* often violates those assumptions about the error process. According to Hicks (1994), from period to period errors tend not to be independent. Therefore, errors may be serially correlated within cross-sectional units or countries. For instance, errors in country *i* at time *t* are correlated with errors in country *i* at time *t*+1. Many national features (i.e. population) are not independent across years.

Additionally, errors tend to be correlated across countries. For instance, the *t*th error term in the *i*th country is correlated with the *t*th error term in the *j*th country. This type of correlation is called contemporaneous correlation. Those errors contain the influence on attendance of structural factors that have been omitted from the equation. Such factors might include the impact from TV broadcasting, the advent of advertising and sponsoring, the high-tech stadium infrastructure, and the progress in technology manufacturing football material.

Lastly, errors also tend to be heteroskedastic, that is, they have different variances across countries. This may be explained by the substantial difference both in size and population among the examined European countries. For instance, as is already shown in Chapter 7, the volatility of the indices of competitive balance greatly differs among European countries. Such a variation in volatility is also expected in other national traits due to the different levels of the variables across countries.

8.3.4 The Seemingly Unrelated Regressions

Given the characteristics of our data, it is critical to determine the optimal method for the estimation of the model in (8.11). The equality of slopes in explanatory variables connects individual equations. However, such constraint improves the efficiency only if the error assumptions are not violated. A common technique to improve the model is to allow for a contemporaneous correlation between error terms across equations. This method is the *Seemingly Unrelated Regressions* (*SUR*) estimation, which is an *Estimated Generalised Least Squares* approach (*EGLS*) (Greene, 2008).

The *SUR* technique is developed by Zellner (1962) based on the assumption that equations seem to be unrelated, but the additional information provided by the correlation between errors signifies that the joint estimation via generalised least squares estimation is more appropriate than the single equation least squares estimation. According to Kmenta and Gilbert (1968), if errors are normally distributed, iterating *SUR* yields the maximum likelihood estimates (*MLEs*). Especially, Hill, Griffiths, and Lim (2008) propose this technique for the estimation of "long and narrow" panels instead of the "conventional" fixed or random effects models. Moreover, Beck and Katz (1995, 1996) claim that *SUR* application may be used only if T is quite large relative to n, which is our case. They claim that only in that case is the contemporaneous variance-covariance matrix well estimated, and the *SUR* technique improves the model.

The joint estimation of equations using the *SUR* technique accounts not only for the contemporaneous correlation between the errors but also for the different variances of the error terms in the equations. It is also possible that the *SUR* and *OLS* techniques provide identical results. In particular, no gains may be obtained from the *SUR* procedure either if the regressors are the same across units or if the variance-covariance matrix of errors is diagonal.

8.3.5 Testing for the Seemingly Unrelated Regressions

Provided that the explanatory variables in (8.11) differ among countries, there is a number of tests that can be undertaken using a variety of methods for identifying equality of variances and zero contemporaneous correlation between errors across equations (Greene, 2008). In particular, in the present study a quite simple Lagrange Multiplier (*LM*) test is employed, which is suggested by Breusch and Pagan (1980). The correlation coefficient between the ith and jth residuals is estimated first using simple *OLS*. The product of sample size times the sum of all squared estimated correlations provides the test statistic for *LM*:

$$LM = T\sum_{i=2}^{n}\sum_{j=1}^{i-1} r_{ij}^{2}, \tag{8.12}$$

where T and n stand for number of time periods and cross-sectional units respectively. The *LM* test is distributed as a chi-square (χ^2) with degrees of freedom equal to the total number of correlations. In particular, under the null hypothesis of no contemporaneous correlation, for large samples this test has a χ^2 distribution with

$n(n-1)/2$ degrees of freedom. If the null hypothesis of zero correlation is not rejected, there is no evidence to recommend that *SUR* improves the model.

8.3.6 The Serial Autocorrelation Issue

The serial autocorrelation issue is usually resolved by employing an *ADL* scheme including lags for the response variable. Otherwise, a first-autoregressive model *AR*(1) may be used following the procedure of Parks-Kmenta; see Parks (1966) and Kmenta (1971, 1986). According to this method, two sequential *EGLS* transformations are required for *SUR AR*(1) models. The first *EGLS* eliminates the serial correlation of the errors. This can be done by employing *OLS* in the initial equation model. The residuals from this estimation are employed to estimate the unit-specific serial correction of the errors. Those errors are then used to transform the model with serially independent errors. Subsequently, the second *EGLS* eliminates contemporaneous correlations and automatically corrects for any panel heteroskedasticity via the *SUR* method (Podesta, 2002).

A fairly simple test for first order autocorrelation is based upon the Durbin-Watson test in which the alternative hypothesis is given by (Durbin & Watson, 1950, 1951):

$$\varepsilon_{it} = \rho\varepsilon_{i,t-1} + \upsilon_{it} \tag{8.13}$$

where υ_{it} is i.i.d. across units and time and $|\rho|<1$. For a panel data model following an *AR*(1) process, Bhargava, Franzini and Narendranathan (1982) suggest a generalisation of the Durbin-Watson statistic with lower and upper bounds on the true critical values that depend on n, T, and the number of exogenous variables (Baltagi, 2005). Unlike the true time series case, the inconclusive region for the panel data Durbin-Watson test is much smaller. When testing against positive autocorrelation, Bhargava et al. (1982) suggest simply testing if the computed statistic is less than two (Verbeek, 2004).

8.4 Empirical Results

For the econometric analysis, the quantitative software Eviews 7.0 and Excel has been used. Initially the serial autocorrelation issue is investigated, since our panel data is 'temporal dominant'. Using simple *OLS*, two lags of ln*ATT* we found to be significant even at α=1% level of significance, which is expected to solve the first order-autocorrelation issue. The Durbin-Watson test statistic results for every competitive balance index included in model (8.11) are reported in Table 8.3. As was anticipated, all Durbin-Watson values (very close to two) clearly indicate absence of serial autocorrelation. Consequently, the Cochrane-Orcutt estimation is not required according to the original estimates from *OLS*.

Table 8.3: Durbin-Watson (*D-W*) Test Statistic from *OLS*

Index in the Model	*D-W*	*Index in the Model*	*D-W*
$\ln NAMSI$	2.006	$\ln r_s$	2.002
$\ln HHI^*$	2.013	$\ln DN_t^*$	1.994
$\ln AGINI$	2.006	$\ln DN_1$	1.993
$\ln AH$	2.007	$\ln DN_K$	1.989
$\ln nID$	1.996	$\ln DN^I$	1.994
$\ln nCB_{qual}$	2.008	$\ln ADN_K$	1.978
$\ln S$	2.005	$\ln SDN_K^I$	1.980
$\ln NCR_1$	2.007	$\ln aG$	1.987
$\ln NCR_K$	2.005	$\ln DC_1$	1.983
$\ln NCR^I$	2.003	$\ln DC^I$	1.993
$\ln ACR_K$	2.007	$\ln ADC_K$	1.984
$\ln SCR_K^I$	2.007	$\ln SDC_K^I$	1.992
$\ln \tau$	2.002		

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

The necessity of the *SUR* technique in the reparameterized *ADL* model is tested in a second step. Therefore, the correlations between the residuals of each country (derived from the *OLS*) are estimated. For illustration, the correlation results for the SDC_K^I index, are displayed in the correlation matrix in Table 8.4. According to (8.12), the *LM* test statistic for Table 8.4 is equal to 42.189 (*p*-value based on χ^2 with 23 dfs equal to 0.008). The results from the *LM* test for all competitive balance indices included in the model are displayed in Table 8.5. Based on the *LM* test results, the null hypothesis of no contemporaneous correlation between the errors of the equations is significantly rejected for all competitive balance indices. Consequently, the estimation of the model (8.11) can be significantly improved by employing the *SUR* technique.

Table 8.4: Residual Correlation Matrix with SDC_K^I in the Model

	BEL	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
BEL	1							
ENG	-0.159	1						
FRA	0.018	-0.024	1					
GER	0.000	-0.075	0.142	1				
GRE	-0.191	-0.090	-0.059	-0.264	1			
ITA	-0.112	-0.115	0.062	0.003	0.047	1		
NOR	0.270	0.065	-0.231	0.092	-0.200	0.030	1	
SWE	0.139	0.343	-0.293	-0.034	-0.269	0.071	0.442	1

Table 8.5: *LM* Test Statistic for *SUR* Testing

Index in the Model	*LM*	*Index in the Model*	*LM*
$\ln NAMSI$	41.644^{***}	$\ln r_s$	41.841^{***}
$\ln HHI^*$	41.472^{**}	$\ln DN_t^*$	39.161^{**}
$\ln AGINI$	41.897^{***}	$\ln DN_1$	39.927^{**}
$\ln AH$	41.894^{***}	$\ln DN_K$	43.551^{***}
$\ln nID$	39.406^{**}	$\ln DN^I$	39.298^{**}
$\ln nCB_{qual}$	42.052^{***}	$\ln ADN_K$	39.810^{**}
$\ln S$	42.054^{***}	$\ln SDN_K^I$	39.151^{**}
$\ln NCR_1$	46.751^{***}	$\ln aG$	37.904^{**}
$\ln NCR_K$	44.428^{***}	$\ln DC_1$	39.002^{**}
$\ln NCR^I$	40.164^{**}	$\ln DC^I$	39.927^{**}
$\ln ACR_K$	45.466^{***}	$\ln ADC_K$	42.230^{***}
$\ln SCR_K^I$	44.539^{***}	$\ln SDC_K^I$	42.189^{***}
$\ln \tau$	41.441^{**}		

An overview of the indices by type and dimension is presented in Table 6.1 (p.132).
*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

Furthermore, the White cross-section covariance method for *SUR* models is applied, which is suggested by Wooldridge (2002). More specifically, this is an *EGLS* method which assumes that the errors are contemporaneously (cross-sectionally) correlated and provides heteroskedasticity-robust estimate of the variance-covariance matrix. Moreover, the pooled regression is treated as a multivariate regression and robust standard errors are computed for the system of equations. The estimator is robust both to cross-equation (contemporaneous) correlation and heteroskedasticity (White, 1980, 1984).

Using the *EGLS-SUR* method, two lags of attendance are found to be highly significant; therefore, the first lag of both the level and the innovation of attendance are included as regressors. Consequently, the initial reparameterised *ADL* model in (8.11) is of second order. The results of the version when the SDC_K^I index is included in the model are presented in equation (8.14) and in Table 8.6 while the overall results for all other indices are presented in Tables C.1-C.24 on the Appendix C.

$$\begin{aligned}\Delta \ln ATT_t = {} & C_i - 0.213 \ln SDC_{K,t-1}^1 - 0.174 \Delta \ln SDC_{K,t}^I \\ & + 0.856 \ln POP_{t-1} - 3.799 \Delta \ln POP_{t-1} \\ & + 0.099 \ln RGNI_{t-1} + 0.157 \Delta \ln RGNI_t \\ & + 0.026 \ln UN_{t-1} - 0.186 \ln ATT_{t-1} - 0.109 \Delta \ln ATT_{t-1} \\ & - 0.015t + 0.0002t^2\end{aligned} \tag{8.14}$$

The issue of first order serial autocorrelation does not arise here, since the *D-W* test statistic is very close to two. Depending upon the index included, the model explains from 12% to 17.5% of the observed variation of attendance. The adjusted R^2 is small because of two important factors: a) the inability to include other important variables for demand in attendance like ticket price, televised games, information for particular leagues or seasons, and b) the substantial reduction in the collinearity of the regressors. For our dataset, the correlation coefficient between economic variables ranges from 0.21 to 0.39. There is no unit root in the residuals, since the *ADF-Fisher* panel unit root test is rejected even at α=1% significance level. The normality assumption concerning the distribution of the residuals of the equations cannot be rejected based on the results of the Jarque-Bera statistic, which is the appropriate normality test. Normality is rejected only in Belgium residuals, when DN_t^* and *AG* indices are included in the model.

The main interest in this study is the long-run impact of the variables on attendance, which is derived by solving the reparameterised *ADL* model (8.11) and setting all first differences to zero.

Table 8.6: *EGLS-SUR* Results for Attendance Model, Europe 1959-2008
Dependent Variable is $\Delta\ln ATT$

	$\ln SDC_K^I$	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1^{st} lag:	-0.213*** (0.037)	0.856*** (0.250)	0.099*** (0.019)	0.026** (0.013)	-0.186*** (0.030)
Δ:	-0.174*** (0.034)		0.157* (0.093)		
1^{st} lag of Δ:		-3.799** (1.926)			-0.109** (0.041)
	d97	*t*	t^2	*D-W*†	R^2adj
		-0.015*** (0.003)	0.0002*** (0.000)	1.991	0.175
χ^2 *ADF-Fisher* $(p)^a$:	Constant 203.594*** (0-2)		Constant & Trend 191.173*** (0-2)		

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.519	0.219	0.919	0.404	0.720	0.665	0.798	0.661

A description of the variables is presented in Section 8.1 (p.198).
Numbers in parentheses are standard errors; Δ is the first difference.
${}^a p$ = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).
*Significant at α=10%; **significant at α=5%; ***significant at α=1%.
†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

For clarification, the equation for the long-run relationship among in level variables, when the comprehensive SDC_K^I index is incorporated, is given by solving (8.14) as follows:

$$\begin{aligned} 0 &= C_i - 0.213\overline{\ln SDC_K^I} + 0.856\overline{\ln POP} + 0.099\overline{\ln RGNI} + 0.026\overline{\ln UN} \\ &\quad - 0.186\overline{\ln ATT} - 0.015t + 0.0002t^2 \\ \overline{\ln ATT} &= C_i / 0.186 - 1.142\overline{\ln SDC_K^I} + 4.591\overline{\ln POP} + 0.534\overline{\ln RGNI} + 0.141\overline{\ln UN} \\ &\quad - 0.082t + 0.01t^2 \end{aligned} \quad \textbf{(8.15)}$$

Following the procedure in equation (8.15), the long-run elasticity effect of the explanatory variables on attendance for all versions of the model as well as trend and dummy variable effect are presented in Table 8.7.

Table 8.7: Long-run Elasticity Effect of Indices and Economic Variables on Attendance; Trend & Dummy Variable Effect

Index in Model		ln*POP*	ln*RGNI*	ln*UN*	*t*	t^2	$d97^{\dagger}$
$\ln NAMSI$	-0.175	5.147***	0.456***	0.203***	-0.081***	0.001***	0.223**
$\ln HHI^*$	-0.088	5.147***	0.456***	0.203***	-0.081***	0.001***	0.223**
$\ln AGINI$	-0.106	5.225***	0.454***	0.202***	-0.082***	0.001***	0.216*
$\ln AH$	-0.045	5.234***	0.453***	0.202***	-0.082***	0.001***	0.217*
$\ln nID$	0.006	5.261***	0.451***	0.204***	-0.082***	0.001***	0.209*
$\ln nCB_{qual}$	-0.378***	4.551***	0.461***	0.197***	-0.077***	0.001***	0.253**
$\ln S$	-0.090	5.232***	0.452***	0.203***	-0.082***	0.001***	0.216*
$\ln NCR_1$	-0.548***	4.452***	0.466***	0.180**	-0.077***	0.001***	0.205*
$\ln NCR_K$	-0.457***	4.746***	0.473***	0.204**	-0.079***	0.001***	0.223**
$\ln NCR^I$	0.059	5.409***	0.445***	0.188**	-0.081***	0.001***	0.187**
$\ln ACR_K$	-0.636***	4.410***	0.475***	0.192***	-0.077***	0.001***	0.226**
$\ln SCR_K^I$	-0.579***	4.577***	0.471***	0.194**	-0.078***	0.001***	0.234**
$\ln \tau$	-0.326	5.024***	0.460***	0.227***	-0.077***	0.001***	0.261**
$\ln r_s$	-0.359	5.107***	0.476***	0.229***	-0.077***	0.001***	0.250**
$\ln DN_t^*$	-0.084	4.983***	0.446***	0.220***	-0.076***	0.001***	0.249**
$\ln DN_1$	-0.005***	5.112***	0.455***	0.192**	-0.080***	0.001***	0.219**
$\ln DN_K$	-0.621***	5.045***	0.487***	0.183**	-0.080***	0.001***	0.177*
$\ln DN^I$	0.071	5.088***	0.444***	0.192**	-0.080***	0.001***	0.197*
$\ln ADN_K$	-0.673***	5.036***	0.501***	0.145**	-0.085***	0.001***	
$\ln SDN_K^I$	-0.850***	4.879***	0.518***	0.153**	-0.086***	0.001***	
$\ln aG$	0.023	5.961***	0.484***	0.176**	-0.074***	0.001***	
$\ln DC_1$	-0.476***	5.238***	0.497***	0.158**	-0.082***	0.001***	
$\ln DC^I$	-0.040	5.192***	0.456***	0.211***	-0.078***	0.001***	0.227***
$\ln ADC_K$	-0.996***	4.662***	0.519***	0.136**	-0.081***	0.001***	
$\ln SDC_K^I$	-1.142***	4.591***	0.534***	0.141**	-0.082***	0.001***	

An overview of the indices by type and dimension is presented in Table 6.1(p.132) and a description of the variables is presented in Section 8.1 (p.198).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†The dummy variable *d97* was excluded from the identified model when it was not found to be significant at the 10% significance level. For interpretation reasons, the time trend (*t*) is tested up to the second grade.

As was expected, the sign of competitive balance indices is negative. In general, the parameters of economic variables are highly significant with the expected type of effects at conventional significance levels. Given that residuals are stationary, there's a strong evidence of a cointegrating relation between attendance and all economic variables (Johnston & DiNardo, 1997). On the other hand, no cointegration relation is evidenced for all indices. The sign of dummy and trend variables enable for a suitable interpretation of the results.

Lastly, the general test for specification error Ramsey *RESET* test has been used for omitted variables, incorrect functional form, and correlation between explanatory variables and residuals (Ramsey, 1969; Ramsey & Schmidt, 1976). Based on the results, the *RESET* test statistic has a *p*-value higher than 0.1 for all versions of the model. The null hypothesis of no misspecification cannot be rejected even at α=10% significance level and, therefore, the model seems to be well-specified[30].

8.5 Discussion of the Findings

Our *ADL* model is of second grade given that two lags of attendance are found to be significant. This implies that both innovation for two seasons before and the level of attendance the previous season have an effect on the current innovation of attendance (see complete results on Tables C.1. to C.24 on the Appendix). Based on the results presented in Table 8.7, it follows a discussion for the effect of all variables on attendance. The findings for the effect of economic, trend, and dummy variables are initially presented, followed by the relevant findings for the competitive balance indices.

8.5.1 The Effect of Economic, Trend, and Dummy Variables on Attendance

With respect to population, in most cases, two lags are found to be significant. As was expected from economic theory (Borland & MacDonald, 2003), the long-run effect of population is found to be positive. In particular, the long-run impact of population on attendance is very strong, since long-run elasticity is close to five regardless of the index employed in the model. Consequently, attendance is highly elastic to population. For illustration, a 1% increase in national population increases football attendance almost by 5%. This result is roughly consistent with the findings from Schmidt and Berri (2001) and Scully (1989). In a similar study with a panel data, using domestic baseball leagues as cross units, the coefficient of population is also found to be positive but not found to be significant (Lee, 2004). Additionally, in

[30] The detailed results are not shown here, however, they are available upon request.

other studies this effect was either reported as ambiguous (Coffin, 1996) or found as non-significant (Humphreys, 2002).

The long-run impact of income on attendance is considerably lower than that of population, and equals close to 0.5. To clarify, 1% increase in real per capita *GNI* brings about 0.5% increase in attendance. The magnitude of income effect keeps up with the small *GDP* effect, which is found by Lee (2004). Consequently, the fans' buying power has little effect on their decision to attend a football game. Attendance is income inelastic and definitely not a luxury good. However, the positive coefficient suggests that attendance is a normal good, which is generally consistent with the findings of Schmidt and Berri (2001) and Scully (1989).

On the other hand, although the unemployment rate is highly significant and has a positive effect on attendance, its magnitude is relatively small. More specifically, the constant elasticity equilibrium of the unemployment rate ranges from 0.14% to 0.22%. The sign of this effect accords with the assumptions of Sandercock and Turner (1981), who imply a positive effect which is justified by social factors as well as with the findings of Burdekin and Idson (1991) and Falter and Perignon (2000). On the contrary, Avgerinou and Giakoumatos (2009) have obtained the more frequent negative effect, based on the review offered by Villar and Guerrero (2009), in their study on Greek professional football.

The dummy variable *d*97 for the period after season 1997 is found to be significant, at least in most cases, with a positive effect on attendance. This suggests a combined effect of approximately 20% increase in attendance due to the two recent structural changes to European football; that is, the Bosman case and the Champions League reformation.

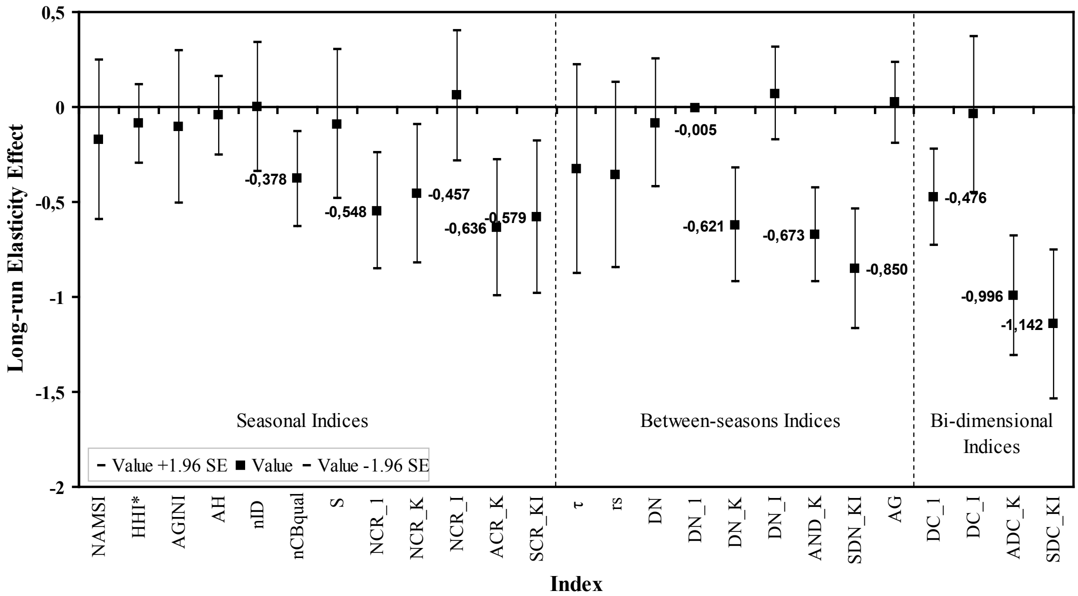
Lastly, quadratic trend was detected. In particular, the overall trend of attendance is interpreted as a downward pattern until the late 1990's and a slight upward pattern onwards. The lowest point is found in the period close to 2000, when *d*97 is included in the model. Otherwise, the lowest point is found to be somewhat earlier in the middle of the 1990's. The trend variable may capture factors that affect demand for attendance that change systematically over time, such as changes in consumer preferences as far as spending their leisure time is concerned and the competition from related sports and entertainment product industry goods. An interpretation of the findings may be derived if we consider that in the early 1960's football in Europe was a highly respectable social phenomenon. However, afterwards modern forms of social events enter the entertainment industry while football remains stagnant and struggles with hooliganism. During the last two decades, the adoption of management and marketing practices by clubs and federations, the construction of high-tech stadiums, and the great exposure by the media have given a new noticeable boost to football.

8.5.2 The Effect of the Competitive Balance Indices on Attendance

The long-run impact of the various competitive balance indices on attendance is of the upmost importance to this study. Therefore, one of the first issues to examine is to test the response of attendance to the variation of competitive balance in European domestic leagues. Based on the results, the long-run elasticity effect of the majority of the new indices is highly significant with the correct negative sign while the magnitude of the effect considerably varies. On the other hand, most conventional indices are not found to have a significant long-run elasticity effect on attendance, as is illustrated in Figure 8.1. In that figure what is also presented is the 95% confidence intervals of all indices and the value of the effect when is found to be significant at conventional significance levels α.

The findings that refer to the new indices support the suggestion that the more balanced the league, the more game attendance at the stadium. Therefore, when the new indices are employed, there is a strong indication that *UOH* and Neale's (1964) assumption concerning the *League Standing Effect* are supported by the model. The indices found to have a significant effect on attendance can successfully capture the fan's response; thus, they may be considered as more important for the quantification of competitive balance in European football. It should also be noted that in most cases in Appendix C, the innovation of the indices is highly significant and correctly signed. This implies that innovation in competitive balance has an inverse effect on the innovation of attendance. The discussion for the effect of seasonal indices on attendance is presented, followed by the relevant discussion for the between-seasons and bi-dimensional competitive balance indices.

Figure 8.1: Long-run Elasticity and 95% Confidence Intervals of the Effect of Competitive Balance Indices on Attendance



An overview of the indices by type and dimension is presented in Table 6.1 (p.132).

The Effect of Seasonal Indices on Attendance

With concern to the summary seasonal indices, only the modified nCB_{qual} index is found to have a significant long-run negative effect on attendance with elasticity being close to -0.37%. This may be justified by the greatest sensitivity of nCB_{qual} to the first and the second level as well as by its insensitiveness to the third level, as was shown in the sensitivity analysis. Those results are consistent with the findings by Lee (2004) for a non-significant *RSD* index, which is the corresponding index to *NAMSI*. On the other hand, Schmidt and Berri (2001) argue that the *Gini* coefficient, which is the corresponding index to *AGINI*, has a significant effect on attendance, yet only when a 3-season or a 5-season average of the index is employed in their model. It may be assumed that, using a conventional method of measuring seasonal competitive balance, the information gathered fails to capture the fan’s interest. Alternatively, the aspect of competitive balance which is captured by those indices is not important from the fan's perspective. Evidently, as will be shown shortly, the seasonal performance of middle and low ranking teams is not particularly important for the majority of the fans.

With respect to the partial seasonal indices, their effect is found to be highly significant with the exception of the NCR^I index, which captures the behaviour of the relegated teams. Consequently, the relative weakness of the relegated teams in the course of a particular season does not affect the fan's behaviour. The latter raises questions regarding the relative significance of the promotion-relegation rule in the course of a season as an important regulatory mechanism in European football. The inability of NCR^I to capture the fans' interest may explain the fact that the SCR_K^I index is found to have a slightly lower effect than the ACR_K index, although the latter captures only two of the three important levels in European football.

In effect, ACR_K has the greatest seasonal long-term effect with a negative constant elasticity which equals -0.63%. For illustration, the magnitude of that effect for the worst (1972) and the best seasons (1985) in Greece in terms of the competitive balance values, is interpreted as a 31.5% increase in annual attendance. Consequently, ACR_K may be considered as the most important index for the measurement of seasonal competitive balance, given that among all seasonal indices it is found to have the greatest effect. Essentially, ACR_K is a composite index, which effectively captures the seasonal dimension due to its hypersensitivity to the first and the second level of European football. Given that ACR_K is insensitive to changes in the teams' performance in the middle ranking places and given that it displays very low sensitivity to the third level, it may be assumed that fans are mostly interested in the seasonal performance of the teams at the top of the ladder.

The analysis of the remaining partial seasonal indices also provides some interesting observations. ACR_K is found to have a greater effect than NCR_K, thus, entailing that the degree of competition among the top K teams is also important for the fans. Surprisingly enough, NCR_1 (refers only to the champion's performance) has a greater negative effect on attendance than the conventional NCR_K (refers to the top K teams), which provides much more information than the former. This may signify that the champion's performance during the season is not only particularly important for fans but it also proves to be even more important than the remaining top K teams. It can also justify our assumption for an increasingly relative importance from the Kth to the 1st ranking position offered by the averaging approach. Quite impressively, the long-run elasticity of NCR_1 is very close to that of more sophisticated partial indices, such as ACR_K and SCR_K^I. Therefore, for parsimonious reasons, NCR_1 may also be considered to be a very important seasonal index.

The Effect of Between-seasons Indices on Attendance

With regard to the between-seasons dimension, though with the correct negative sign, all summary indices are not found to have a significant effect on attendance. Therefore, it may be inferred that the overall ranking mobility across seasons is not important for fans regardless of the employed index. Similarly to the summary seasonal indices, the innovation of the between-seasons indices inversely affects innovation in attendance. Regarding the partial between-seasons indices, only DN^I and AG are found to have a non-significant effect. Similarly to the relative weakness of the relegated teams into the season, the relative mobility of those teams across seasons is not considered to be important for fans. On the other hand, the aG index should be tested for various numbers of top teams as well as alternative time periods before drawing conclusive remarks for its effect.

As for the remaining partial between-seasons indices, they are found to have a significant negative effect on attendance. However, the effect of DN_1 is relatively small, since its long-run elasticity is almost zero, as it equals -0.005%. The magnitude of the champion's mobility effect across seasons is in sharp contrast with the corresponding effect of the champion's performance into the season. A possible explanation may be provided by the fact that the value of DN_1 equals unity in 124 out of a total of 377 cases. In reality, the sample average of DN_1 equals 0.845, which is very close to the upper bound of unity (the upper bound is reached, when the champion is the same for two consecutive seasons).

The effect of the partial DN_K, ADN_K, and SDN_K^I indices is higher than the corresponding seasonal indices. In general, this signifies that ranking mobility captures more effectively the fans' interest than seasonal performance. Consequently, the between-seasons dimension appears to have a greater effect on attendance than the seasonal dimension. The latter suggestion also accords with the findings presented from other related studies (Borland & MacDonald, 2003; Humphreys, 2002). It is important to note that the impact of the three indices depends on the information they provide. In particular, the SDN_K^I index has the greatest effect on attendance with a constant elasticity -0.85% followed by ADN_K and DN_K with elasticity close to -0.67% and -0.62% respectively.

Therefore, SDN_K^I, which captures all three important levels of European football, can be suggested as the between-seasons index which reflects more the fans' reactions. By comparing the effect of SDN_K^I with that of ADN_K, it may be stated that the relative mobility of relegated teams does affect attendance, although this cannot be verified by examining only the DN^I. Additionally, the comparison between the effects of ADN_K and DN_K suggests that ranking mobility among the top K teams across seasons also matters to the fans; however, it seems that fans are mostly attracted by the level of competition among the top K teams into the season[31].

The Effect of Bi-dimensional Indices on Attendance

Lastly, the effect of the bi-dimensional indices in annual attendance was examined. As was expected from the previously-discussed results, DC^I (which captures the third level in both the seasonal and the between-seasons dimension) is the only index with a non-significant long-run effect. However, the innovation of DC^I is found to have a significant -0.05% elasticity effect on attendance innovation. On the other hand, the other three bi-dimensional indices have a highly significant impact on attendance. More specifically, DC_1 (which captures the champion's seasonal performance and ranking mobility across two adjacent seasons) displays a considerable -0.476% long-run elasticity.

[31] Seasonal competition or ranking mobility among the top K teams is derived by the difference of ACR_K with NCR_K and ADN_K with DN_K indices respectively.

The ADC_K index, which captures the first two levels in both dimensions, has an almost negative elastic effect on attendance, since its constant elasticity equals -0.996. The SDC_K^I index has the greatest effect with a -1.142 long-run elasticity. Therefore, attendance is highly negatively elastic to changes of SDC_K^I (which captures all three important levels in both the seasonal and between-seasons dimension), since it increases by 1.142% for a 1% reduction in the index. The magnitude of such a large impact may be better exemplified using the empirical results. For instance, from the examination of the worst (1999) and the best seasons (1987) in Greece in terms SDC_K^I's values, this effect stands for a 38.9% increase in annual attendance or 2.829 more fans to the stadium per league game. As more impressive effect as the 15.333 more fans per league game for the worst (2007) and best (1961) seasons in England. Evidently, this effect has a considerably large economic impact in total revenues both from attendance and other relates sources such as marketing, sponsoring, merchandising and parking revenues.

The SDC_K^I may be considered as the optimal index for the study of competitive balance in European football, since it is suggested from the above analysis as the most important index from the fans' perspective. The comparison between the SDC_K^I and the ACR_K indices allows us to assume that the third level also plays an important role in European football, although this cannot be confirmed by the examination of DC^I by itself. The bi-dimensional indices have a greater effect on attendance than the corresponding seasonal and between-seasons indices; what is more, their effect is greater than any set of two carefully selected indices in the demand equation[32]. The latter signifies that bi-dimensional indices solve any collinearity issue, which arises even when correlation between included indices is very low.

8.6 Conclusion

The main objective of the present chapter, which answers the sixth issue of the thesis, was to determine the relative significance of the indices for the study of

[32] The selection of the set of two indices refers only to those indices that are found to have a significant effect. The criteria are based on the correlation results and the meaningful interpretation of competitive balance. The results are not presented here, but are available upon request.

competitive balance in the complex structure of European football. Following Zimbalist's (2003) suggestion, the main criterion is fans'-consumers' sensitivity, which is expressed by their attendance at football games. Based on the *UOH* hypothesis, a reparemeterised *ADL* pooled regression model was constructed for each competitive balance index using attendance as response variable. Given the "temporal dominant" nature of our dataset and after testing for assumptions violation, the model was analysed with the *EGLS-SUR* method. Our main objective was to find the constant elasticity equilibrium among parameters, and therefore, a number of reasonable assumptions were embodied in our model. The finally selected *ADL* model is of second grade, since two lags of attendance are found to be highly significant. In general, the model seems to be well-specified, because successfully passed the diagnostic tests and coefficients are both of the expected sign and statistically significant.

From the findings, which are generally consistent with the findings from other related studies, national population was shown to have a greater positive effect on attendance than the economic variables of national income and unemployment rate. In particular, a 1% increase in national population raises attendance at football games almost by 5%. On the other hand, the long-run impact of income is close to 0.5, whereas that of the unemployment rate is relatively small ranging from 0.14% to 0.22%. A dummy variable for the period after season 1997, which accounts for two recent structural changes to European football as well as a quadratic trend are also found to have a significant effect.

The long-run impact of the various competitive balance indices on attendance is of the upmost importance to this study. The findings that refer to the new indices support the suggestion that the more balanced the league, the greater the game attendance at the stadium. Therefore, when the new indices are employed, there is a strong indication that *UOH* and Neale's (1964) assumption concerning the *League Standing Effect* are supported by the model. In particular, the long-run elasticity effect of the majority of the new indices is highly significant with the correct negative sign while the magnitude of the effect varies considerably. On the other hand, most conventional indices are not found to have a significant long-run elasticity effect on attendance. Consequently, the results confirm both the assumption concerning the importance of the three identified levels of European football and the assumption regarding the weighting pattern offered by the averaging approach based on fans' reaction. It was also argued that as a dimension of competitive balance the between-seasons dimension is slightly more important than the seasonal dimension, which signifies that ranking mobility captures more effectively the fans' interest than seasonal performance.

ACR_K may be considered as the most important index for the measurement of seasonal competitive balance, since it is found to have the greatest effect on attendance with a -0.63% long-run elasticity. Given that ACR_K is hyper-sensitive to the first and the second levels of European football, it may be assumed that fans are mostly interested in the seasonal performance of the teams at the top of the ladder. On the other hand, the SDN_K^I index may be considered as the most important index for the study of the between-seasons dimension, since it is found to have the greatest effect on attendance with a -0.85% long-run elasticity. Essentially, SDN_K^I is a comprehensive index, which captures all three important levels of European football.

Finally, the best or optimal index for the study of European football may be the most comprehensive bi-dimensional SDC_K^I index, which captures all three levels in both dimensions, since it is found to have the greatest effect with a -1.142% long-run elasticity. Evidently, this effect has a considerably large economic impact on total revenues both concerning attendance and other relates sources. In conclusion, our findings support the assumption that the new quantification approach capture factors of competitive balance that attract the fans' interest in the context of the complex structure of European football.

Chapter 9. Summary and Conclusions

The aim of the present thesis is to offer a systematic approach to an enhanced quantification of competitive balance in professional team sports by providing an implementation and an empirical investigation in European football, which, according to Gerrard (2004, p. 39), is the heartland of football, the only truly global team sport. Given on the one hand the multi-dimensionality aspect of the concept and on the other the issues arising in the context of European football, we have argued that a new conceptual approach is required for the proper quantification of competitive balance in professional team sports.

The importance of competitive balance for the welfare of any professional sport league is an essential proposition in sports economics, which is substantiated by its effect on demand for league games or other associated league products. Due to its prominent importance, competitive balance has become a crucial topic in sports economics research, however, its quantification is still problematic (Zimbalist, 2003). In particular, although the diversity of approaches as well as indices that have been proposed in the relevant literature is quite extensive (Zimbalist, 2002), the quantification of competitive balance is still hampered by the intricate definition of its concept (Downward et al., 2009; Michie & Oughton, 2004). The main inadequacy of the related studies in analysing the quantification of competitive balance mainly derives from the limited number of the incorporated indices. Moreover, although any optimal index may be different from sport to sport (Zimbalist, 2003), the complex championship structure of European football leagues has not so far been taken into consideration for the development of related indices. What is more, the optimality of any index, which is determined by its effect on fans' behaviour (Zimbalist, 2003), concerns studies testing the "*Uncertainty of Outcome Hypothesis*" which is a relatively underdeveloped area of research (Borland & MacDonald, 2003). In particular, there is a limited number of econometric studies across countries or leagues while there is an absence of related studies on European level. In reality, there is a dearth of empirical studies of competitive balance across European football leagues.

This thesis, which uses an analytical methodological framework, aims to make a number of valuable contributions to the quantification of competitive balance in professional team sports in the context of European football. In addition, the fundamentals of that framework could also be followed for other team sport or leagues. In what follows, we will discuss our contributions in more detail followed by an introduction to subjects for future research arising from the present thesis.

9.1 Extensive Number of Existing Indices under Investigation

Using an all-embracing approach, our study offers a comprehensive review of existing indices in the literature that refer to the seasonal and the between-seasons dimensions of competitive balance, which are the most important dimensions from the fans' perspective (Borland & MacDonald, 2003). The review offers an in-depth analysis of the development, the derived function, and the main features of the indices. Following the identification of the basic characteristics of European football, we determine the appropriateness of an extensive number of indices for the study of competitive balance across domestic leagues and/or seasons.

For a more reliable calculation of some existing indices, an appropriate modification is undertaken to account for the identified variability in the number (N) of teams across leagues and/or seasons.

a. The formula for the suggested *normalised Index of Dissimilarity* (*nID*) is introduced, since the upper bound of the existing *Index of Dissimilarity* (*ID*) is proven to be a decreasing function of N.
b. *Relative Entropy* (*R*) is modified by introducing *Adjusted Entropy* (*AH*), given that the lower bound of the former is not zero, as in the standard industry, but rather an increasing function of N.
c. *Normalised Concentration Ratio* (NCR_K) is introduced for the application of the conventional *Concentration Ratio* (*CR*) in the sport setting, since the existing CR_K and C_5ICB versions suffer from a number of deficiencies for a cross examination with variant N.
d. The introduced *Normalised Quality Index* (nCB_{qual}) constitutes a modification of the existing *Quality Index* (CB_{qual}). What is shown is that the upper bound of the latter is a decreasing function of N.

e. The G index (G) is modified by presenting the alternative *Adjusted G* (aG) index to adjust for the variability in N, which is derived by accounting for the feasible range in the calculation of the original index.

9.2 Development of Specially Designed Indices

We argue that existing indices have not been derived in the context of the identified complex structure of European football leagues, in which domestic championships are multi-prize tournaments as opposed to common North American ones with a single prize. In our view, domestic European championships are considered as three-levelled tournaments, in which teams compete for the corresponding ordering set of prizes or punishments:

a) First level or first prize is the championship title which is the most prestigious prize in any league.
b) Second level or second set of prizes are the qualifying places for participation in European tournaments the following season.
c) Third level or set of punishments are the relegation places.

The development of new indices is grounded on an averaging approach, which takes into consideration the competition at each level and rates ranking positions according to their significance from the fans' perspective.

a) Seasonal Indices:
   i. *Normalised Concentration Ratio for the Champion* (NCR_1), which captures the first level.
   ii. *Adjusted Concentration Ratio* (ACR_K), which captures the first two levels.
   iii. *Normalised Concentration Ratio for Relegated Teams* (NCR^I), which captures the third level.
   iv. *Special Concentration Ratio* (SCR_K^I), which captures all three levels.
b) Between-seasons Indices:
   i. *Dynamic Index for the Champion* (DN_1), which captures the first level.
   ii. *Adjusted Dynamic Index* (ADN_K), which captures the first two levels.

iii. *Dynamic Index for Relegated Teams* (DN^I), which captures the third level.

iv. *Special Dynamic Index* (SDN_K^I), which captures all three levels.

The approach followed also enables for a comprehensive analysis by creating bi-dimensional indices that capture both the seasonal and the between-seasons dimensions of competitive balance.

c) Bi-dimensional indices:

i. *Dynamic Concentration for the Champion* (DC_1), which captures the first level.

ii. *Adjusted Dynamic Concentration* (ADC_K), which captures the first two levels.

iii. *Dynamic Concentration for Relegated Teams* (DC^I), which captures the third level.

iv. *Special Dynamic Concentration* (SDC_K^I),which captures all three levels.

9.3 Investigation of the Behaviour of the Indices

To further explore the behaviour of the indices, an innovative sensitivity analysis is employed followed by an empirical investigation. The combination of those two processes reflects the concern for an advanced understanding of the aspects of competitive balance each index stands for.

What we can infer from the sensitivity analysis is that the indices exhibit diverse behaviour, which illustrates the different aspects of competitive balance they capture. The sensitivity analysis also unveils features of the indices that are not easily distinguishable from their derived function. In particular, the sensitivity of the summary indices to the various hypothetical league states is not easily determined from the theoretical foundation. On the other hand, the behaviour of the partial indices is quite straightforwardly explained by their design. Based on the findings, the usefulness of the composite single-dimensional partial indices (SCR_K^I and SDN_K^I) is identified while what is also implied is the optimality -for the study of competitive balance in European football- of the more sophisticated bi-dimensional SDC_K^I index, which captures all three levels in both dimensions.

The empirical investigation, which employs real data from eight domestic leagues for the last 45-50 seasons, further elucidates the key points of the indices by exploring their degree and trend both on Europe and country wise. Using various statistical methods, the quite large number of the calculated indices (25 in total) unveils interesting facts concerning the historical behaviour of competitive balance in European football. Moreover, the findings reveal that the indices exhibit different patterns of behaviour. As is designated in the theoretical foundation and confirmed by the sensitivity analysis, the indices capture different components of competitive balance. Consequently, part of this diversity derives from the design of the indices; thus, for a suitable interpretation of the empirical results it is important to clearly define the aspect of competitive balance the index refers to.

What is uncovered is that the seasonal dimension does not present an issue in European football, since it reaches tolerable values; however, what is of concern is the between-seasons dimension of competitive balance, given that its value is closer to perfect imbalance, which may be interpreted as low ranking mobility across seasons. As a result, regardless of the uncertainty during the season, the stronger team finally prevails. Additionally, the competition in the middle is higher than in the top K teams and comparable with that in the low I ranking places. What is more, our study also confirms the effectiveness of the promotion-relegation rule in promoting competitive balance and the absence of competition for the championship title in European football.

The value of competitive balance greatly differs among the investigated European countries. Based on the comprehensive bi-dimensional SDC_K^I index, Sweden is the most competitive country followed by Norway, France and Germany; the ranking continues with England and Italy while Belgium and Greece are the least competitive countries. In reality, in terms of competitive balance intensity, the last four countries form the worst in a total of two distinct groups identified by cluster analysis.

Correlation analysis verifies that hardly ever is any of the top *K* teams relegated or does any of the promoted teams become the champion the following season. The latter may be interpreted by the fact ranking in the course of the previous season determines more the success for the championship title than the success for escaping relegation. Alternatively, the number of teams that are candidates for relegation is far greater than the number of teams competing for the championship title.

9.4 Significance of the Indices

Following Zimbalist's (2003) suggestion that the fans' sensitivity should be used as a filter among potential indices, an econometric study has been designed to determine the relative significance of all discussed indices. Based on the longstanding *Uncertainty of Outcome Hypothesis* (*UOH*) (Fort & Maxcy, 2003), a reparameterised *ADL* pooled regression model, using the *EGLS-SUR* method, is constructed to analyse the relationship between competitive balance and fans' interest which is exhibited by their demand for league games. The main findings of the econometric model are as follows:

a) All economic variables are found to have a significant effect on attendance. In particular, national population is shown to have the greatest effect with a long-run elasticity almost 5%. On the other hand, the long-run elasticity of income is close to 0.5%, whereas that of the unemployment rate is relatively small ranging from 0.14% to 0.22%, depending on the index included in the model.
b) In the economic theory it is suggested that the more balanced the league, the greater the game attendance at the stadium, which is supported by our findings that refer to the new indices. As a result, there is a strong indication that Neale's (1964) assumption concerning the *League Standing Effect* is supported by the model. Therefore, the results confirm the assumption concerning the importance of the three identified levels of competition in European football.
c) Given that most conventional indices are not found to have a significant long-run elasticity effect on attendance, the assumption concerning the relative significance of ranking positions from the fans' perspective is also confirmed by the model.

d) Both the seasonal and the between-seasons dimensions of competitive balance are found to be significant, although the latter is shown to have a slightly greater effect on attendance.

e) The ACR_K index for the seasonal dimension and the SDN_K^I index for the between-seasons dimension may be considered as the most important indices for the measurement of competitive balance, since they are found to have the greatest effect on attendance with a -0.63% and a -0.85% long-run elasticity respectively.

f) It may argued that the best or optimal index for the overall study of competitive balance in European football may be the most comprehensive bi-dimensional SDC_K^I index, since it is found to have the greatest effect on attendance with a -1.142% long-run elasticity. Evidently, such a large effect has a considerably large economic impact on total revenues, which reflects the importance of competitive balance for leagues and teams.

Conclusively, our findings support the assumption that, in the context of the complex structure of European football, the new averaging approach captures aspects of competitive balance that, although they are important for fans, they have so far not been taken into consideration. Essentially, all three levels in both dimensions are important; however, the relative significance of levels and ranking positions greatly varies as designated by the weighting pattern offered by the optimal SDC_K^I as well as the important ACR_K and SDN_K^I indices.

In effect, the further examination of the most important indices may prove to be a powerful tool for an in-depth analysis of competitive balance since it reveals interesting facts for league officials. For instance, our discussion for the promotion-relegation rule is related with the recent news of US-owners of English teams coveting to move to a North American closed-league system.

Similarly, explanations derived from the analysis of those indices can facilitate policy makers in their effort to preserve the viability of European football leagues, which is threatened by the worsening values of competitive balance. Regarding the identified decline of competitive balance, the explanation adopted is that offered by Goossens (2006) for the Champions League effect. In reality, bonuses for participation and successful results in European tournaments were dramatically increased during the last decade. Additionally, the increasing loyalties from the broadcasting industry are in favour of the successful teams at the top of the ladder (Michie & Oughton, 2004). Therefore, there is a widening revenue gap among the teams at the top and the remaining positions associated with competitive balance deterioration. The relatively egalitarian redistribution mechanisms appear to be an important reason for more competitive championships in France and Germany in comparison with England and Italy. This derives from the high correlation between successful results and wage expenditure (Hall, Szymanski, & Zimbalist, 2002). The striking successful results from the same group of teams in European tournaments in the absence of a generous redistribution system may be the main source of the serious decline of competitive balance in England.

9.5 Future Research

From the discussion above it is clear that the present thesis may offer ample scope for future research in the areas of the concept of competitive balance, the design of special indices, and the econometric application across countries. Our study focuses on the seasonal and between-seasons dimensions, since the shortest dimension of match uncertainty does not effectively capture the interest of the fans (Borland & MacDonald, 2003); more information (matches or games) may be required to assess the importance of competitive balance.

The seasonal dimension concerns the relative qualities of teams in the course of the season while the between-seasons dimension concerns the relative qualities of teams across a number of seasons employing end of season results or ranking positions. However, after excluding the shortest dimension of match uncertainty, a fairly large time-gap exists between match and seasonal dimension. That time-gap might generate a misleading idea regarding the value of competitive balance. Aside from single matches, an important component for the design of the domestic championship format during the season is the weekly round. Round is an essential element for football fans, since the round schedule is known to all competitors before the start of each season and it usually takes place during the weekend, when every team competes in home or away matches in rotation. A group of individual matches composes each round and, in turn, rounds compose the season. If we were able to measure competitive balance at round level, that would be a suitable candidate for the aforementioned time-gap. Neale (1964, pp. 3-4) indirectly mentions this concept in his discussion of "*league standings*" and emphasises "*the progress towards a championship or daily changes in the standings*".

Intuitively, competitive balance at round level may demonstrate in detail its development throughout the season. For that reason, round uncertainty has been introduced as a new dimension to account for the fluctuation of competitive balance in the course of the season (Manasis, Avgerinou, & Ntzoufras, 2011). In contrast to the conventionally static approach which only makes use of the final league table, they propose a dynamic approach that incorporates all weekly rounds of the league. In particular, Manasis et al. (2011) measure the seasonal dimension using round-based indices capturing a slightly different set of competitive balance factors. We suggest that such a dynamic approach can also be followed for the between-seasons dimension by employing round uncertainty for the calculation of the introduced single and bi-dimensional indices.

Regarding the design of special indices, the proposed weighting pattern of ranking positions meets the set criteria and provides a benchmark for the study of competitive balance in European football. However, the adopted averaging approach enables us to achieve alternative weighing patterns by appropriately changing the identity of the component indices. Consequently, various weighting schemes, based on the specific structure of a domestic league, could be tested for their optimality using a properly designed econometric study on European level. Furthermore, for a more reliable estimation of the relative importance of ranking places, such an econometric study could initially involve a country wise analysis using a number of country-specific variables. Subsequently, the findings concerning country-specific weighting schemes could be used for the re-estimation of competitive balance prior to a more comprehensive econometric analysis on European level, which entails a considerably large number of countries. For the estimation of the variables' coefficients we can employ random effects using Hierarchical Bayesians Models (Gelman & Hill, 2007) and WinBUGS statistical package (Spiegelhalter, Thomas, & Best, 1998).

Bibliography

Adelman, M. (1969). Comment on the 'H' Concentration Measure as a Numbers Equivalent. *Review of Economics and Statistics, 51*, 99-101.

Arnaut, J. L. (2006). *Independent European Sport Review*. Nyon: UEFA.

Asteriou, D., & Hall, S. G. (2007). *Applied Econometrics. A Modern Approach using EViews and Microfit*. New York, N.Y.: Palgrave Macmillan.

Attanasio, O. P., Picci, L., & Scorpu, A. E. (2000). Saving, Growth, and Investment: A Macroeconomic Analysis Using a Panel of Countries. *Review of Economics and Statistics., 82*(1), 182-211.

Avgerinou, V., & Giakoumatos, S. (2009). Price, Income & Unemployment Effects on Greek Professional Football. *IASE/NAASE Working Paper Series, No.09-07*.

Balfour, A., & Porter, P. (1991). The Reserve Clause in Professional Sports: Legality and Effect on Competitive Balance. *Labor Law Journal, 42*(1), 8-18.

Baltagi, B. H. (2005). *Econometric Analysis of Panel Data* (3rd ed.). Hoboken, NJ: John Wiley & Sons.

Baltagi, B. H., Griffin, J. M., & Xiong, W. (2000). To pool or not to pool: Homogeneous versus heterogeneous estimators applied to cigarette demand *Review of Economics and Statistics, 82*, 117-126.

Banerjee, A., Dolado, J. J., Galbraith, J. W., & Hendry, D. F. (1993). *Co-Integration, Error-Correction, and the Econometric Analysis of Non-Stationary Data*. Oxford: Oxford University Pres.

Beck, N., & Katz, J. N. (1995). What To Do (and Not To Do) with Time-Series Cross-Section Data. *American Political Science Review, 89*, 634-647.

Beck, N., & Katz, J. N. (1996). Nuisance vs. Substance: Specifying and Estimating Time-Series-Cross-Section Models. *Political Analysis, 6*, 1-36.

Bennett, R. W., & Fizel, J. L. (1995). Telecast Deregulation and Competitive Balance: Regarding NCAA Division I Football. *American Journal of Economics and Sociology, 54*(2), 183-199.

Bhargava, A., Franzini, L., & Narendranathan, W. (1982). Serial correlation and fixed effects model. *Review of Economic Studies, 49*, 533-549.

Bikker, J. A., & Haaf, K. (2002). Measures of competition and concentration in the banking industry: a review of the literature. *Economic & Financial Modelling, 9*, 53-98.

Bird, P. J. (1982). The Demand for League Football. *Applied Economics, 14*(6), 637-649.

Booth, R. (2005). Comparing Competitive Balance in Australian Sports Leagues: Does a Salary Cup and Player Draft Measure Up? *Sport Management Review, 8*, 119-143.

Borland, J., & Lye, J. (1992). Attendance at Australian Rules Football: A Panel Study. *Applied Economics, 24*, 1053-1058.

Borland, J., & MacDonald, R. (2003). Demand for Sport. *Oxford Review of Economic Policy, 19*(4), 478-502.

Bracewell, P. J., Forbes, D. G. R., Jowett, C. A., & Kitson, H. I. J. (2009). Determining the Eveness of Domestic Competition Using a Generic Rating Engine. *Journal of Quantitative Analysis in Sports, 5*(1), ISSN (Online) 1559-0410, DOI: 1510.2202/1559-0410.1152.

Brandes, L., & Franck, E. (2007). Who made who? An empirical analysis of competitive balance in European soccer leagues. *Eastern Economic Journal, 33*(3), 379-403.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange Multiplier Test and its Application to Model Specification in Econometrics. *Review of Economic Studies, 47*, 239-253.

Burdekin, R. C., & Idson, T. L. (1991). Customer Preferences, Attendance and the Racial Structure of Professional Basketball Teams. *Applied Economics, 23*(1B), 179-186.

Butler, M. R. (1995). Competitive Balance in Major League Baseball. *The American Economist, 39*(2), 46-52.

Buzzacchi, L., Szymanski, S., & Valletti, T. (2003). Equality of Opportunity and Equality of Outcome: Open Leagues, Closed Leagues and Competitive Balance. *Journal of Industry, Competition and Trade, 3*(3), 167-186.

Cain, L. P., & Haddock, D. D. (2006). Measuring parity: Tying into the Idealized Standard Deviation. *Journal of Sports Economics, 7*, 330-338.

Cairns, J. (1987). Evaluating changes in league structure: the reorganization of the Scottish Football League. *Applied Economics, 19*(2), 259-275.

Cairns, J., Jennett, N., & Sloane, P. J. (1986). The Economics of Professional Team Sports: A Survey of Theory and Evidence. *Journal of Economic Studies, 13*(1), 1-80.

Catao, L., & Terrones, M. (2001). Fiscal Deficits and Inflation: A New Look at the Emmerging Market Evidence. *IMF working paper*, 01/74.

Clarke, S., & Norman, J. (1995). Home ground advantage of individual clubs in English soccer. *The Statistician, 44*(4), 509-521.

Close, P. (2010). Olympiads as Mega-events and the Pace of Globalization: Beijing 2008 in Context. *The International Journal of the History of Sport, 27*(16-18), 2976-3007.

Coffin, D. A. (1996). If You Build It, Will They Come? Attendance and New Stadium Construction. In J. Fizel, E. Gustafson & L. Hadley (Eds.), *Baseball Economics*. Westport, CT: Praeger Publishers.

Czarnitzki, D., & Stadtmann, G. (2002). Uncertainty of Outcome versus reputation: Empirical evidence for the First German Football Division. *Empirical Economics, 27*, 101-112.

Daly, G., & Moore, W. J. (1981). Externalities, property rights and the allocation of resources in Major League Baseball. *Economic Inquiry, 19*, 77-95.

Davies, C. (2010). The financial crisis in the English Premier League: is a salary cap the answer? *European Competition Law Review, 31*(11), 442-448.

Depken, C. A., II. (1999). Free-Agency and the Competitiveness of Major League Baseball. *Review of Industrial Organization, 14*, 205-217.

Depken, C. A., II. (2002). Free Agency and the Concentration of Player Talent in Major League Baseball. *Journal of Sports Economics, 3*(4), 335-353.

Depken, C. A., II, & Wilson, D. P. (2006). *The Uncertainty of Outcome Hypothesis in Division IA College Football*.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association, 74*, 427-431.

Dietl, H., Fort, R., & Lang, M. (2011). International Sports League Comparisons. *University of Zurich, Institute for Strategy and Business Economics, Working Paper, No. 144*.

Dietl, H., Franck, E., Lang, M., & Rathke, A. (2008). Welfare Effects of Salary Caps in Sports Leagues with Win-Maximizing Clubs. *AIES /IASE Working Paper Series, No 08-25*.

Djolov, G. (2006). *The Economics of Competition: The Race to Monopoly*. Binghampton, NY: The Haworth Press Inc.

Dobson, S., & Goddard, J. (2001). *The Economics of Football*. Cambridge, UK: Cambridge University Press.

Dobson, S. M., & Goddard, J. A. (1996). The Demand for Football in the Regions of England and Wales. *Regional Studies, 30*, 443-453.

Donihue, M. R., Findlay, D. W., & Newberry, P. W. (2007). An Analysis of Attendance at Major League Baseball Spring Training Games. *Journal of Sports Economics, 8*(1), 39-61.

Downward, P., Dawson, A., & Dejonghe, T. (2009). *Sports Economics*. Oxford, UK: Elsevier.

Durbin, J., & Watson, G. S. (1950). Testing for Serial Correlation in Least Squares Regression. *Biometrika, 37*, 409-428.

Durbin, J., & Watson, G. S. (1951). Testing for Serial Correlation in Least Squares Regression. *Biometrika, 38*, 159-178.

Eckard, W. (1998). The NCAA Cartel and Competitive Balance in College Football. *Review of Industrial Organization, 13*, 347-369.

Eckard, W. (2001a). Baseball's Blue Ribbon Economic Report: Solutions in Search of a Problem. *Journal of Sports Economics, 2*(3), 213-227.

Eckard, W. (2001b). Free Agency, Competitive Balance, and Diminishing Returns to Pennant Contention. *Economic Inquiry, 39*(3), 430-443.

Eckard, W. (2003). ANOVA-Based Competitive Balance Measure: A Defence. *Journal of Sports Economics, 4*(1), 74-80.

El-Hodiri, M., & Quirk, J. (1971). An Economic Model of a Professional Sports League. *The Journal of Political Economy, 79*(6), 1302-1319.

Ericsson, N. R., Campos, J., & Tran, H.-A. (1990). PC-GIVE and David Hendry's Econometric Methodology. *Revista de Econometria, 10*, 7-117.

Everitt, B. (1993). *Cluster Analysis* (3rd ed.). New York: Halsted Press.

Everitt, B. S., Landau, S., & Leese, M. (2001). *Cluster Analysis* (4th ed.). New York: Oxford University Press, Inc.

Falter, J., & Perignon, C. (2000). Demand for Football and Intramatch Winning Probability: An Essay on the Glorious Uncertainty of Sports. *Applied Economics, 32*, 1757-1765.

Fisher, R. A. (1932). *Statistical Methods for Research Workers* (4th ed.). Edinburgh: Oliver & Boyd.

Fizel, J. (1997). Free Agency and Competitive Balance. In D. Marburger (Ed.), *Stee-rike Four! What's Wrong with the Business of Baseball?* (pp. 61-72). Westport, CT: Praeger.

Forbes. (2011). The World's 50 Most Valuable Sports Teams. http://www.forbes.com/sites/kurtbadenhausen/2011/2007/2012/the-worlds-2050-most-valuable-sports-teams/.

Fort, R. (2003). Thinking (Some More) About Competitive Balance. *Journal of Sports Economics, 4*(4), 280-283.

Fort, R. (2006a). Competitive Balance in North American Professional Sports. In J. Fizel (Ed.), *Handbook of Sports Economics Research*. Armork, New York: M.E. Sharpe, Inc.

Fort, R. (2006b). *Sports Economics 2nd ed*. Upper Saddle River, NJ: Pearson.

Fort, R. (2007). Comments on "Measuring Parity". *Journal of Sports Economics, 8*(6), 642-651.

Fort, R., & Maxcy, J. (2003). Competitive Balance in Sports League: An Introduction. *Journal of Sports Economics, 4*(2), 154-160.

Fort, R., & Quirk, J. (1995). Cross-subsidization, Incentives, and Outcomes in Professional Team Sports Leagues. *Journal of Economic Literature, 33*(3), 1265-1299.

Fort, R., & Quirk, J. (2004). Owner Objectives and Competitive Balance. *Journal of Sports Economics, 5*, 20-32.

Gelman, A., & Hill, J. (2007). *Data Analysis Using Regression and Multilevel / Hierarchical Models*. New York, NY: Cambridge University Press.

Gerrard, B. (1998). *Competitive Balance the F.A. Premier League.* Mimeo. Leeds University Business School.

Gerrard, B. (2004). Still Up for Grabs? Maintaining the Sporting and Financial Viability of European Club Soccer. In R. Fort & J. Fizel (Eds.), *International Sports Economics Comparisons* (pp. 39-59). Westport, CT: Praeger Publishers.

Gilbert, C. L. (1986). Professor Hendry's Econometric Methodology. *Oxford Bulletin of Economics and Statistics, 48*, 283-307.

Girish, P., & Stewart, D. W. (1983). Cluster Analysis in Marketing Research: Review and Suggestions for Applications. *Journal of Marketing Research, 20*, 134-148.

Gladden, J. M., & Sutton, W. A. (2003). Professional Sport. In J. B. Parks & J. Quarterman (Eds.), *Contemporary Sport Management*. Champaign, IL: Human Kinetics.

Goossens, K. (2006). Competitive Balance in European Football: Comparison by Adapting Measures: National Measure of Seasonal Imbalance and TOP 3. *RIVISTA DI DIRITTO ED ECONOMIA DELLO SPORT, II*(2), 77-122.

Goossens, K., & Kesenne, S. (2007). National Dominance in European football leagues. In M. M. Parent & T. Slack (Eds.), *International perspectives on the management of sport* (pp. 127-148). Amsterdam: Elsevier.

Granger, C. W. J., & Newbold, P. (1974). Spurious regression in econometrics. *Journal of Econometrics, 2*(2), 111-120.

Greene, W. H. (2008). *Econometric Analysis* (6th ed.). Upper Saddle River, NJ: Prentice-Hall.

Groot, J., & Groot, L. (2003). The competitive balance of French football 1945-2002. *Economie Appliquee, LVI*(4), 91-113.

Groot, L. (2008). *Economics, Uncertainty and European Football: Trends in Competitive Balance*. Northampton: Edward Elgar Publishing Limited.

Haan, M., Koning, R. H., & van Witteloostuijn, A. (2002). Market Forces in European Soccer. *University of Groningen, SOM Research Reports 02F18*.

Haan, M., Koning, R. H., & van Witteloostuijn, A. (2008). Competitive balance in national European soccer competitions. In J. Albert & R. H. Koning (Eds.), *Statistical Thinking in Sports*. Boca Raton, FL: Taylor & Francis Group.

Hadley, L., Cieka, J., & Krautmann, A. C. (2005). Competitive Balance in the Aftermath of the 1994 Players' Strike. *Journal of Sports Economics, 6*(4), 379-389.

Hall, S., Szymanski, S., & Zimbalist, A. (2002). Testing causality between team performance and payroll: the cases of Major League Baseball and English soccer. *Journal of Sports Economics, 3*(2), 149-168.

Harris, D. (1986). *The league: The rise and decline of the NFL*. New York: Bantam Books.

Hendry, D. F., & Doornik, J. A. (2009). *Empirical Econometric Modelling using PcGive: Volume I*. London: Timberlake Consultants Press.

Hendry, D. F., & Ericsson, N. R. (1991). Modeling the Demand for Narrow Money in the United Kingdom and the United States. *European Economic Review, 35*, 833-886.

Hendry, D. F., & Nielsen, B. (2007). *Econometric Modelling: A Likelihood Approach*. Princeton: Princeton University Press.

Hicks, A. (1994). Introduction to Pooling. In T. Janoski & A. Hicks (Eds.), *The Comparative Political Economy of the Welfare State*: Cambridge University Press.

Hill, R. C., Griffiths, W. E., & Lim, G. C. (2008). *Principles of Econometrics* (3rd ed.). Hoboken, NJ: Wiley & Sons.

Hoehn, T., & Szymanski, S. (1999). The Amaricanization of European Football. *Economic Policy, 14*(28), 205-240.

Horowitz, I. (1997). The Increasing Competitive Balance in Major League Baseball. *Review of Industrial Organization, 12*(3), 373-387.

Howell, D. (1987). *Statistical Methods for Psychology* (Second ed.). Boston, MA: Duxbury Press.

Hsiao, C. (2003). *Analysis of Panel Data* (2nd ed.). Campridge, UK: Campridge University Press.

Humphreys, B. R. (2002). Alternative Measures of Competitive Balance in Sports Leagues. *Journal of Sports Economics, 3*(2), 133-148.

Humphreys, B. R. (2003). The ANOVA-Based Competitive Balance Measure: A reply. *Journal of Sports Economics, 4*(1), 81-82.

Hymer, S., & Pashigian, P. (1962). Turnover of Firms as a measure of Market Behaviour. *Review of Economics and Statistics., 44*(1), 82-87.

James, B. (2003). *The New Bill James Historical Baseball Abstract*. New York: Free Press.

Jassens, P., & Kesenne, S. (1986). Belgian Soccer Attendances. *Tijdschrift voor Economie en Management, 32*(3), 305.

Jennett, N. (1984). Attendances, Uncertainty of Outcome and Policy in Scottish League Football. *Scottish Journal of Political Economy, 31*(1), 176-198.

Johnston, J., & DiNardo, J. (1997). *ECONOMETRIC METHODS* (4th ed.). New York: McGraw-Hill.

Jones, J. C. H. (1969). The Economics of the National Hockey League. *The Canadian Journal of Economics, 2*(1), 1-20.

Kamerschen, D. R., & Lam, N. (1975). A survey of measures of Market Power. *Rivista Internazionalle di Scienze Economiche e Commercialli, 22*, 1131-1156.

Kaplan, A., Nadeau, J., & O'Reilly, N. (2011). The Hope Statistic as an Alternative Measure of Competitive Balance. *The International Journal of Sport Finance, 6*(2).

Kendall, M., & Stuart, A. (1963). *The Advanced Theory of Statistics, Vol. I: Distribution Theory* (2nd ed.). New York: Hafner.

Kennedy, P. (2008). *A Guide to Econometrics* (6th ed.). Oxford, UK: Blackwell Publishing.

Kesenne, S. (2000). Revenue Sharing and Competitive Balance in Professional Team Sports. *Journal of Sports Economics, 1*, 56-65.

Kesenne, S. (2005). The Organization of European Football and the Competitive Balance within and between Nations. Dept. of Economics, University of Antwerp, Research paper.

Kesenne, S. (2006). The Win Maximization Model Reconsidered: Flexible Talent Supply and Efficiency Wages. *Journal of Sports Economics, 7*, 416-427.

Kesenne, S. (2007). *The Economic Theory of Professional Team Sports*. Cheltnham, UK: Edward Elgar.

Kmenta, J. (1971). *Elements of Econometrics*. New York, USA: Macmillan.

Kmenta, J. (1986). *Elements of Econometrics* (2nd ed.). New York, USA: Macmillan.

Kmenta, J., & Gilbert, R. (1968). Small Sample Properties of Alternative Estimators of Seemingly Unrelated Regressions. *Journal of the American Statistical Association, 63*, 1180-1200.

Knowles, G., Sherony, K., & Haupert, M. (1992). The demand for major league baseball: a test of the uncertainty of outcome hypothesis. *The American Economist, 36*, 72-80.

Koning, R. H. (2000). Balance in competition in Dutch Soccer. *The Statistician, 49*(3), 419-431.

Krautmann, A. C., & Hadley, L. (2006). Dynasties versus Pennant Races: Competitive Balance in Major League Baseball. *Managerial and Decision Economics, 27*, 287-292.

Kringstad, M., & Gerrard, B. (2007). Beyond Competitive Balance. In M. M. Parent & T. Slack (Eds.), *International Perspectives on the Management of Sports*. Burlington, MA: Elsevier Academic Press.

Kwoka, J. (1985). The Herfindahl Index in Theory and Practice. *Antitrust Bulletin, 30*, 915-947.

Lambert, P. J. (1993). *The distribution and redistribution of income: A mathematical analysis.* Manchester, UK: Manchester University Press.

Lee, Y. H. (2004). Competitive Balance and Attendance in Japanese. Korean, and U.S. Professional Baseball Leagues. In R. Fort & J. Fizel (Eds.), *International Sports Economics Comparisons* (pp. 281-292). Westport, CT: Praeger Publishers.

Lee, Y. H., & Fort, R. (2008). Attendance and the Uncertainty-of-outcome Hypothesis in Baseball. *Review of Industrial Organization, 33*(4), 281-295.

Leeds, M. A., & von Allmen, P. (2008). *The economics of Sports 3rd Ed.* Boston, MA: Pearson Education, Inc.

Lenten, L. (2009). Towards a New Dynamic Measure of Competitive Balance: A Study Applied to Australia's Two Major Professional 'Football' Leagues. *Economic Analysis & Policy, 39*(3), 407-428.

Levin, R. C., Mitchell, G. J., Volcker, P. A., & Will, G. F. (2000). *The Report of the Independent Members of the Commissioner's Blue Ribbon Panel on Baseball Economics*. NY: Major League Baseball.

MacKinnon, J. G. (1991). Critical Values for Cointegration Tests. In R. F. Eagle & C. W. J. Granger (Eds.), *Long-run Economic Relationships: Readings in Cointegration (Advance Texts in Econometics)*. Oxford, UK.: Oxford University Press.

MacKinnon, J. G. (1996). Numerical Distibution Functions for Unit Root and Cointegration Tests. *Journal of Applied Econometrics, 11*, 601-618.

Maddala, G. S., & Wu, S. (1999). A Comperative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics, 61*, 631-652.

Madrigal, R. (1995). Cognitive anb affective determinants of fan satisfaction with sporting event attendance. *Journal of Leisure Research, 27*, 205-227.

Manasis, V., Avgerinou, V., & Ntzoufras, I. (2011). A new approach for the measurement of the seasonal competitive balance. In E. Emrich, C. Pierdzioch & M.-P. Buch (Eds.), *Europäische Sportmodelle - Gemeinsamkeiten und Differenzen in international vergleichender Perspektive (European sport models: Similarities and differences from an internationally comparative perspective)* (Vol. 13 Series of Sports Economics, pp. 117-134). Schorndorf, Germany: Hofmann Verlag GmbH & Co.

Marfels, C. (1971). A Guide to the Literature on the Measurement of Industrial Concentration in the Post-War Period. *Zeitschrift fur Nationalokonomie, 31*, 483-505.

Maxcy, J. (2002). Rethinking restrivctions in player mobility in Major League Baseball. *Contemporary Economic Policy, 20*(2), 145-159.

Maxcy, J., & Mondello, M. (2006). The Impact of Free Agency on Competitive Balance in North American Professional Team Sports Leagues. *Journal of Sport Management, 20*, 345-365.

Michie, J., & Oughton, C. (2004). *Competitive Balance in Football: Trends and Effects*. London: The Sports Nexus.

Michie, J., & Oughton, C. (2005a). *Competitive Balance in Football: 2005 Data Analysis*. Mimeo. FGRC, Birkbeck, University of London.

Michie, J., & Oughton, C. (2005b). *Competitive Balance in Football: An Update*. London: Football Governance Research Centre.

Mizak, D., Neral, J., & Stair, A. (2007). The adjusted churn: an index of competitive balance for sports leagues based on changes in team standings over time. *Economics Bulletin, 26*(3), 1-7.

Mizak, D., & Stair, A. (2004). The relationship between payroll and performance disparity in major league baseball: an alternative measure. *Economics Bulletin, 12*(9), 1-14.

Mizak, D., Stair, A., & Rossi, A. (2005). Assessing alternative competitive balance measures for sport leagues: a theoritical examination of standard deviations, gini coefficients, the index of dissimilarity. *Economics Bulletin, 12*(5), 1-11.

Mullin, B. J., Hardy, S., & Sutton, W. A. (2000). *Sport Marketing*. Champaign, IL: Human Kinetics.

Neale, W. (1964). The peculiar economics of professional sports. *Qurterly Journal of Economics, 78*(1), 1-14.

Newey, W., & West, K. (1994). Automatic Lag Selection in Covariance Matrix Estimation. *Review of Economic Studies*(61), 631-653.

Noll, R. G. (1988). Professional Basketball. Stanford University Studies in Industrial Economics Paper no. 144, Stanford, Stanford University.

O'Reilly, N., Kaplan, A., Rahinel, R., & Nadeau, J. (2008). If you Can't Win, Why Should I Buy a Ticket? Hope, Fan Welfare, and Competitive Balance. *International Journal of Sports Finance, 3*, 42-57.

Owen, P. D. (2009). Pitfalls in Using the Relative Standard Deviation of Win Percentages to Measure Competitive Balance in Sports Leagues. *Economics Discussion Papers*, No 0908, University of Otago.

Owen, P. D. (2010a). Limitations of the relative standard deviation of win percentages for measuring competitive balance in sports leagues. *Economics Letters, 109*(1), 38-41.

Owen, P. D. (2010b). Measuring Parity in Sports Leagues with Draws: Further Comments. *Economics Discussion Papers*, No. 1005, University of Otago.

Owen, P. D., Ryan, M., & Weatherston, C. R. (2007). Measuring Competitive Balance in Professional Team Sports Using the Herfindahl-Hirschman Index. *Review of Industrial Organization, 31*(4), 289-302.

Palomino, F., & Rigotti, L. (2000). The Sport League's Dilemma: Competitive Balance versus Incentives to Win. *Working Paper, Tilburg University*.

Parks, R. W. (1966). Efficient Estimation of a system of Regression Equations When Disturbances are Both Serially and Contemporaneously Correlated. *Journal of the American Statistical Association, 62*, 500-509.

Phillips, P. C. B. (1986). Understanding Spurious Regressions in Econometrics. *Journal of Econometrics, 33*, 311-340.

Phillips, P. C. B., & Moon, H. R. (1999). Linear regression limit theory for nonstationary panel data. *Econometrica, 67*(5), 1057-1112.

Phillips, P. C. B., & Moon, H. R. (2000). Nonstationary panel data analysis: An overview of some recent development. *Econometric Reviews, 19*(3), 263-286.

Phillips, P. C. B., & Perron, P. (1988). Testing for a Unit Root in Time Series Regression. *Biometrika, 75*, 335-346.

Podesta, F. (2002). Recent developments in quantitative methodology: The case of Pooled Time-Series Cross-Section Analysis. *DSS Papers SOC*(3-02).

Quirk, J., & Fort, R. (1997). *Pay Dirt: The Business of Professional Team Sports.* Princeton, New Jersey: Princeton University Press.

Ramsey, J. B. (1969). Tests for Specification Error in Classical Linear Least Squares Analysis. *Journal of the Royal Statistical Society, Series B, 31*, 350-371.

Ramsey, J. B., & Schmidt, P. (1976). Some Further Results on the Use of OLS and BLUS Residuals in Specification Error Tests. *Journal of the American Statistical Association, 71*, 389-390.

Reilly, T., & Williams, M. (2005). Introduction to science and soccer. In T. Reilly & M. Williams (Eds.), *SCIENCE and SOCCER* (2nd ed.). New York, NY: Routledge.

Rivers, D. H., & DeSchriver, T. D. (2002). Star Players, Payroll Distribution, and Major League Baseball Attendance. *Sport Marketing Quarterly, 11*(3), 175-184.

Rottenberg, S. (1956). The Baseball Players' Labor Market. *The Journal of Political Economy, 64*(3), 242-258.

Sandercock, L., & Turner, I. (1981). *Up Where Cazaly? The Great Australian Game*. Sydney: Granada.

Sanderson, A. (2002). The Many Dimensions of Competitive Balance. *Journal of Sports Economics, 3*(2), 204-228.

Sanderson, A., & Siegfried, J. J. (2003). Thinking about Competitive Balance. *Journal of Sports Economics, 4*(4), 225-279.

Sass, M. (2012). Long-Term Competitive Balance under UEFA Financial Fair Play Regulations. *University of Magdeburg, Faculrty of Economics and Management, Working Paper, No 5/2012*.

Schmidt, M. B. (2001). Competition in Major League Baseball: the impact of expansion. *Applied Economics Letters, 8*, 21-26.

Schmidt, M. B., & Berri, D. J. (2001). Competitive Balance and Attendance. The case of Major League Baseball. *Journal of Sports Economics, 2*(2), 145-167.

Schmidt, M. B., & Berri, D. J. (2002). Competitive Balance and Market Size in Major League Baseball: A Response to Baseball's Blue Ribbon Panel. *Review of Industrial Organization, 21*, 41-54.

Schollaert, P. T., & Smith, D. H. (1987). Team Racial Composition and Sports Attendance. *The Sociological Quarterly, 28*(1), 71-87.

Scully, G. W. (1989). *The Business of Major League Baseball*. Chicago, IL: University of Chicago Press.

Shannon, C. B. (1948). A Mathematical Theory of Communication. *Bell System Technical Journal, 27*, 379-423.

Simmons, R. (1996). The Demand for English League Football: A Club-Level Analysis. *Applied Economics, 28*, 139-155.

Sims, C. A., Stock, J. H., & Watson, M. W. (1990). Inference in Linear Time Series Models with Some Unit Roots. *Econometrica, 58*, 113-144.

Sloane, P. J. (1971). The Economics of Professional Football: The Football Club as a Utility Maximiser. *Scottish Journal of Political Economy, 18*(2), 121-146.

Snedecor, G., & Cohran, W. (1967). *STATISTICAL METHODS* (Sixth edition ed.). Iowa: The Iowa State University Press.

Spiegelhalter, D., Thomas, A., & Best, N. (1998). *WinBUGS user manual, version 1.1.1*. Cambridge, UK.

Stimson, J. A. (1985). Regression in Space and Time: A Statistical Essay. *American Journal of Political Sciences, 29*(4), 914-947.

Sutton, W. A., & Parret, I. (1992). Marketing the core product in professional team sports in the United States. *Sport Marketing Quarterly, 1*(2), 7-19.

Szymanski, S. (2001). Income inequality, competitive balance and the attractiveness of team sports: Some evidence and a natural experiment from English soccer. *The Economic Journal, 111*, F69-F84.

Szymanski, S. (2003). The Economic Design of Sporting Contests. *Journal of Economic Literature, XLI*, 1137-1187.

Szymanski, S. (2011). Sport financing and governance in Europe. In W. Andreff (Ed.), *Contemporary Issues in Sports Economics*. Cheltenham, UK: Edward Elgar.

Szymanski, S., & Kesenne, S. (2004). Competitive Balance and Gate Revenue Sharing in Team Sports. *The Journal of Industrial Economics, LII*(1), 165-177.

Szymanski, S., & Kuypers, T. (1999). *Winners and Loosers: The business strategy of football*: Penguin Books.

Szymanski, S., & Valletti, T. (2003). Promotion and relegation in sporting contest. mimeo: Tanaka Business School, Imperial College.

Szymanski, S., & Zimbalist, A. (2005). *National pastime: how Americans play baseball and the rest of the world plays soccer*. Washington, DC: Brookings Institution Press.

Theil, H. (1967). *Economics and Information Theory*. Amsterdam: North-Holland Publishing Company.

Topkis, J. H. (1949). Monopoly in Professional Sports. *The Yale Law Journal, 58*(5), 691-712.

Trandel, G. A., & Maxcy, J. G. (2011). Adjusting Winning-Percentage Standard Deviations and a Measure of Competitive Balance for Home Advantage. *Journal of Quantitative Analysis in Sports, 7*(1), 1-15.

UEFA. (2012). UEFA rankings. from http://www.uefa.com.

Utt, J., & Fort, R. (2002). Pitfalls to Measuring Competitive Balance with Gini Coefficients. *Journal of Sports Economics, 3*(4), 367-373.

Verbeek, M. (2004). *A Guide to Modern Econometrics* (2nd ed.). Hoboken, NJ: John Wiley & Sons.

Villar, J. G., & Guerrero, P. R. (2003). Analysis empirico de la demanda en los deportes profesionales: un panorama. *Revista Asturiana de Economia, 26*, 23-60.

Villar, J. G., & Guerrero, P. R. (2009). Sports Attendance: A survey of the literature 1973-2007. *RIVISTA DI DIRITTO ED ECONOMIA DELLO SPORT, 5*(2), 111-151.

Vrooman, J. (1996). The Baseball Players' Labor Market Reconsidered. *Southern Economic Journal, 63*(2), 339-360.

Vrooman, J. (2007). Theory of the beautiful game: The unification of European football. *Scottish Journal of Political Economy, 54*(3), 314-354.

Ward, J. H. (1963). Hierarchical Grouping to Optimize an Objective Function. *Journal of American Statistical Association, 48*, 236-244.

Whannel, G. (1992). *Fields in Vision: Television Sport and Cultural Transformation*. London: Routledge.

White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica, 48*, 817-838.

White, H. (1984). *Asymptotic Theory for Econometricians*. Orlando, FL: Academic Press.

Wilson, P., & Sim, B. (1995). The Demand for Semi-Pro League Football in Malaysia 1989-91. A Panel Data Approach. *Applied Economics, 27*, 131-138.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross-Section and Panel Data*. Cambridge, MA: MIT Press.

Zellner, A. (1962). An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias. *Journal of the American Statistical Association, 57*, 348-368.

Zimbalist, A. S. (2002). Competitive Balance in Sports Leagues: An Introduction. *Journal of Sports Economics, 3*(2), 111-121.

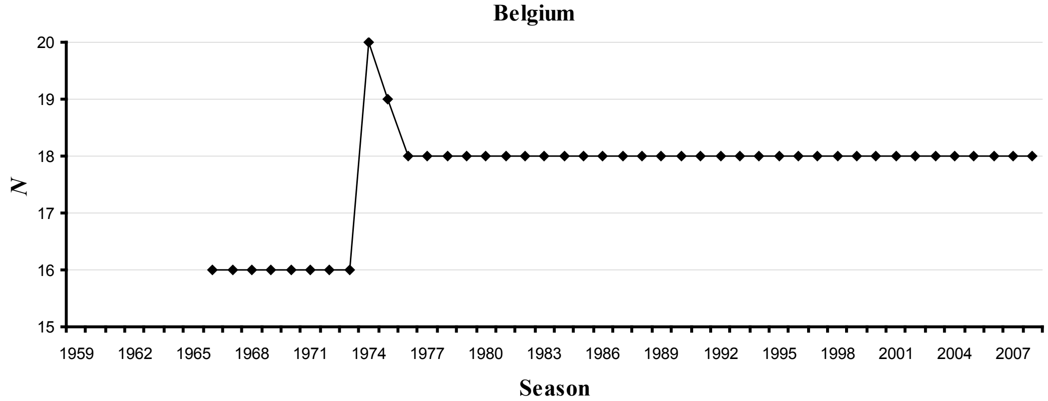
Zimbalist, A. S. (2003). Competitive Balance Conundrums: Response to Fort and Maxcy's Comment. *Journal of Sports Economics, 4*(2), 161-163.

Appendix A. Data, Sources, and Descriptive Statistics

Table A.1: Number of Teams (*N*) in the Highest League

	Country							
N	*Belgium*	*England*	*France*	*Germany*	*Greece*	*Italy*	*Norway*	*Sweden*
10							9	2
12							23	23
14					1		14	24
16	8			2	23	21		1
18	34		9	43	26	24		
20	1	33	41	1		5		
22		17						

Figure A.1a: Number of Teams (*N*) in the Highest League



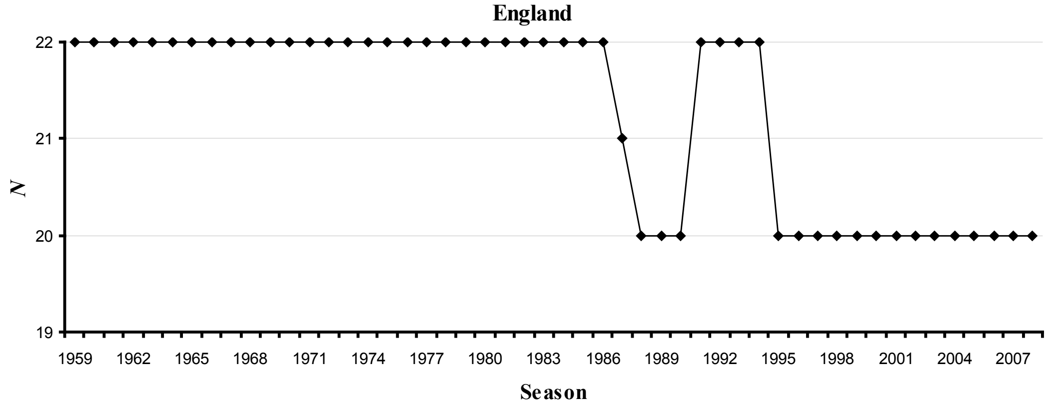
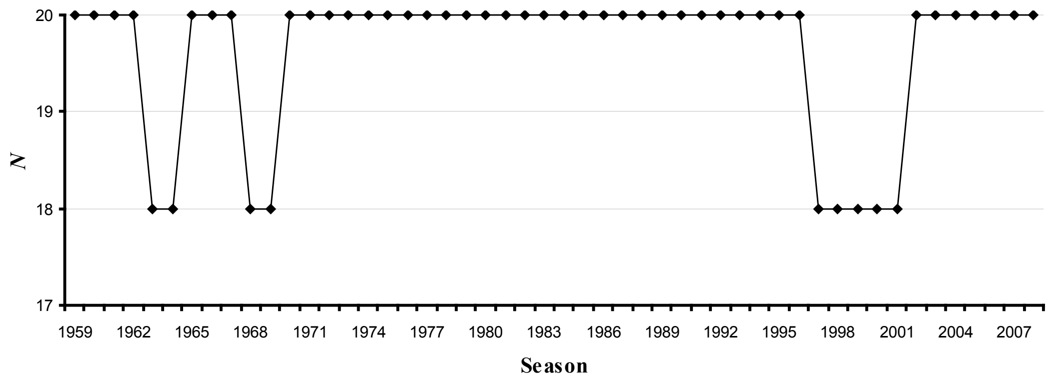
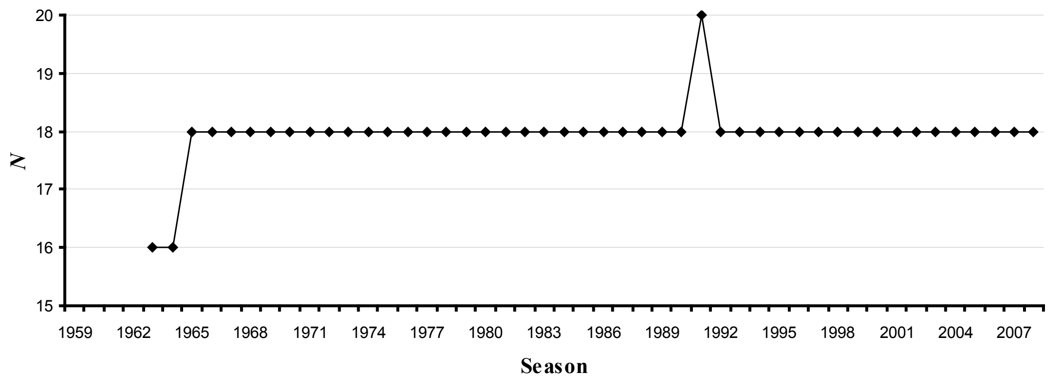


Figure A.1b: Number of Teams (*N*) in the Highest League

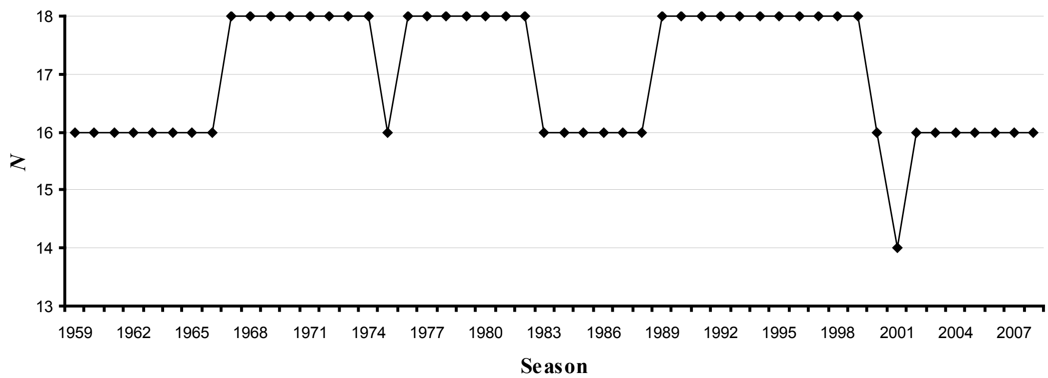
France



Germany



Greece



Italy

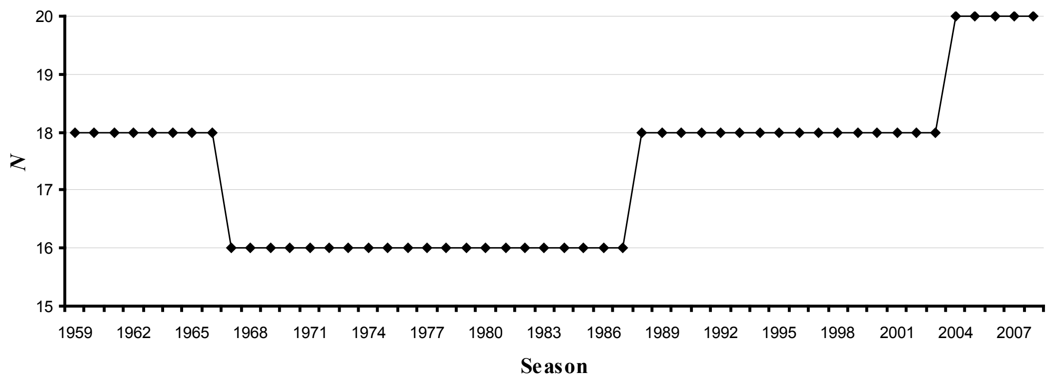
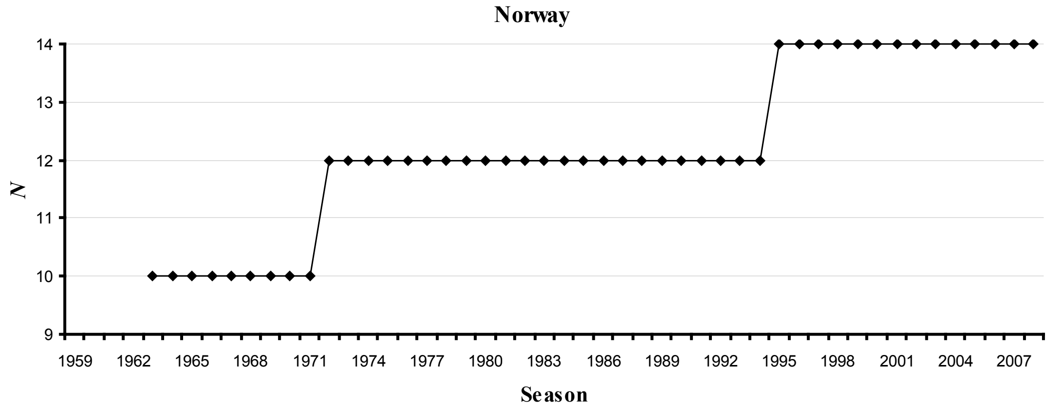


Figure A.1c: Number of Teams (*N*) in the Highest League



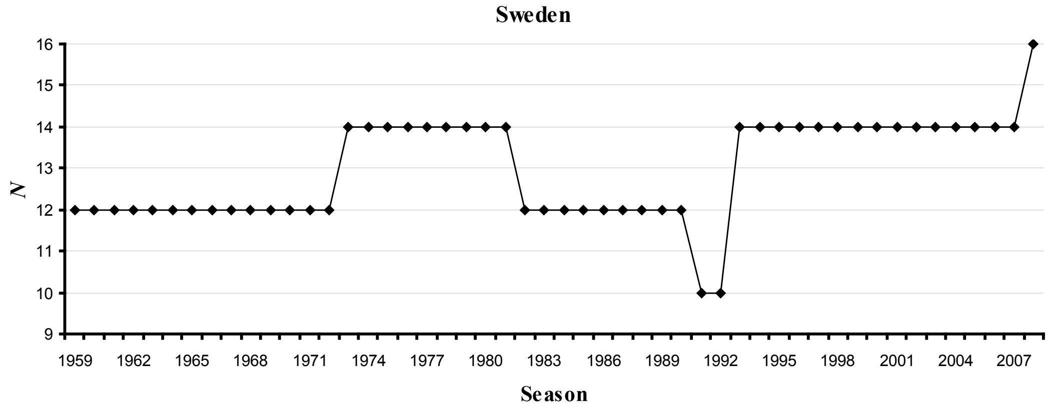


Table A.2: Data Sources for Results and Final Rankings in the Highest League

Country	*Source*
Belgium	Belgian Soccer Database www.bsdb.be
England	Soccerway www.soccerway.com
France	Ligue de Football Professionnel www.lfp.fr
Germany	Bundesliga www.bundesliga.com
Greece	Hellenic Football Federation www.epo.gr
Italy	The Rec.Sport.Soccer Statictics Foundation (RSSSF) www.rsssf.com
Norway	RSSSF Norway – Norwegian football statistics www.rsssf.no
Sweden	Sveriges Fotbollshistoriker och Statistiker www.bolletinen.se

Table A.3: Data Sources for Final Rankings in the Second League

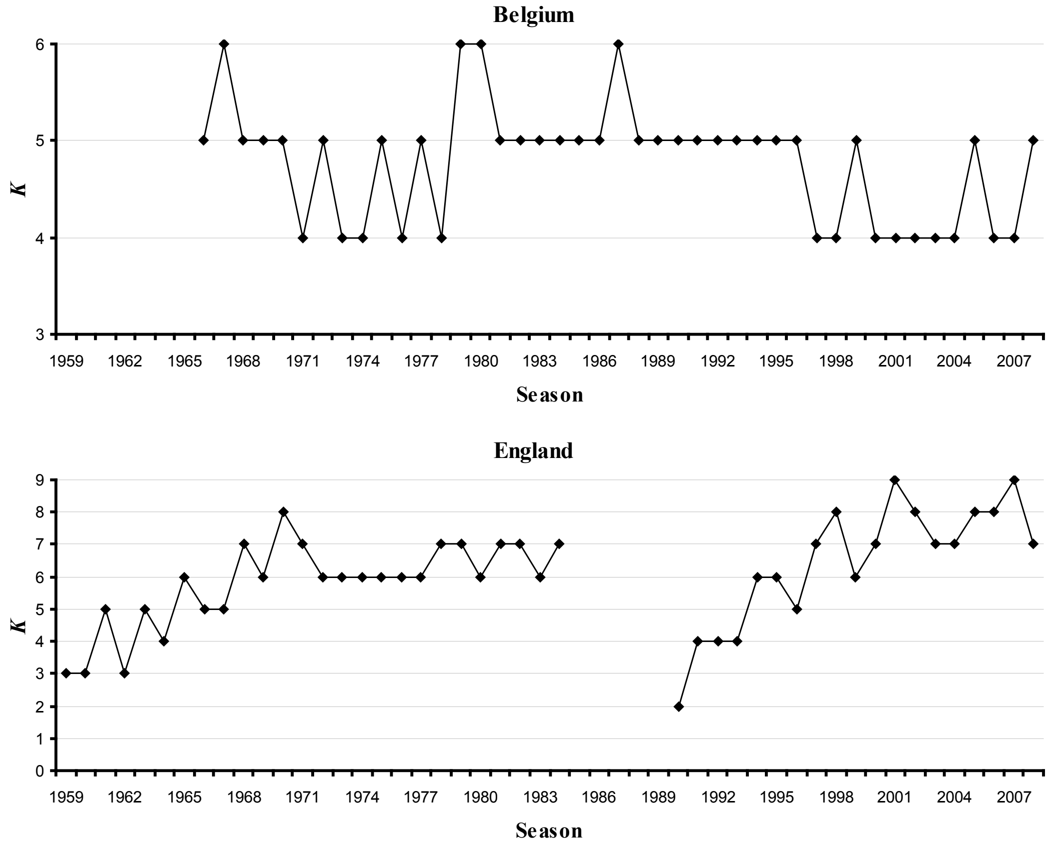
Country	*Source*
Belgium	Belgian Soccer Database www.bsdb.be The Rec.Sport.Soccer Statictics Foundation (RSSSF) www.rsssf.com
England	The Rec.Sport.Soccer Statictics Foundation (RSSSF) www.rsssf.com
France	Ligue de Football Professionnel www.lfp.fr Football Stats www.footballstats.fr
Germany	Das Deutsche FuBball-Archiv www.f-archiv.de
Greece	The Rec.Sport.Soccer Statictics Foundation (RSSSF) www.rsssf.com
Italy	The Rec.Sport.Soccer Statictics Foundation (RSSSF) www.rsssf.com
Norway	RSSSF Norway – Norwegian football statistics www.rsssf.no
Sweden	Wikipedia – Swedish Football en.wikipedia.org/wiki/Swedish_football_Division_2 Clas Glenning Homepage home.swipnet.see/clasglenning/Index.htm

Table A.4: Number of Teams (*K*) Qualifying in European Tournaments*

	Country							
K	*Belgium*	*England*	*France*	*Germany*	*Greece*	*Italy*	*Norway*	*Sweden*
0		5						
1					2		3	4
2		1	2				1	1
3		3	2		7		22	10
4	14	4	13		31	6	15	29
5	25	5	17		2	5	5	6
6	4	13	4	25	8	19		
7		12	6	17		13		
8		5	5	4		7		
9		2						
10			1					

Data Source: UEFA European Cup Football Results & Qualification by Bert Kassies
www.xs4all.nl/~Kassiesa/bert/uefa/data/index.html

Figure A.2a: Number of Teams (*K*) Qualifying in European Tournaments



*In the period 1985-1989 English teams were banned from European tournaments due to hooliganism.

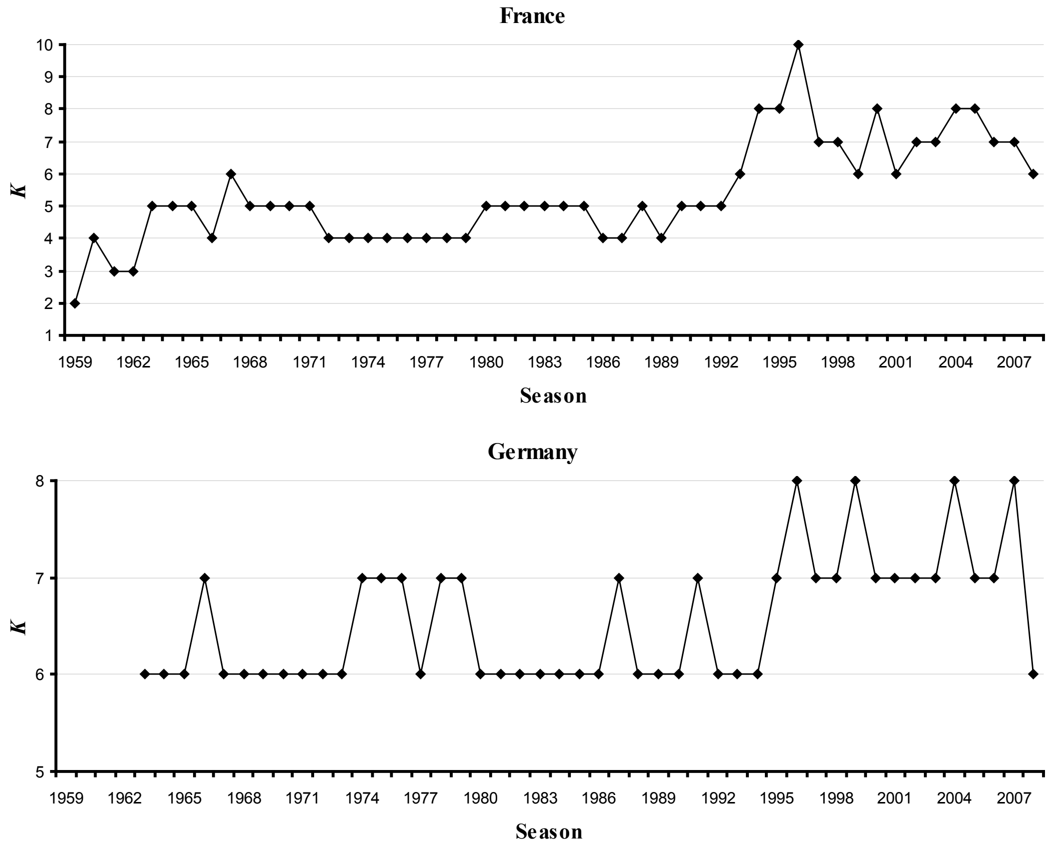


Figure A.2b: Number of Teams (*K*) Qualifying in European Tournaments

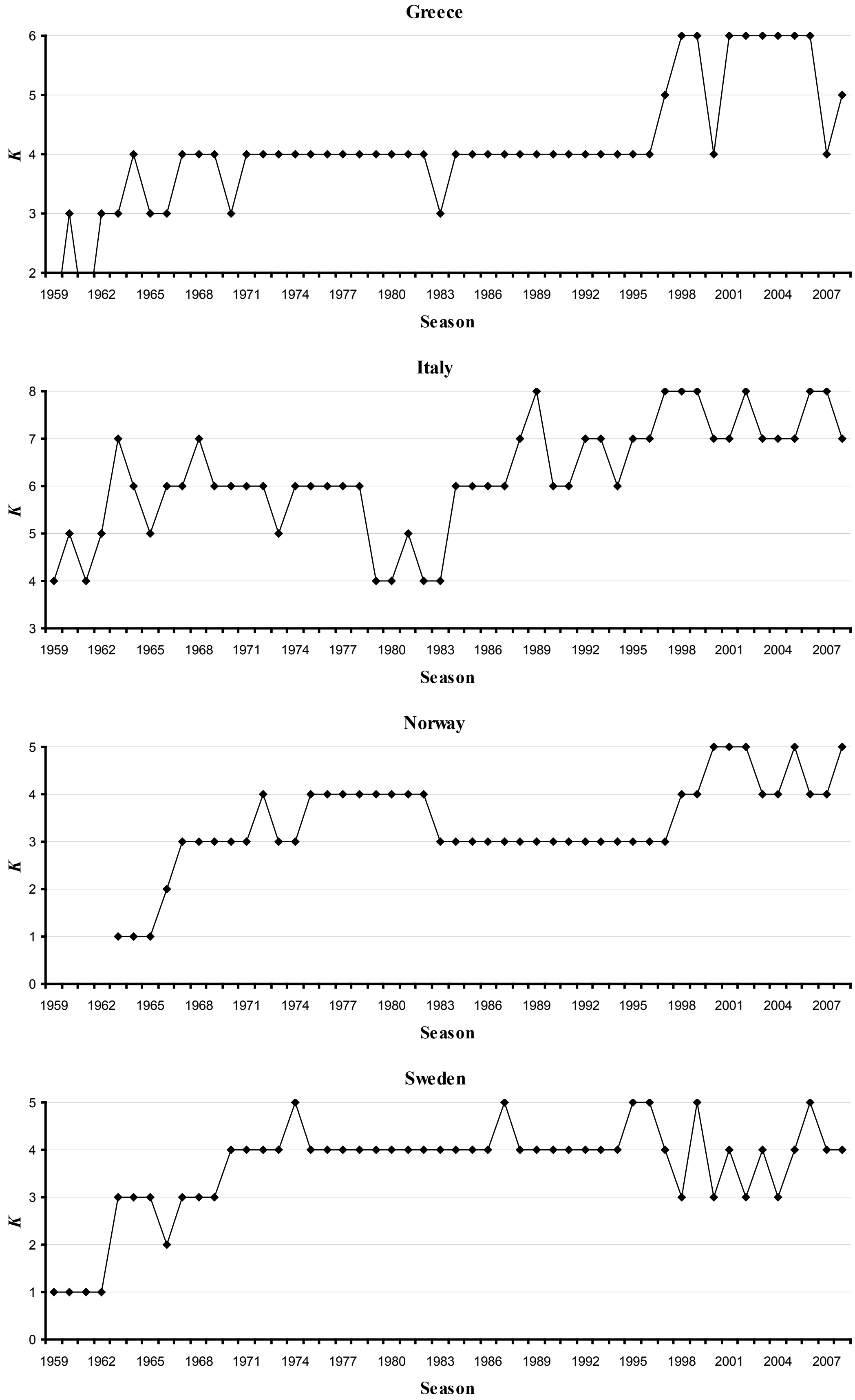
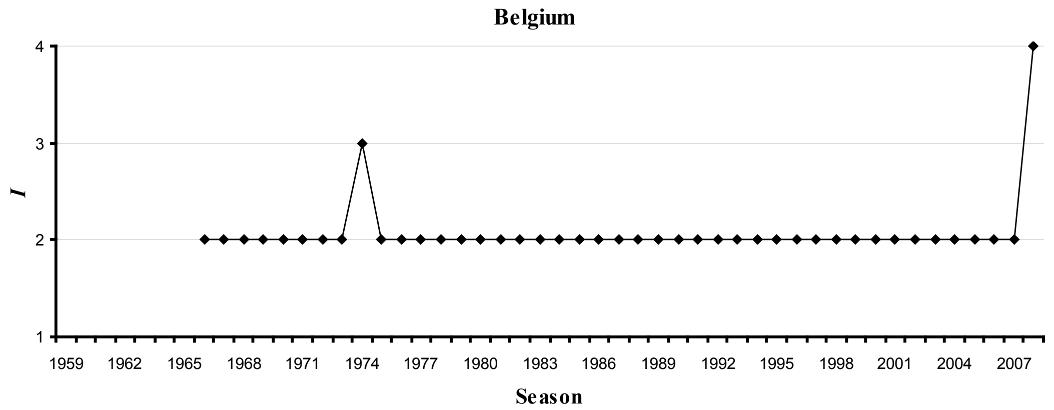


Table A.5: Number of Relegated teams (*I*)

I	*Belgium*	*England*	*France*	*Germany*	*Greece*	*Italy*	*Norway*	*Sweden*
	Country							
0					1			
1			2		1		1	2
2	41	15	9	10	14	1	9	28
3	1	33	32	35	23	33	36	9
4	1	2	7	1	7	16		11
5					3			
6					1			

Relegated are also considered teams participating in play-off games with teams from the immediate lower league.

Figure A.3a: Number of Relegated teams (*I*)



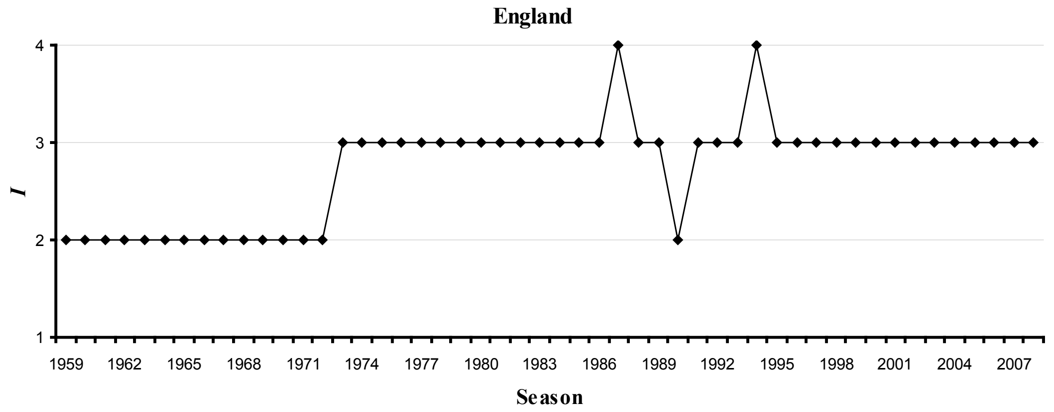
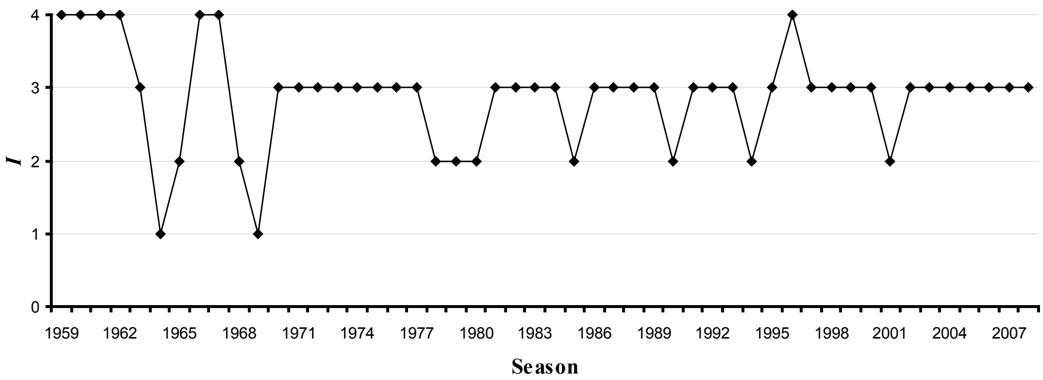
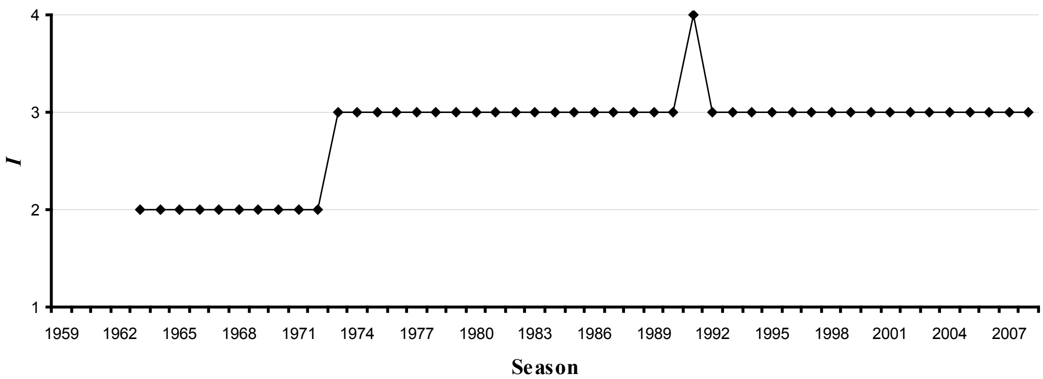


Figure A.3b: Number of Relegated teams (*I*)

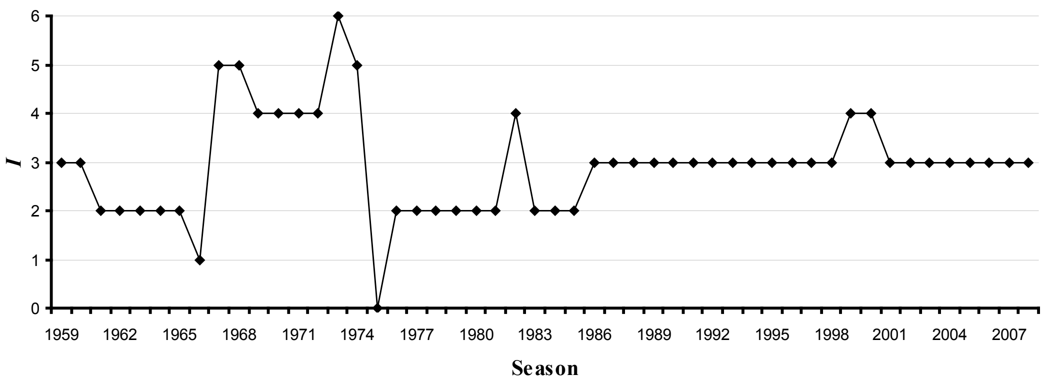
France



Germany



Greece



Italy

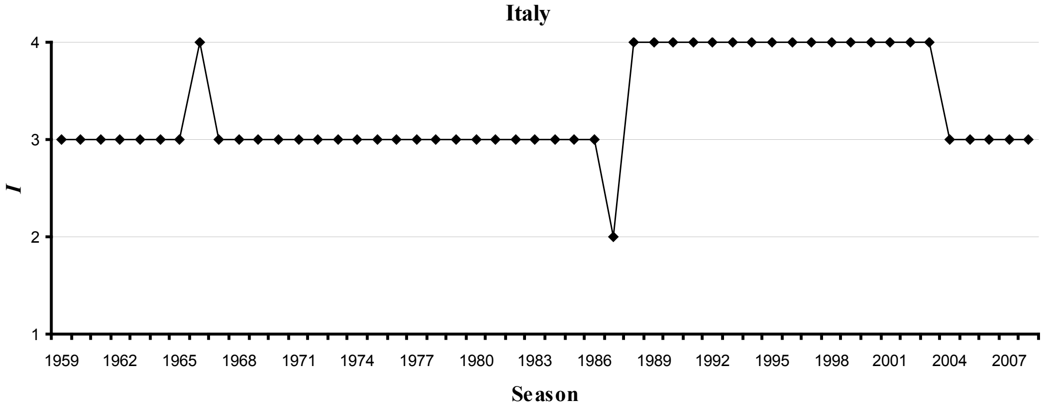
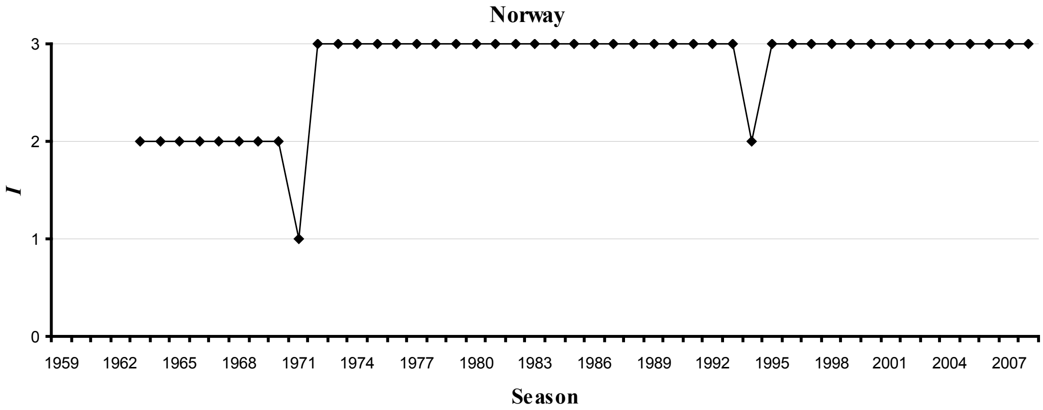


Figure A.3c: Number of Relegated teams (*I*)



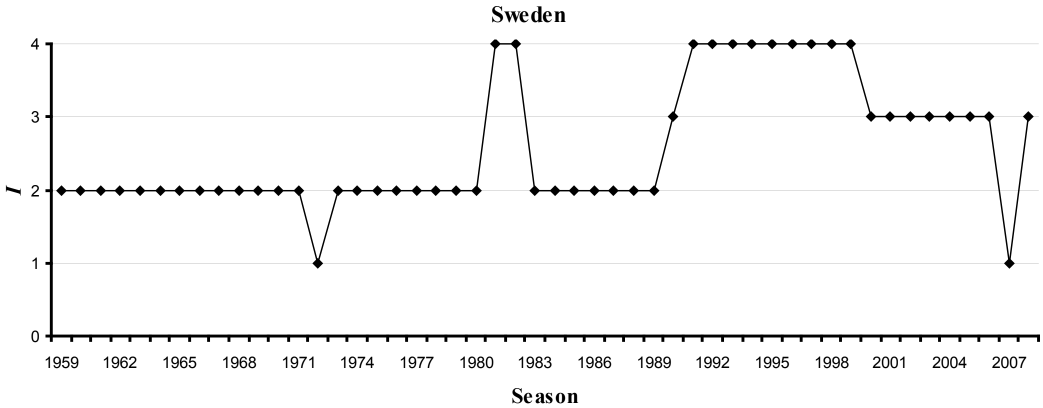


Table A.6: Number of Teams in the Second League

Season	*Belgium*	*England*	*France*	*Germany*	*Greece*	*Italy*	*Norway*	*Sweden*
59		22	20		24	20		46
60		22	19		37	20		46
61		22	19		62	20		46
62		22	19		60	20		46
63		22	18	88	62	20	16	45
64		22	16	82	65	20	16	46
65		22	19	85	48	20	16	46
66	16	22	18	85	54	20	16	46
67	16	22	18	85	32	21	16	47
68	16	22	21	85	36	20	16	48
69	16	22	16	85	54	20	16	48
70	16	22	48	85	54	20	16	48
71	16	22	48	83	60	20	16	48
72	16	22	36	82	60	20	20	36
73	16	22	36	83	61	20	20	28
74	16	22	35	40	60	20	20	28
75	16	22	36	40	40	20	20	28
76	16	22	36	40	40	20	20	28
77	16	22	36	40	40	20	30	28
78	16	22	36	40	40	20	30	28
79	16	22	36	40	40	20	24	28
80	16	22	36	40	40	20	24	28
81	16	22	36	20	40	20	24	28
82	16	22	36	20	40	20	24	24
83	16	22	37	20	20	20	24	24
84	16	22	36	20	20	20	24	28
85	16	22	36	20	20	20	24	28
86	16	22	36	20	20	20	24	28
87	16	23	36	20	18	20	24	28
88	16	24	36	20	18	20	24	28
89	16	24	36	20	18	20	24	28
90	16	24	36	20	18	20	24	28
91	16	24	36	24	18	20	24	32
92	16	24	36	24	18	20	24	32
93	16	24	22	20	18	20	24	32
94	18	24	22	18	18	20	24	28
95	18	24	22	18	18	20	24	28
96	18	24	22	18	18	20	24	28
97	18	24	22	18	18	20	14	28
98	18	24	20	18	18	20	14	28
99	18	24	20	18	18	20	14	28
00	18	24	20	18	16	20	14	16
01	18	24	20	18	14	20	16	16
02	18	24	20	18	16	20	16	16
03	18	24	20	18	16	24	16	16
04	18	24	20	18	16	22	16	16
05	18	24	20	18	16	22	16	16
06	18	24	20	18	18	22	16	16
07	19	24	20	18	18	22	16	16
08	19	24	20	18	18	22	16	16

Table A.7: Data Sources for Attendance

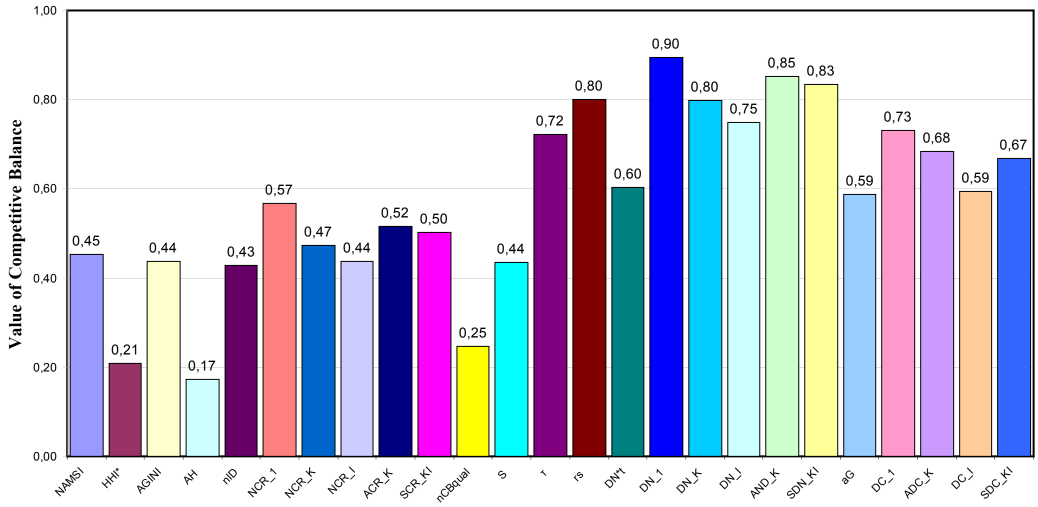
Country	*Source*
Belgium	Belgian Soccer History www.belgiumsoccerhistory.com European Football Statistics http://www.european-football-statistics.co.uk/index1.htm
England	European Football Statistics http://www.european-football-statistics.co.uk/index1.htm
France	Football Stats www.footballstats.fr
Germany	European Football Statistics http://www.european-football-statistics.co.uk/index1.htm
Greece	European Football Statistics http://www.european-football-statistics.co.uk/index1.htm Athlitki Hxo Digital Archive www.athlitikihxo.gr/
Italy	European Football Statistics http://www.european-football-statistics.co.uk/index1.htm
Norway	RSSSF Norway – Norwegian football statistics www.rsssf.no
Sweden	Sveriges Fotbollshistoriker och Statistiker www.bolletinen.se

Table A.8: Data Sources for Population and Economic Variables

Country	*Source*
Population (*POP*)	Organization for Economic Co-operation and Development (*OECD*) http://www.oecd.org/
Gross National Disposal Income per Capita (*GNI*)	European Comission Economic and Financial Affairs http://ec.europa.eu/economy_finance/index_en.htm
Consumer Price Index (*CPI*)	Worldwide Inflation Data http://nl.inflation.eu/
Unemployment Rate (*Un*)	European Comission Economic and Financial Affairs http://ec.europa.eu/economy_finance/index_en.htm

Table A.9: Competitive Balance Indices for Belgium

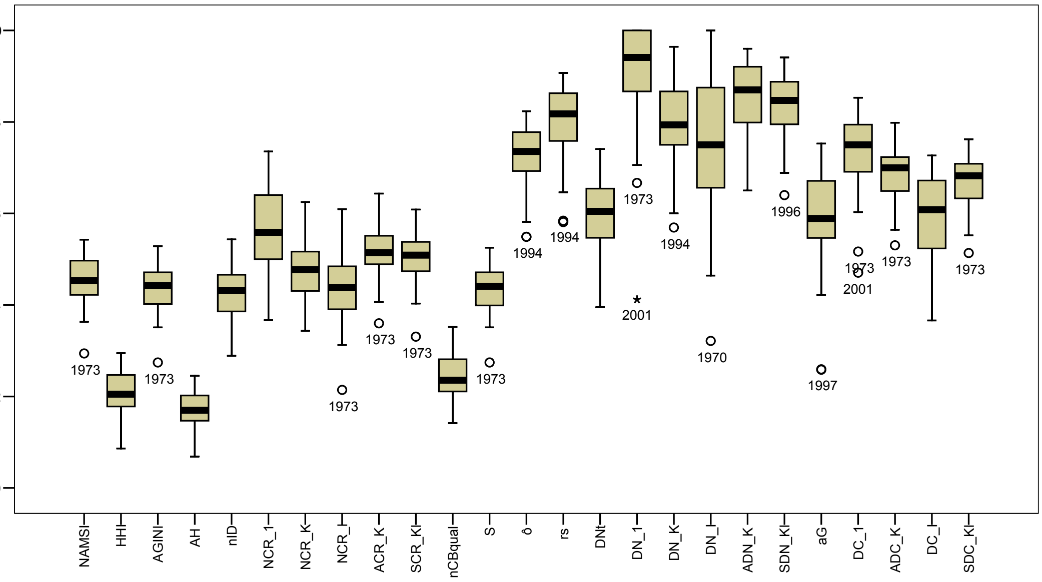
Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
NAMSI	Seasonal	0.453	0.052	0.294	0.422	0.453	0.497	0.543
HHI^*		0.208	0.046	0.086	0.178	0.205	0.247	0.295
AGINI		0.436	0.052	0.274	0.402	0.442	0.471	0.528
AH		0.172	0.039	0.069	0.147	0.170	0.202	0.245
nID		0.428	0.055	0.289	0.386	0.432	0.466	0.543
NCR_1		0.568	0.090	0.367	0.500	0.559	0.640	0.735
NCR_K		0.472	0.064	0.344	0.431	0.477	0.517	0.625
NCR^I		0.437	0.075	0.214	0.391	0.438	0.484	0.609
ACR_K		0.517	0.067	0.360	0.489	0.514	0.551	0.643
SCR^I_K		0.503	0.061	0.331	0.474	0.509	0.538	0.608
nCB_{qual}		0.246	0.052	0.142	0.211	0.236	0.281	0.352
S		0.436	0.052	0.274	0.399	0.441	0.471	0.525
τ	Between-seasons	0.722	0.065	0.549	0.694	0.735	0.774	0.824
r_s		0.800	0.076	0.581	0.759	0.817	0.861	0.907
DN^*_t		0.602	0.080	0.395	0.549	0.605	0.654	0.741
DN_1		0.895	0.119	0.412	0.867	0.941	1.000	1.000
DN_K		0.798	0.090	0.569	0.750	0.793	0.865	0.964
DN^I		0.749	0.155	0.321	0.662	0.750	0.875	1.000
ADN_K		0.851	0.081	0.650	0.800	0.870	0.919	0.960
SDN^I_K		0.833	0.072	0.640	0.796	0.847	0.888	0.941
aG		0.588	0.119	0.258	0.547	0.589	0.671	0.753
DC_1	Bi-dimensional	0.732	0.085	0.471	0.691	0.750	0.791	0.853
ADC_K		0.684	0.060	0.530	0.649	0.699	0.723	0.798
DC^I		0.594	0.091	0.366	0.523	0.608	0.672	0.727
SDC^I_K		0.668	0.054	0.514	0.633	0.682	0.708	0.762



Mean values of Competitive Balalance Indices in Belgium

An overview of the indices by type and dimension is presented in Table 6.1.

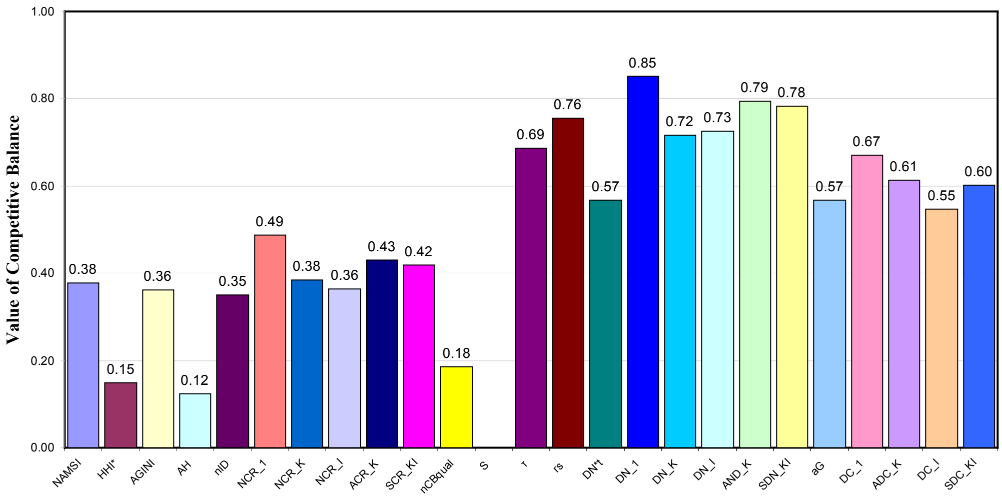
Figure A.4: Box-plot of the Indices in Belgium



An overview of the indices by type and dimension is presented in Table 6.1.

Table A.10: Competitive Balance Indices for England

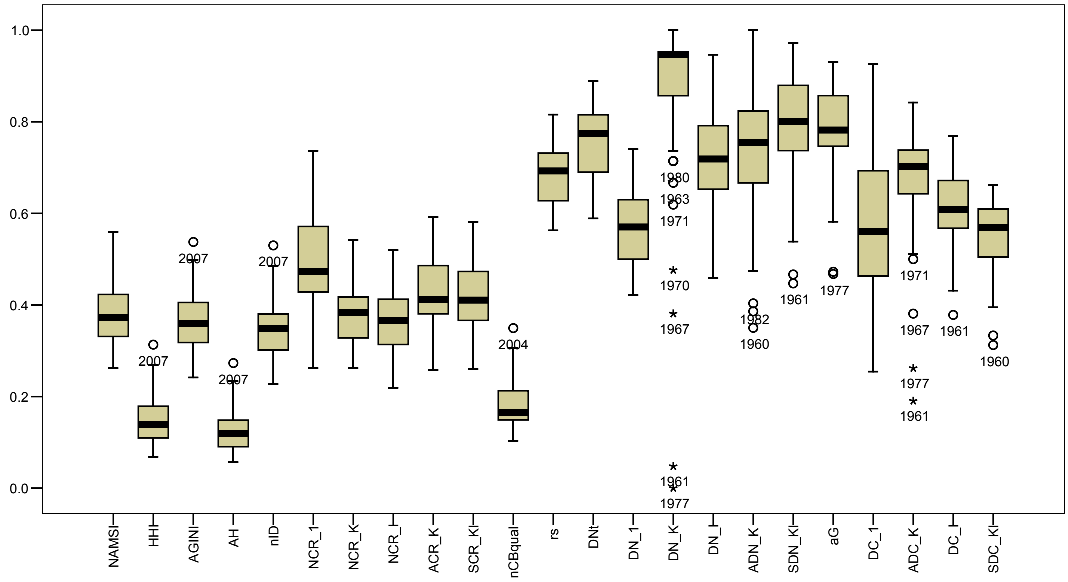
Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
$NAMSI$	Seasonal	0.378	0.070	0.262	0.332	0.372	0.422	0.560
HHI^*		0.148	0.054	0.069	0.110	0.139	0.178	0.313
$AGINI$		0.362	0.066	0.242	0.319	0.360	0.405	0.538
AH		0.124	0.046	0.057	0.091	0.119	0.148	0.273
nID		0.350	0.066	0.227	0.304	0.349	0.380	0.530
NCR_1		0.487	0.103	0.262	0.429	0.474	0.571	0.737
NCR_K		0.384	0.063	0.262	0.329	0.383	0.417	0.542
NCR^I		0.364	0.076	0.219	0.314	0.366	0.412	0.520
ACR_K		0.430	0.078	0.258	0.381	0.412	0.486	0.592
SCR_K^I		0.419	0.075	0.260	0.368	0.411	0.470	0.582
nCB_{qual}		0.184	0.056	0.104	0.149	0.166	0.213	0.349
S								
τ	Between-seasons	0.687	0.064	0.563	0.628	0.693	0.732	0.816
r_s		0.756	0.077	0.589	0.690	0.775	0.815	0.889
DN_t^*		0.567	0.081	0.421	0.500	0.570	0.630	0.740
DN_1		0.850	0.219	0.000	0.857	0.947	0.952	1.000
DN_K		0.717	0.111	0.458	0.653	0.719	0.792	0.947
DN^I		0.725	0.136	0.350	0.667	0.754	0.824	1.000
ADN_K		0.793	0.115	0.447	0.737	0.801	0.879	0.972
SDN_K^I		0.783	0.106	0.468	0.747	0.782	0.857	0.930
aG		0.568	0.165	0.255	0.463	0.560	0.679	0.925
DC_1	Bi-dimensional	0.671	0.132	0.190	0.643	0.702	0.738	0.842
ADC_K		0.613	0.081	0.378	0.568	0.609	0.672	0.769
DC^I		0.546	0.083	0.313	0.505	0.569	0.610	0.662
SDC_K^I		0.602	0.075	0.390	0.568	0.605	0.657	0.756



Mean values of Competitive Balalance Indices in England

An overview of the indices by type and dimension is presented in Table 6.1.

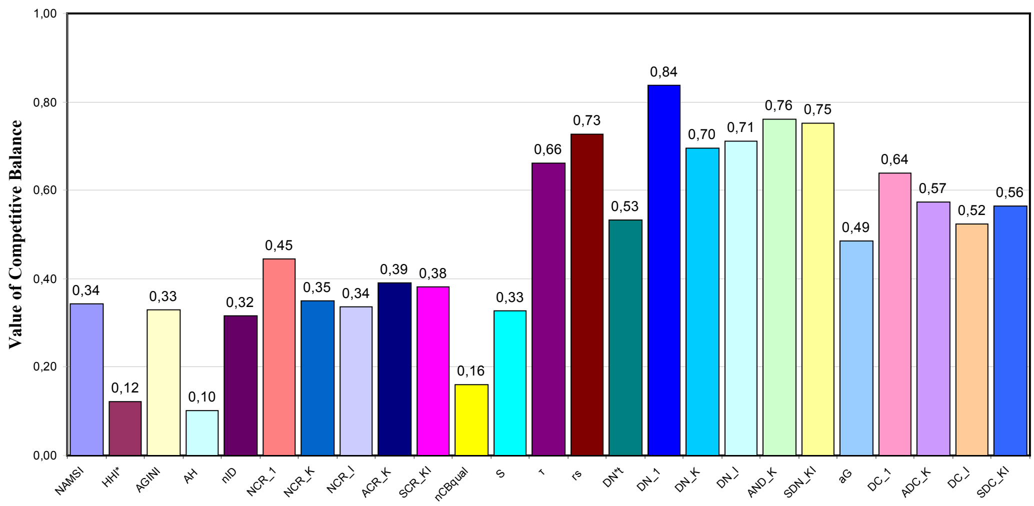
Figure A.5: Box-plot of the Indices in England



An overview of the indices by type and dimension is presented in Table 6.1.

Table A.11: Competitive Balance Indices for France

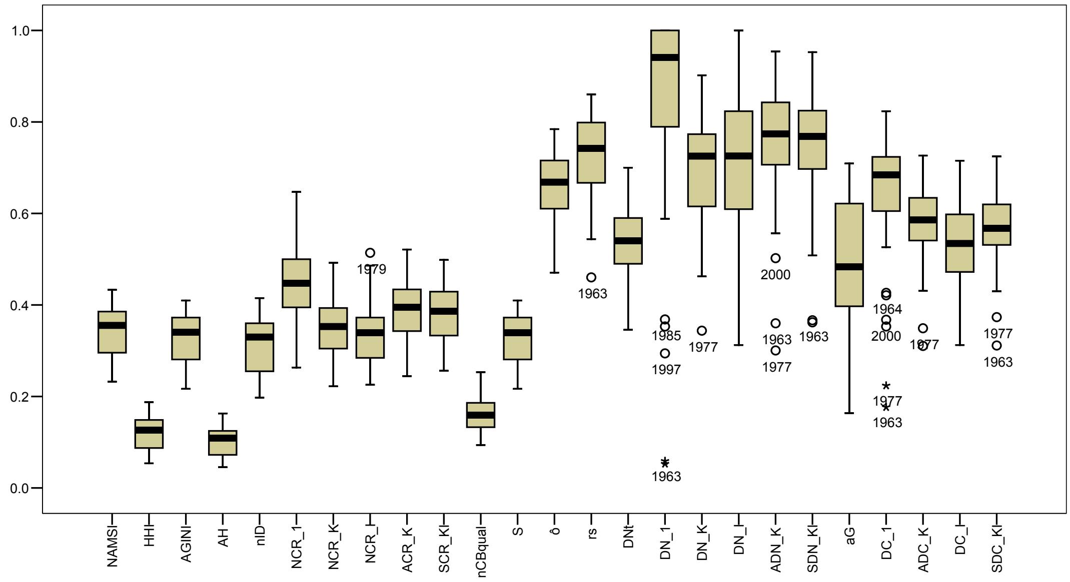
Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
NAMSI	Seasonal	0.344	0.055	0.232	0.296	0.355	0.385	0.433
HHI^*		0.121	0.036	0.054	0.088	0.126	0.149	0.188
AGINI		0.329	0.054	0.217	0.281	0.341	0.373	0.410
AH		0.102	0.031	0.045	0.072	0.109	0.125	0.163
nID		0.315	0.056	0.198	0.259	0.330	0.359	0.415
NCR_1		0.445	0.088	0.263	0.395	0.447	0.500	0.647
NCR_K		0.350	0.067	0.222	0.305	0.353	0.393	0.492
NCR^I		0.337	0.068	0.225	0.284	0.340	0.373	0.514
ACR_K		0.390	0.070	0.244	0.347	0.395	0.433	0.521
SCR_K^I		0.382	0.065	0.256	0.335	0.386	0.428	0.498
nCB_{qual}		0.159	0.037	0.094	0.133	0.159	0.186	0.253
S		0.328	0.054	0.217	0.281	0.339	0.372	0.410
τ	Between-seasons	0.661	0.071	0.471	0.611	0.668	0.716	0.784
r_s		0.726	0.093	0.460	0.667	0.742	0.799	0.860
DN_t^*		0.532	0.085	0.346	0.490	0.540	0.590	0.700
DN_1		0.837	0.236	0.053	0.789	0.941	1.000	1.000
DN_K		0.695	0.125	0.344	0.615	0.725	0.773	0.902
DN^I		0.713	0.153	0.313	0.609	0.725	0.824	1.000
ADN_K		0.760	0.136	0.300	0.707	0.774	0.843	0.954
SDN_K^I		0.751	0.119	0.362	0.697	0.768	0.825	0.953
aG		0.486	0.137	0.164	0.400	0.483	0.621	0.709
DC_1	Bi-dimensional	0.640	0.139	0.176	0.605	0.684	0.724	0.824
ADC_K		0.574	0.086	0.310	0.541	0.586	0.634	0.726
DC^I		0.524	0.094	0.313	0.472	0.534	0.598	0.715
SDC_K^I		0.565	0.077	0.311	0.531	0.568	0.620	0.725



Mean values of Competitive Balalance Indices in France

An overview of the indices by type and dimension is presented in Table 6.1.

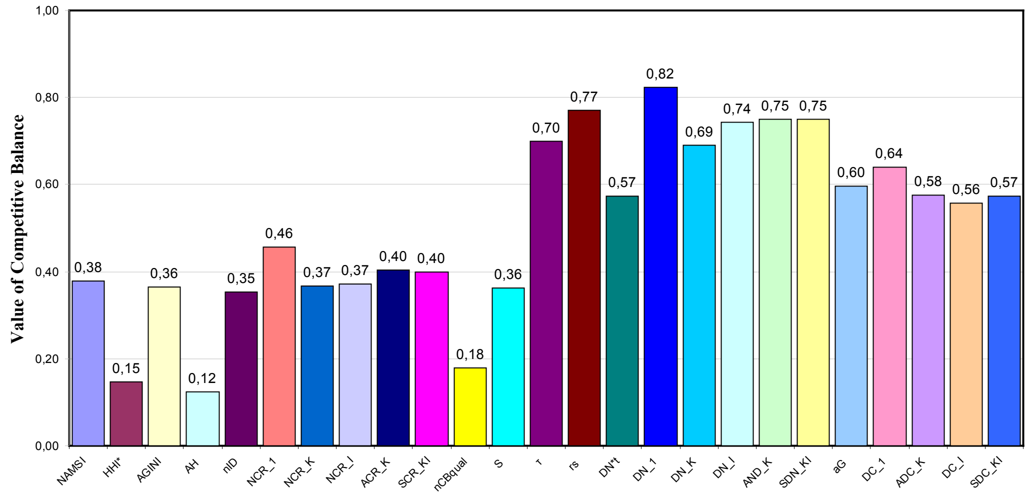
Figure A.6: Box-plot of the Indices in France



An overview of the indices by type and dimension is presented in Table 6.1.

Table A.12: Competitive Balance Indices for Germany

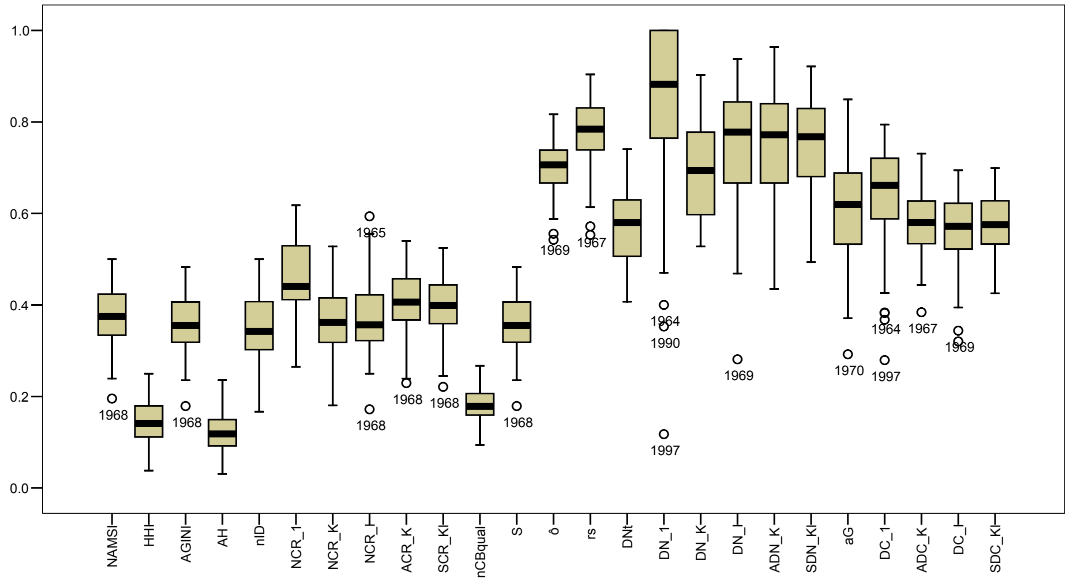
Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
NAMSI	Seasonal	0.378	0.066	0.195	0.336	0.375	0.423	0.500
HHI^*		0.147	0.049	0.038	0.113	0.141	0.179	0.250
AGINI		0.364	0.066	0.179	0.320	0.355	0.406	0.483
AH		0.124	0.043	0.031	0.093	0.118	0.149	0.235
nID		0.352	0.069	0.167	0.304	0.343	0.406	0.500
NCR_1		0.456	0.086	0.265	0.412	0.441	0.529	0.618
NCR_K		0.367	0.072	0.181	0.320	0.362	0.414	0.528
NCR^I		0.371	0.083	0.172	0.322	0.356	0.422	0.594
ACR_K		0.403	0.071	0.229	0.369	0.406	0.456	0.540
SCR_K^I		0.399	0.068	0.221	0.363	0.399	0.442	0.525
nCB_{qual}		0.179	0.039	0.094	0.160	0.178	0.207	0.267
S		0.363	0.066	0.179	0.320	0.355	0.406	0.483
τ	Between-seasons	0.700	0.068	0.542	0.667	0.706	0.739	0.817
r_s		0.771	0.088	0.553	0.739	0.784	0.831	0.904
DN_t^*		0.574	0.093	0.407	0.506	0.580	0.630	0.741
DN_1		0.823	0.215	0.118	0.765	0.882	1.000	1.000
DN_K		0.691	0.106	0.528	0.597	0.694	0.778	0.903
DN^I		0.744	0.139	0.281	0.667	0.778	0.844	0.938
ADN_K		0.750	0.114	0.435	0.667	0.772	0.840	0.964
SDN_K^I		0.749	0.101	0.494	0.681	0.768	0.829	0.921
aG		0.597	0.133	0.292	0.533	0.620	0.688	0.849
DC_1	Bi-dimensional	0.639	0.127	0.279	0.588	0.662	0.721	0.794
ADC_K		0.576	0.076	0.384	0.534	0.581	0.627	0.731
DC^I		0.558	0.088	0.320	0.522	0.572	0.622	0.694
SDC_K^I		0.574	0.069	0.425	0.533	0.575	0.628	0.699



Mean Values of Competitive Balalance Indices in Germany

An overview of the indices by type and dimension is presented in Table 6.1.

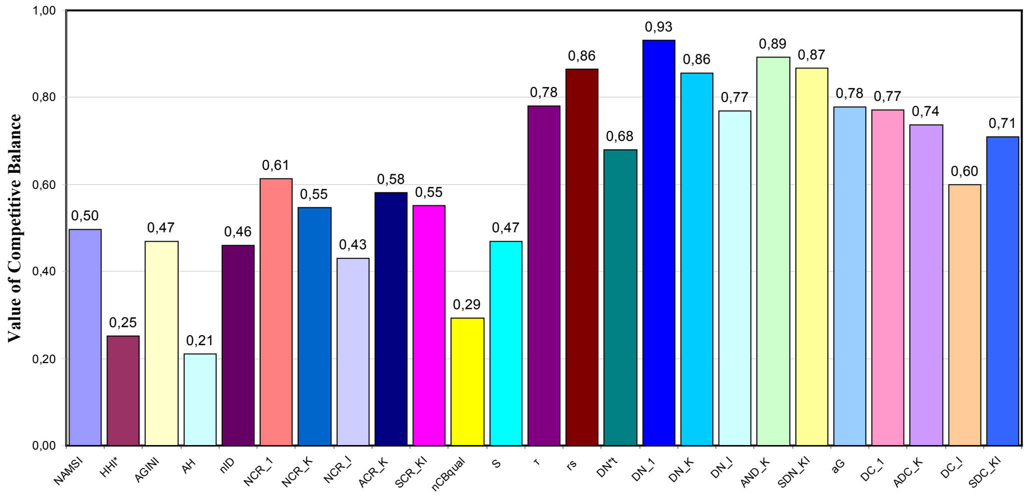
Figure A.7: Box-plot of the Indices in Germany



An overview of the indices by type and dimension is presented in Table 6.1.

Table A.13: Competitive Balance Indices for Greece

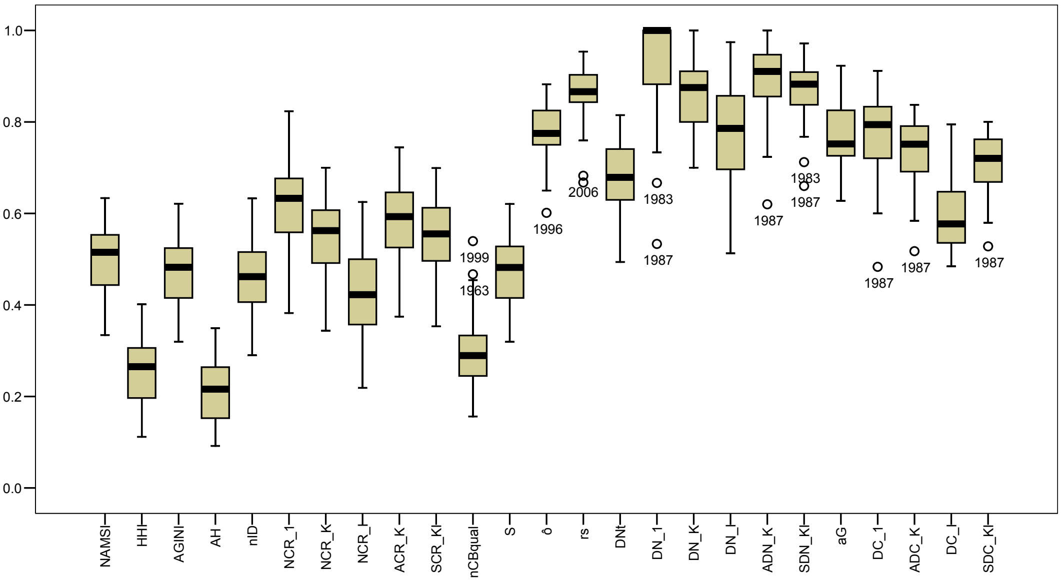
Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
NAMSI	Seasonal	0.496	0.079	0.334	0.445	0.515	0.552	0.634
HHI^*		0.252	0.076	0.112	0.198	0.265	0.305	0.401
AGINI		0.470	0.079	0.319	0.418	0.482	0.523	0.621
AH		0.210	0.068	0.092	0.155	0.216	0.264	0.349
nID		0.461	0.077	0.290	0.407	0.462	0.514	0.633
NCR_1		0.614	0.102	0.382	0.561	0.633	0.676	0.824
NCR_K		0.548	0.089	0.344	0.494	0.563	0.606	0.700
NCR^I		0.431	0.102	0.219	0.360	0.423	0.500	0.625
ACR_K		0.582	0.094	0.375	0.528	0.593	0.646	0.744
SCR_K^I		0.551	0.086	0.353	0.498	0.555	0.611	0.699
nCB_{qual}		0.294	0.083	0.156	0.246	0.290	0.333	0.539
S		0.469	0.079	0.319	0.417	0.482	0.526	0.621
τ	Between-seasons	0.780	0.057	0.601	0.750	0.775	0.825	0.882
r_s		0.864	0.058	0.668	0.843	0.866	0.903	0.954
DN_t^*		0.679	0.075	0.494	0.630	0.679	0.741	0.815
DN_1		0.931	0.102	0.533	0.882	1.000	1.000	1.000
DN_K		0.855	0.076	0.700	0.800	0.875	0.911	1.000
DN^I		0.769	0.101	0.513	0.696	0.786	0.857	0.974
ADN_K		0.892	0.075	0.620	0.856	0.911	0.947	1.000
SDN_K^I		0.868	0.063	0.660	0.838	0.883	0.909	0.972
aG		0.778	0.083	0.628	0.726	0.752	0.824	0.923
DC_1	Bi-dimensional	0.772	0.084	0.483	0.721	0.794	0.833	0.912
ADC_K		0.736	0.072	0.518	0.691	0.751	0.791	0.838
DC^I		0.599	0.078	0.484	0.536	0.577	0.647	0.795
SDC_K^I		0.709	0.063	0.528	0.669	0.720	0.762	0.800



Mean Values of Competitive Balalance Indices in Greece

An overview of the indices by type and dimension is presented in Table 6.1.

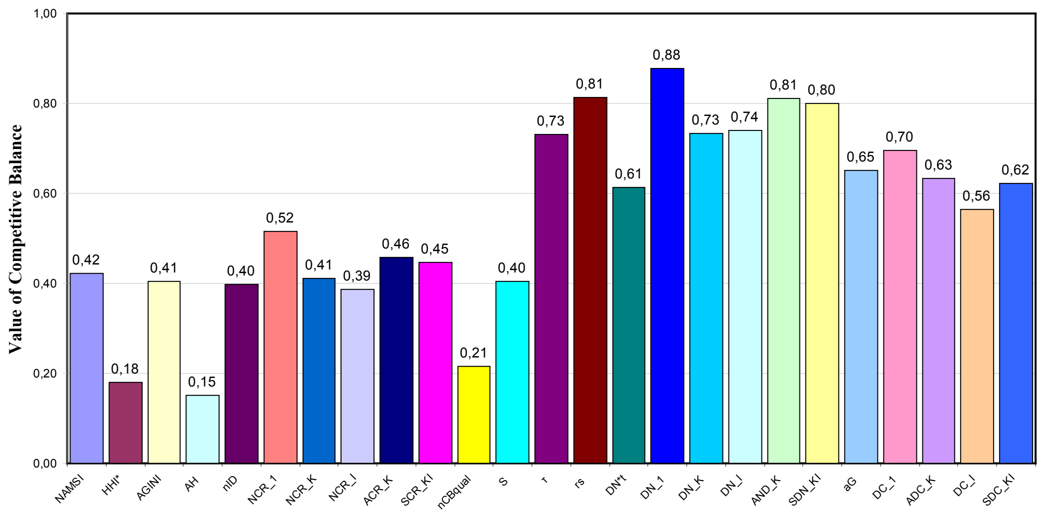
Figure A.8: Box-plot of the Indices in Greece



An overview of the indices by type and dimension is presented in Table 6.1.

Table A.14: Competitive Balance Indices for Italy

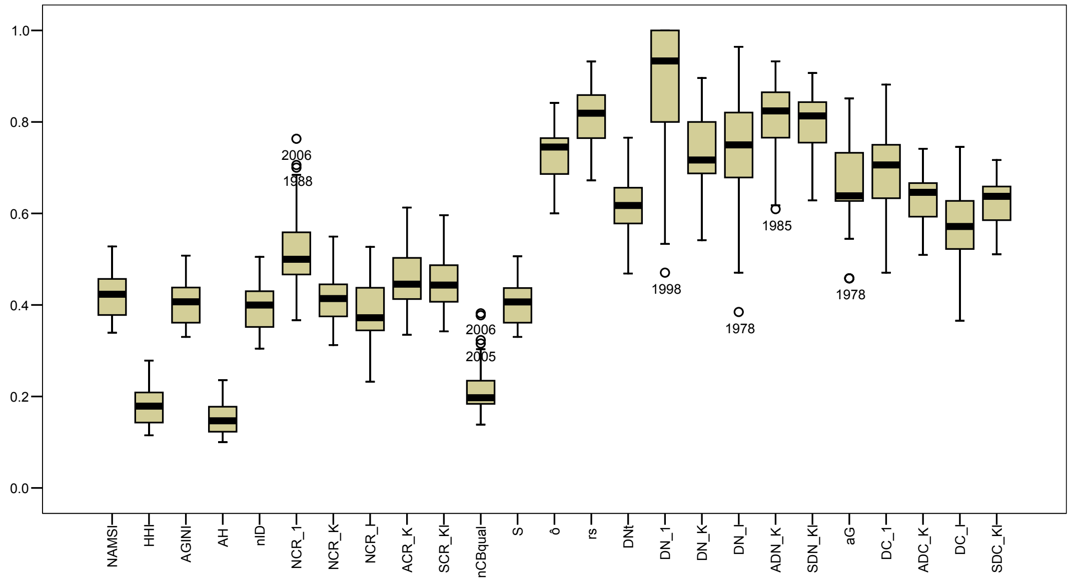
Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
$NAMSI$	Seasonal	0.423	0.047	0.339	0.380	0.423	0.456	0.528
HHI^*		0.181	0.040	0.115	0.144	0.179	0.208	0.279
$AGINI$		0.405	0.047	0.330	0.362	0.407	0.437	0.508
AH		0.152	0.036	0.100	0.123	0.147	0.176	0.236
nID		0.397	0.048	0.305	0.354	0.400	0.429	0.505
NCR_1		0.516	0.086	0.367	0.467	0.500	0.559	0.763
NCR_K		0.412	0.049	0.313	0.375	0.414	0.444	0.549
NCR^I		0.386	0.067	0.232	0.345	0.372	0.436	0.527
ACR_K		0.457	0.059	0.335	0.414	0.446	0.502	0.613
SCR_K^I		0.447	0.054	0.342	0.407	0.444	0.487	0.596
nCB_{qual}		0.215	0.053	0.138	0.184	0.197	0.234	0.382
S		0.404	0.047	0.330	0.361	0.406	0.436	0.506
τ	Between-seasons	0.732	0.060	0.600	0.686	0.745	0.765	0.842
r_s		0.814	0.068	0.672	0.765	0.819	0.859	0.932
DN_t^*		0.614	0.072	0.469	0.578	0.617	0.656	0.766
DN_1		0.878	0.128	0.471	0.800	0.933	1.000	1.000
DN_K		0.733	0.082	0.542	0.688	0.717	0.800	0.896
DN^I		0.740	0.124	0.385	0.679	0.750	0.821	0.964
ADN_K		0.810	0.072	0.609	0.766	0.824	0.865	0.933
SDN_K^I		0.800	0.063	0.628	0.755	0.813	0.843	0.907
aG		0.652	0.100	0.458	0.627	0.639	0.732	0.852
DC_1	Bi-dimensional	0.696	0.082	0.471	0.633	0.706	0.750	0.882
ADC_K		0.633	0.053	0.509	0.593	0.646	0.666	0.741
DC^I		0.564	0.077	0.365	0.522	0.571	0.627	0.746
SDC_K^I		0.623	0.046	0.511	0.585	0.637	0.659	0.717



Mean Values of Competitive Balalance Indices in Italy

An overview of the indices by type and dimension is presented in Table 6.1.

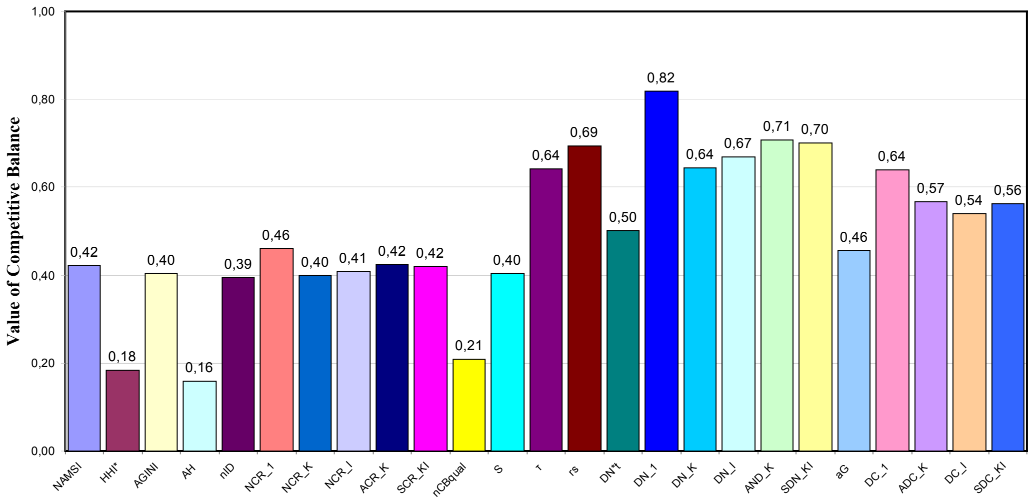
Figure A.9: Box-plot of the Indices in Italy



An overview of the indices by type and dimension is presented in Table 6.1.

Table A.15: Competitive Balance Indices for Norway

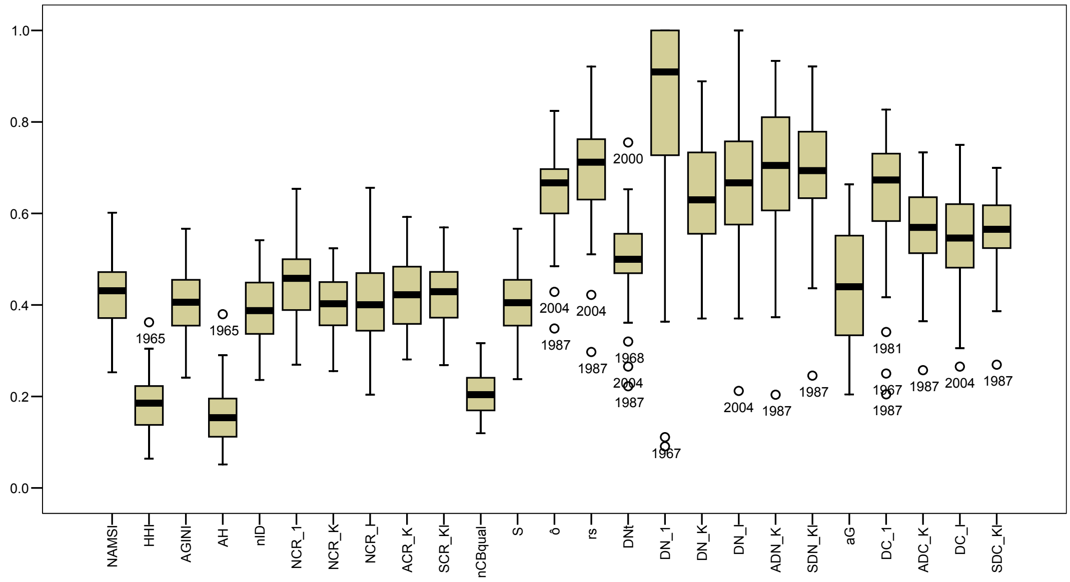
Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
$NAMSI$	Seasonal	0.421	0.081	0.253	0.372	0.431	0.471	0.602
HHI^*		0.183	0.068	0.064	0.138	0.186	0.222	0.362
$AGINI$		0.404	0.077	0.241	0.356	0.406	0.455	0.567
AH		0.158	0.066	0.051	0.113	0.153	0.195	0.380
nID		0.395	0.081	0.236	0.337	0.388	0.448	0.542
NCR_1		0.460	0.103	0.269	0.389	0.458	0.500	0.654
NCR_K		0.399	0.070	0.256	0.356	0.402	0.447	0.524
NCR^I		0.409	0.100	0.204	0.346	0.401	0.469	0.656
ACR_K		0.424	0.079	0.281	0.364	0.423	0.483	0.592
SCR_K^I		0.421	0.076	0.269	0.373	0.429	0.471	0.569
nCB_{qual}		0.208	0.052	0.119	0.170	0.204	0.241	0.317
S		0.403	0.077	0.238	0.356	0.405	0.455	0.567
τ	Between-seasons	0.642	0.092	0.348	0.600	0.667	0.697	0.824
r_s		0.693	0.115	0.297	0.630	0.712	0.762	0.921
DN_t^*		0.500	0.101	0.222	0.469	0.500	0.556	0.755
DN_1		0.818	0.239	0.091	0.727	0.909	1.000	1.000
DN_K		0.644	0.132	0.370	0.556	0.630	0.733	0.889
DN^I		0.668	0.172	0.212	0.576	0.667	0.758	1.000
ADN_K		0.708	0.150	0.204	0.607	0.705	0.810	0.934
SDN_K^I		0.700	0.124	0.245	0.633	0.694	0.779	0.921
aG		0.456	0.125	0.204	0.335	0.440	0.552	0.664
DC_1	Bi-dimensional	0.641	0.147	0.205	0.583	0.673	0.731	0.827
ADC_K		0.567	0.097	0.257	0.513	0.569	0.635	0.733
DC^I		0.539	0.104	0.265	0.481	0.546	0.620	0.750
SDC_K^I		0.561	0.085	0.269	0.524	0.565	0.618	0.700



Mean Values of Competitive Balalance Indices in Norway

An overview of the indices by type and dimension is presented in Table 6.1.

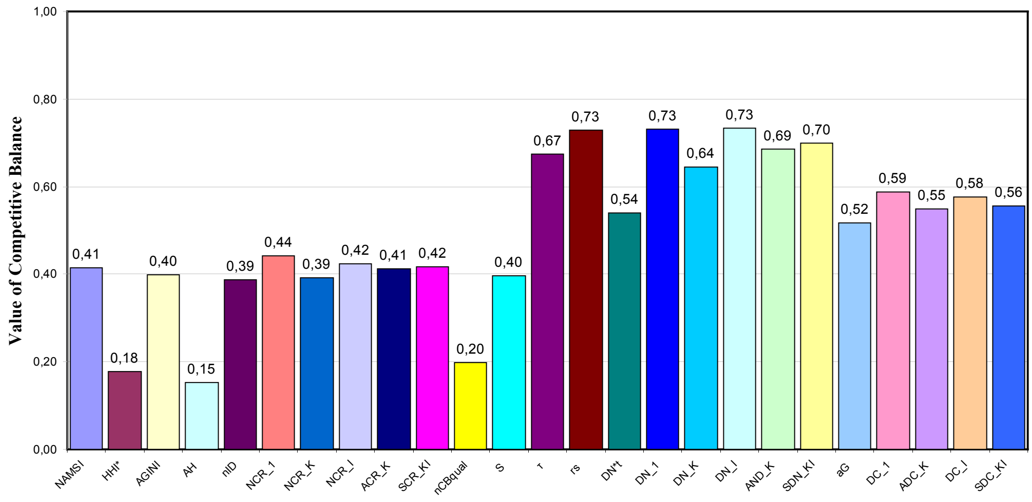
Figure A.10: Box-plot of the Indices in Norway



An overview of the indices by type and dimension is presented in Table 6.1.

Table A.16: Competitive Balance Indices for Sweden

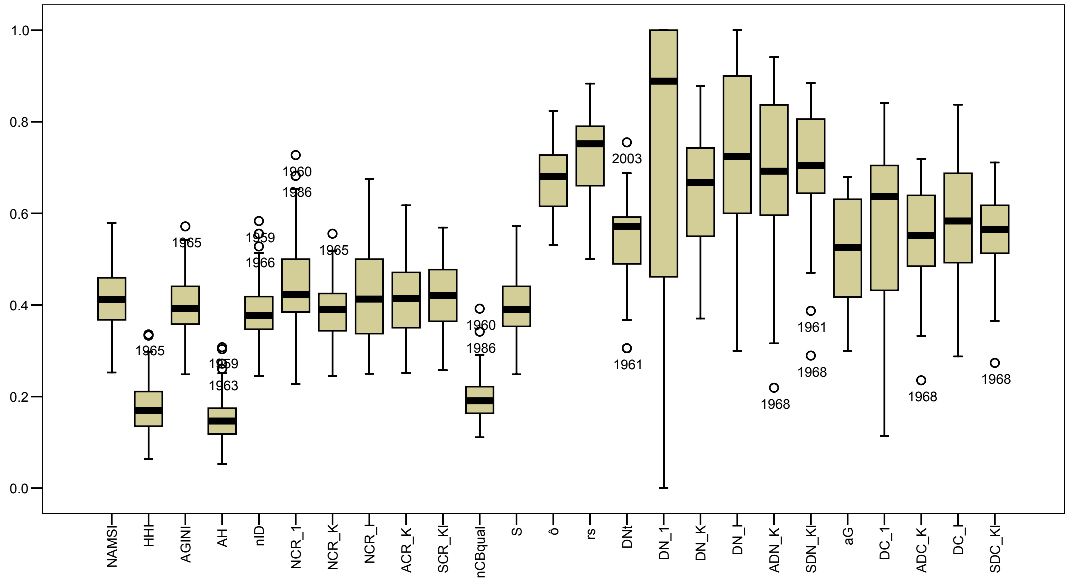
Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
NAMSI	Seasonal	0.414	0.074	0.252	0.370	0.412	0.458	0.579
HHI^*		0.177	0.062	0.064	0.137	0.170	0.210	0.336
AGINI		0.398	0.071	0.248	0.360	0.392	0.440	0.572
AH		0.153	0.059	0.052	0.119	0.147	0.174	0.308
nID		0.386	0.075	0.245	0.347	0.376	0.418	0.583
NCR_1		0.442	0.098	0.227	0.385	0.423	0.492	0.727
NCR_K		0.392	0.067	0.244	0.344	0.390	0.425	0.556
NCR^I		0.424	0.106	0.250	0.339	0.413	0.495	0.675
ACR_K		0.413	0.076	0.252	0.350	0.413	0.466	0.617
SCR_K^I		0.416	0.073	0.257	0.365	0.421	0.476	0.569
nCB_{qual}		0.198	0.053	0.111	0.164	0.191	0.220	0.392
S		0.396	0.072	0.248	0.354	0.390	0.440	0.572
τ	Between-seasons	0.673	0.074	0.530	0.615	0.681	0.727	0.824
r_s		0.730	0.096	0.500	0.661	0.752	0.790	0.884
DN_t^*		0.539	0.095	0.306	0.490	0.571	0.592	0.755
DN_1		0.732	0.292	0.000	0.462	0.889	1.000	1.000
DN_K		0.644	0.136	0.370	0.550	0.667	0.743	0.879
DN^I		0.734	0.177	0.300	0.600	0.725	0.900	1.000
ADN_K		0.687	0.167	0.219	0.596	0.692	0.837	0.941
SDN_K^I		0.699	0.130	0.289	0.644	0.705	0.806	0.885
aG		0.518	0.107	0.300	0.419	0.526	0.629	0.680
DC_1	Bi-dimensional	0.587	0.166	0.114	0.432	0.636	0.705	0.841
ADC_K		0.549	0.103	0.235	0.485	0.552	0.639	0.718
DC^I		0.577	0.122	0.288	0.492	0.583	0.688	0.838
SDC_K^I		0.556	0.084	0.273	0.513	0.564	0.618	0.711



Mean Values of Competitive Balalance Indices in Sweden

An overview of the indices by type and dimension is presented in Table 6.1.

Figure A.11: Box-plot of the Indices in Sweden



An overview of the indices by type and dimension is presented in Table 6.1.

Table A.17: Competitive Balance Indices in Europe

Index	Dimension	Mean	SD	Min	Q_1	Median	Q_3	Max
$NAMSI$	Seasonal	0.413	0.080	0.195	0.362	0.413	0.466	0.634
HHI^*		0.177	0.067	0.038	0.131	0.170	0.217	0.401
$AGINI$		0.396	0.077	0.179	0.345	0.393	0.446	0.621
AH		0.149	0.059	0.031	0.108	0.142	0.181	0.380
nID		0.385	0.079	0.167	0.335	0.377	0.435	0.633
NCR_1		0.498	0.111	0.227	0.423	0.500	0.567	0.824
NCR_K		0.415	0.091	0.181	0.356	0.407	0.463	0.700
NCR^I		0.394	0.091	0.172	0.333	0.389	0.455	0.675
ACR_K		0.452	0.097	0.229	0.388	0.441	0.512	0.744
SCR_K^I		0.442	0.088	0.221	0.383	0.436	0.497	0.699
nCB_{qual}		0.210	0.068	0.094	0.163	0.196	0.244	0.539
S		0.400	0.078	0.179	0.350	0.399	0.452	0.621
τ	Between-seasons	0.700	0.080	0.348	0.653	0.710	0.758	0.882
r_s		0.769	0.099	0.297	0.712	0.783	0.841	0.954
DN_t^*		0.576	0.100	0.222	0.510	0.583	0.642	0.815
DN_1		0.845	0.211	0.000	0.800	0.933	1.000	1.000
DN_K		0.722	0.128	0.344	0.636	0.729	0.819	1.000
DN^I		0.731	0.147	0.212	0.644	0.750	0.825	1.000
ADN_K		0.781	0.135	0.204	0.707	0.805	0.883	1.000
SDN_K^I		0.773	0.115	0.245	0.705	0.794	0.853	0.972
aG		0.581	0.156	0.164	0.471	0.589	0.688	0.925
DC_1	Bi-dimensional	0.672	0.135	0.114	0.618	0.702	0.765	0.912
ADC_K		0.616	0.100	0.235	0.559	0.621	0.681	0.838
DC^I		0.562	0.096	0.265	0.506	0.570	0.627	0.838
SDC_K^I		0.607	0.087	0.269	0.556	0.612	0.668	0.800

An overview of the indices by type and dimension is presented in Table 6.1.

Table A.18: Ten Best Records for DN^{I} and DN^{1} Indices

	DN^{I}			DN^{1}		
R	*Country*	*Season*	*Value*	*Country*	*Season*	*Value*
1	*Norway*	2004	0.212	*Norway*	1969	0,000
2	*Germany*	1969	0.281	*France*	1968	0,059
3	*Sweden*	1970	0.300	*France*	1968	0,059
4	*France*	1968	0.313	*Norway*	1973	0,091
5	*Belgium*	1970	0.321	*France*	1970	0,105
6	*Sweden*	1988	0.350	*Belgium*	1970	0,133
7	*England*	1960	0.350	*Norway*	2001	0,231
8	*Norway*	1987	0.370	*England*	1975	0.238
9	*France*	1970	0.373	*Norway*	1987	0,273
10	*Norway*	1968	0.375	*Belgium*	1997	0,294

Table A.19: Point Scheme

Point System	*Belgium*	*England*	*France*	*Germany*	*Greece*	*Italy*	*Norway*	*Sweden*
3-2-1*					1959-1972			
2-1-0	1966-1994	1959-1980	1959-1987† & 1989-1993	1963-1994	1973-1991	1959-2008	1963-1986	1959-1989
3-2-1-0‡							1987	
3-1-0	1995-2008	1981-2008	1988 & 1994-2008	1995-2008	1992-2008	1994-2008	1988-2008	1990-2008

†In France for the season 1993, one point bonus is for more than three goals. Additionally, for the seasons 1975 and 1975 one point bonus is given to wins with more than 3 goals difference.

‡ Following a draw, an extra point is given for the win in penalties.

* Three points are awarded for a win, two for a draw, and one for a loss.

Appendix B. Analysis of Competitive Balance in European Countries

B.1. Belgium

From the decade ranking presented in Table B.1 it may be drawn that in terms of seasonal competitive balance the last two decades in Belgium are the worst. This also confirms the upward linear trend found in the seasonal dimension. Additionally, in terms of between-seasons competitive balance the last decade is the worst. Therefore, it may be stated that compared with its historical values competitive balance in Belgium has recently worsened. A time-series MA(5) for all indices in Belgium is illustrated in the graphs presented in Figure B.1. As is depicted in Graph 1, the summary seasonal indices present an identical trend pattern and form two distinct groups, as was already indicated for Greece. From Graph 2, it may be noted that NCR_1 demonstrates the highest values, which may be interpreted as high degree of champion domination. Conversely, NCR^I displays the lowest values, which signifies a greater competition in the relegation places. Therefore, it may be drawn that the promotion-relegation rule greatly promotes competitive balance in Belgium. What may be noted for Graphs 3 & 4 is the abrupt drop in the middle of the 1990's, which has already been discussed in relation to the trend analysis. More specifically, the highest drop is observed for the aG index while a similar drop is not observed for the DN_1 index. With the exception of the champion, it may be stated that mobility is more evident both at the top and the bottom of the ladder. Alternatively, the champion dominates the league across seasons and at the same time the league appears more balanced. From Graph 5 it may be derived that the drop identified in the middle of the 1990's is only due to an improvement in the competition at the bottom of the league.

Table B.1: Decade Ranking for All Indices in Belgium

Index	1959-1968	1969-1978	1979-1988	1989-1998	1999-2008
$NAMSI$	1	2	3	4	5
HHI^*	1	2	3	4	5
$AGINI$	1	2	3	4	5
AH	1	2	3	4	5
nID	1	2	3	4	5
NCR_1	2	1	3	5	4
NCR_K	1	2	3	4	5
NCR^I	1	3	2	4	5
ACR_K	2	1	3	4	5
SCR_K^I	2	1	3	4	5
nCB_{qual}	2	1	3	4	5
S	1	2	3	4	5
τ	3	4	2	1	5
r_s	2	4	3	1	5
DN_t^*	2	4	3	1	5
DN_1	5	3	1	4	2
DN_K	2	4	3	1	5
DN^I	1	2	4	3	5
ADN_K	1	4	3	2	5
SDN_K^I	1	4	3	2	5
aG		4	2	1	3
DC_1	2	1	3	5	4
ADC_K	1	2	3	4	5
DC^I	1	2	4	3	5
SDC_K^I	1	2	4	3	5

Figure B.1a: MA(5) for All Indices in Belgium

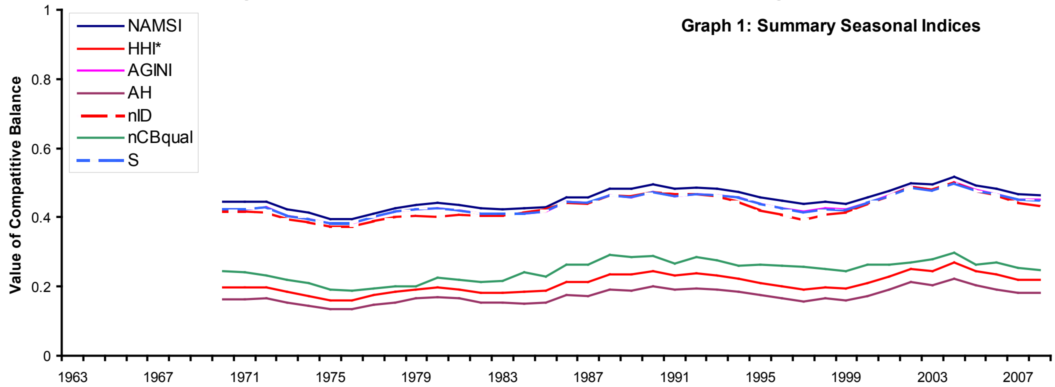
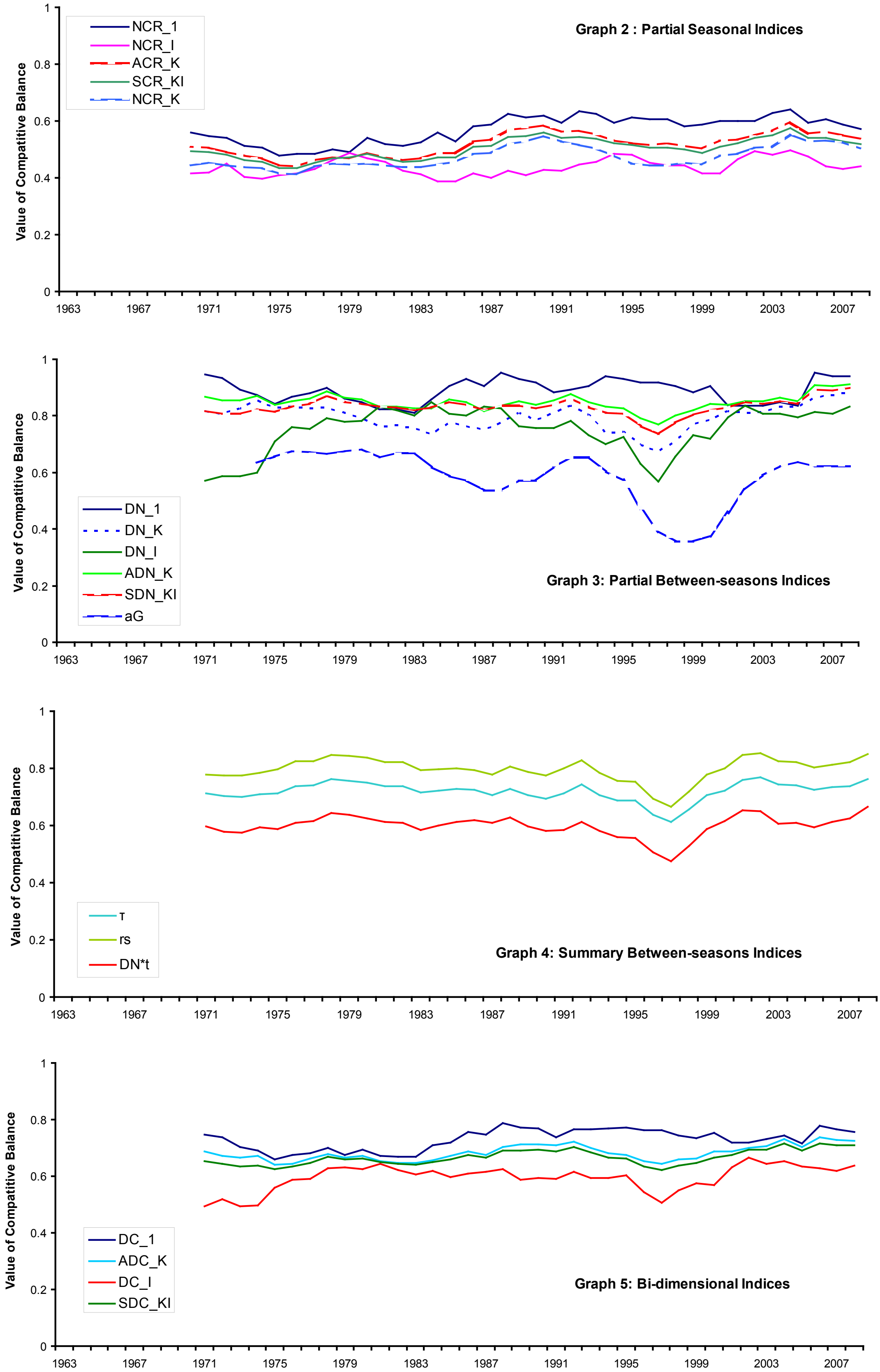


Figure B.1b: MA(5) for All Indices in Belgium



An overview of the indices by type and dimension is presented in Table 6.1.

B.2. England

The decade ranking results presented inTable B.2 reveal that competitive balance in England worsens from decade to decade. More specifically, the first and last decade appear to be the most and the least competitive respectively. This verifies the upward linear trend found in both dimensions. What is noticed in time-series MA(5) presented in Figure B.2 is the identical pattern in two sub-groups of the summary seasonal indices in Graph 1. What may be noted for Graph 2 is that the gap among the partial seasonal indices widens from season to season. This is mostly attributed to the increasing values in NCR_1, which is indicative of seasonal domination by the champion. The same may also be observed in the between-seasons indices depicted in Graph 3. It is important to note that with respect to aG the low levels in the early 1990's are contrasted to the recent high values. Consequently, the worsening of competitive balance in England during the last decade may be explained by the very low mobility of the top five teams across seasons. In Graph 4 the parallel pattern of the summary between-seasons indices is illustrated, which has already been noticed for other countries. From the bi-dimensional indices depicted in Graph 5 it may be verified that the worsening of competitive balance is mainly due to the higher rate of the champion's domination both seasonally and dynamically. On the other hand, the effectiveness of the promotion-relegation rule is ascertained by the relatively high degree of competition at the bottom of the ladder.

Table B.2: Decade Ranking for All Indices in England

Index	*1959-1968*	*1969-1978*	*1979-1988*	*1989-1998*	*1999-2008*
$NAMSI$	1	3	2	4	5
HHI^*	1	3	2	4	5
$AGINI$	1	4	2	3	5
AH	1	4	2	3	5
nID	1	2	4	3	5
NCR_1	1	3	2	4	5
NCR_K	3	1	2	4	5
NCR^I	3	4	2	1	5
ACR_K	2	3	1	4	5
SCR_K^I	1	3	2	4	5
nCB_{qual}	1	3	2	4	5
S	1	3	2	4	5
τ	2	1	3	4	5
r_s	2	1	4	3	5
DN_t^*	2	1	3	4	5
DN_1	1	2	3	4	5
DN_K	3	2	4	1	5
DN^I	1	3	2	4	5
ADN_K	1	2	4	3	5
SDN_K^I	1	2	3	4	5
aG	4	3	2	1	5
DC_1	1	2	3	4	5
ADC_K	1	2	3	4	5
DC^I	2	3	1	4	5
SDC_K^I	1	2	3	4	5

Figure B.2a: MA(5) for All Indices in England

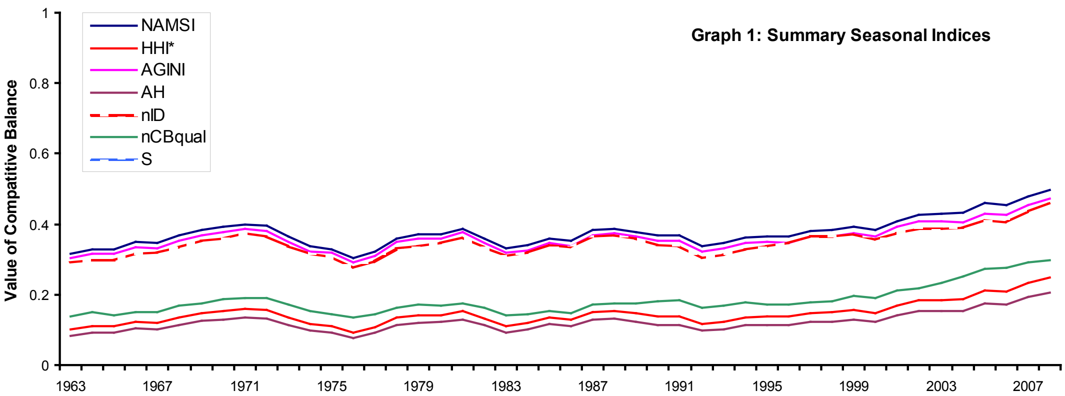
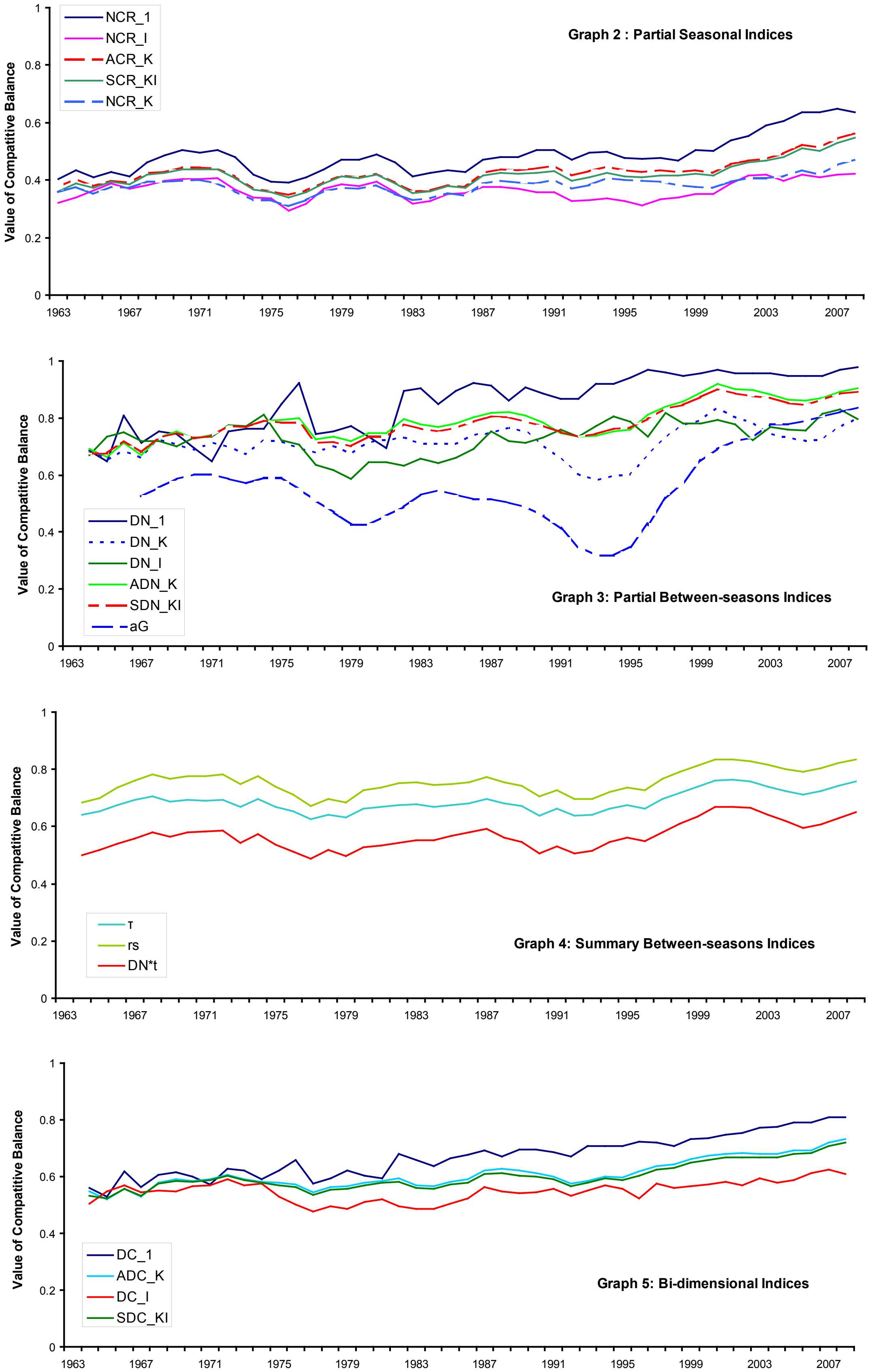


Figure B.2b: MA(5) for All Indices in England



An overview of the indices by type and dimension is presented in Table 6.1.

B.3. France

From Table B.3 it may be derived that in terms of competitive balance values in France the first two decades are the best. Additionally, competitive balance seems to improve in the course of the last decade. For the entire period competitive balance remains quite stable as is revealed by the trend analysis. Based on time-series MA(5) presented in Figure B.3, the identical pattern of the summary seasonal (in two groups - Graph 1) and the between-seasons indices may be verified. In Graph 2 a similar picture is revealed for Belgium, for which the NCR_1 and NCR^I indices demonstrate the highest and the lowest values respectively. Therefore, in contrast to seasonal champion domination, the promotion-relegation rule also promotes competitive balance in France. In Graph 3 a great variability is shown among partial between-seasons indices. That is in sharp contrast to the close values among partial seasonal indices. That may be interpreted by the fact that a quite stable seasonal performance is followed by an inconsistent performance across seasons. It should also be noted that DN_1 displays the highest values while aG the lowest values, which may be interpreted as great mobility in the top teams except for the champion. Alternatively, the change in the top teams' ranking mobility is restricted to second position and below. Those observations are also confirmed by the time series of the bi-dimensional indices, which is displayed in Graph 5.

Table B.3: Decade Ranking for All Indices in France

Index	*1959-1968*	*1969-1978*	*1979-1988*	*1989-1998*	*1999-2008*
$NAMSI$	1	3	5	4	2
HHI^*	1	3	5	4	2
$AGINI$	1	3	5	4	2
AH	1	3	5	4	2
nID	1	2	4	5	3
NCR_1	2	4	5	3	1
NCR_K	2	3	5	4	1
NCR^I	3	4	5	2	1
ACR_K	2	3	5	4	1
SCR_K^I	2	3	5	4	1
nCB_{qual}	3	1	5	4	2
S	1	3	5	4	2
τ	1	2	4	5	3
r_s	1	2	4	5	3
DN_t^*	1	2	3	5	4
DN_1	1	3	2	4	5
DN_K	3	2	4	5	1
DN^I	1	2	5	4	3
ADN_K	3	1	4	5	2
SDN_K^I	3	1	4	5	2
aG	1	2	4	5	3
DC_1	1	3	2	4	5
ADC_K	2	3	4	5	1
DC^I	1	2	5	4	3
SDC_K^I	1	3	4	5	2

Figure B.3a: MA(5) for All Indices in France

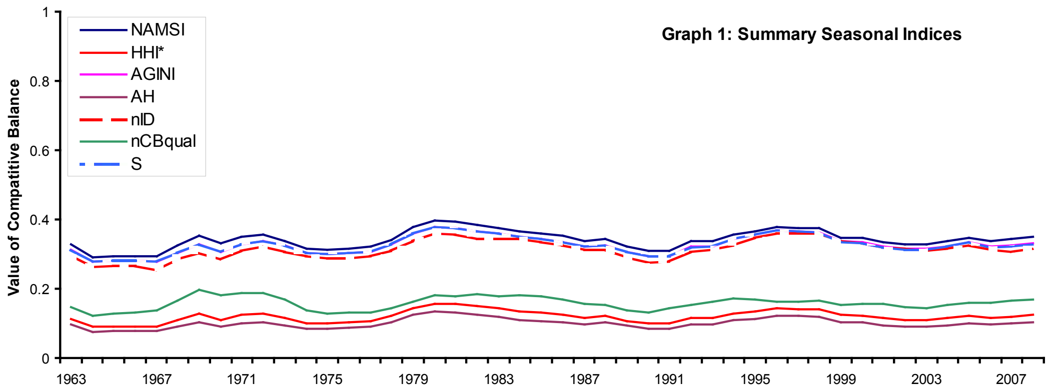
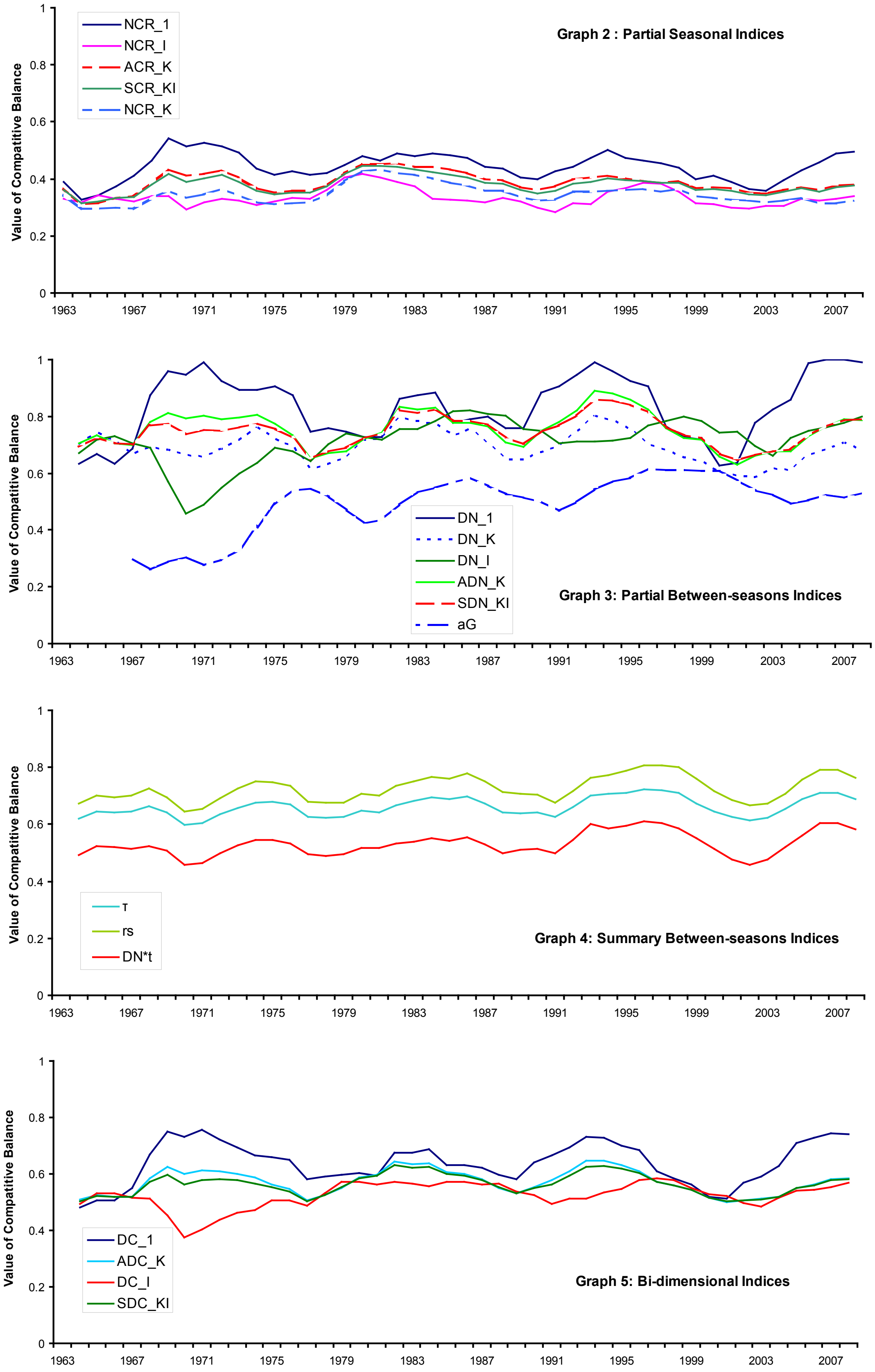


Figure B.3b: MA(5) for All Indices in France



An overview of the indices by type and dimension is presented in Table 6.1.

B.4. Germany

From Table B.4 it is clearly drawn that in terms of competitive balance values in Germany the decade 1959-68 is ranked first while the decade 1979-88 is ranked last in the decade ranking. Moreover, the decade 1999-08 is ranked 4th, which indicates that competitive balance has recently worsened. For the most recent decade, an exception is that the DN^I index is ranked 1st. That signifies that during the decade 1999-08 the promotion-relegation rule efficiently promotes competitive balance. Alternatively, during the recent decade 1999-08, competitive balance levels would be inferior without the promotion-relegation rule. The fluctuation of the indices confirms the cubic trend pattern found in the between-seasons dimension. No significant trend is found in the between-seasons dimension, although it exhibits a drop at the end of the 1990's due to the low levels in the *aG* index. According to time-series MA(5) for all indices in Germany in Figure B.4, what may also be noticed is the similar pattern and the closeness in values for the partial seasonal indices in Graph 2. That indicates that the degree of domination of the top *K* teams is comparable to the degree of weakness of the last *I* teams.

Table B.4: Decade Ranking for All Indices in Germany

Index	*1959-1968*	*1969-1978*	*1979-1988*	*1989-1998*	*1999-2008*
$NAMSI$	1	3	5	2	4
HHI^*	1	3	5	2	4
$AGINI$	1	3	5	2	4
AH	1	3	5	2	4
nID	1	2	5	3	4
NCR_1	1	3	4	2	5
NCR_K	1	3	5	2	4
NCR^I	2	3	5	1	4
ACR_K	1	3	5	2	4
SCR_K^I	1	3	5	2	4
nCB_{qual}	1	3	5	2	4
S	1	3	5	2	4
τ	1	2	5	3	4
r_s	1	2	5	3	4
DN_t^*	1	3	5	2	4
DN_1	1	4	5	2	3
DN_K	1	3	5	2	4
DN^I	2	3	5	4	1
ADN_K	1	3	5	2	4
SDN_K^I	1	3	5	2	4
aG	1	2	5	3	4
DC_1	1	4	5	2	3
ADC_K	1	3	5	2	4
DC^I	1	4	5	3	2
SDC_K^I	1	3	5	2	4

Figure B.4a: MA(5) for All Indices in Germany

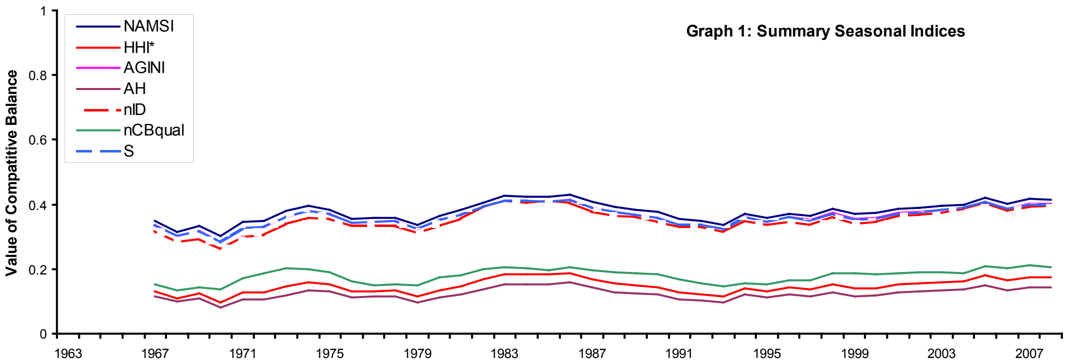
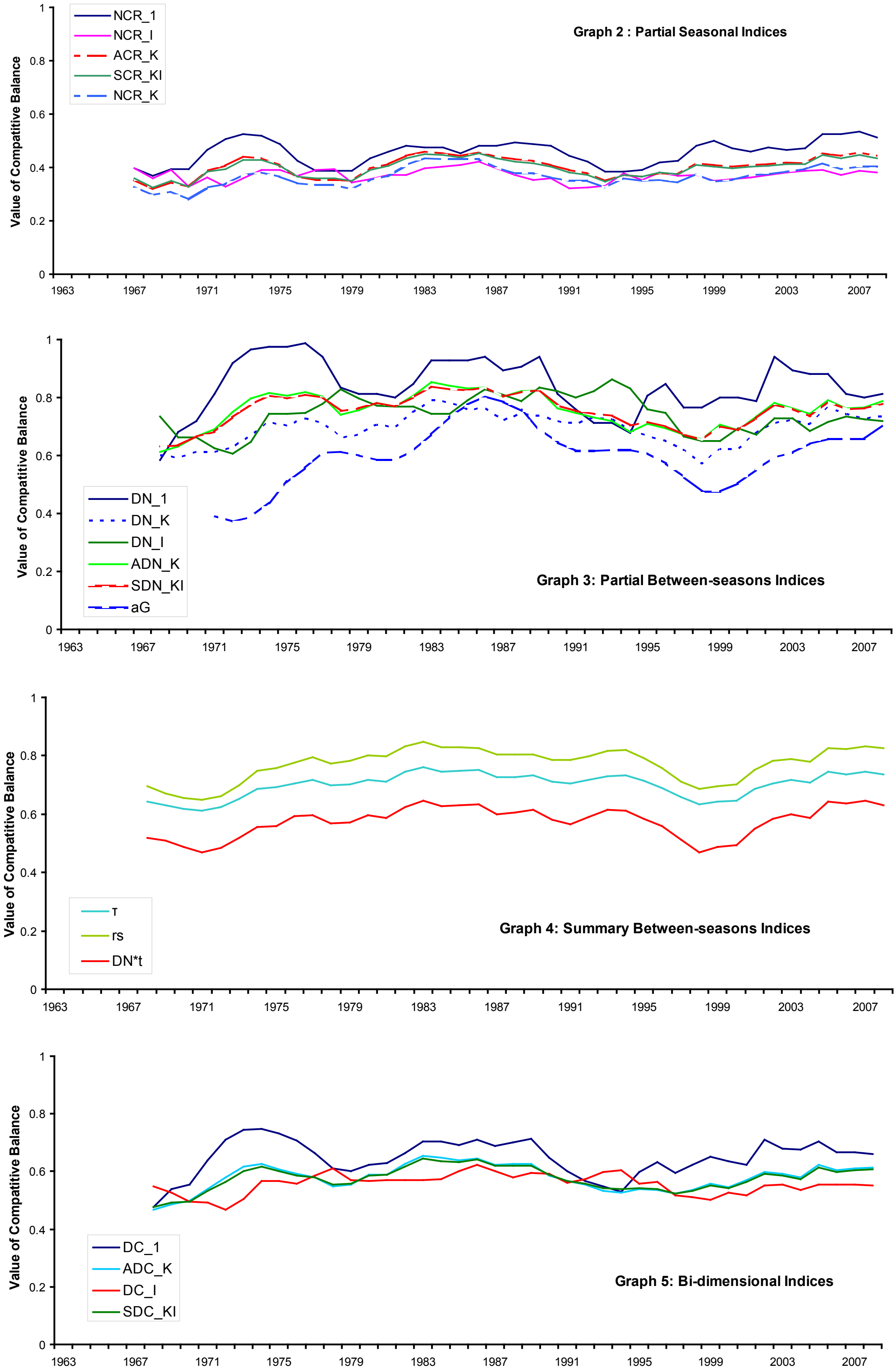


Figure B.4b: MA(5) for All Indices in Germany



An overview of the indices by type and dimension is presented in Table 6.1.

B.5. ***Italy***

From the ranking results in Table B.5 it may be derived that with respect to seasonal competitive balance in Italy the best decade is that of 1979-88. This confirms the quadratic trend found in the seasonal dimension. However, no conclusive remarks can be drawn for the between-seasons dimension, as is also verified by the trend analysis. Furthermore, the absence of a trend pattern is illustrated in the MA(5) time series for all indices in Figure B.5. It may also be drawn from Graph 3 that the high values of the between-seasons indices are indicative of a very unbalanced league across seasons. Additionally, considerable difference may be noticed between the DN_1 and aG indices. That may be interpreted as great mobility in the top K positions with the exception of the champion. What may also be attested is a propensity for the champion's domination across seasons while there is great variation in the teams' identity in the remaining top K positions.

Table B.5: Decade Ranking for All Indices in Italy

Index	*1959-1968*	*1969-1978*	*1979-1988*	*1989-1998*	*1999-2008*
NAMSI	2	3	1	4	5
HHI^*	2	3	1	4	5
AGINI	2	3	1	4	5
AH	2	3	1	4	5
nID	2	3	1	4	5
NCR_1	4	2	1	3	5
NCR_K	4	3	1	2	5
NCR^I	3	2	1	5	4
ACR_K	4	3	1	2	5
SCR_K^I	4	3	1	2	5
nCB_{qual}	3	4	1	2	5
S	2	3	1	4	5
τ	1	4	2	5	3
r_s	1	4	3	5	2
DN_t^*	1	4	2	5	3
DN_1	2	4	1	3	5
DN_K	5	2	4	1	3
DN^I	2	4	3	5	1
ADN_K	4	1	2	3	5
SDN_K^I	3	2	1	4	5
aG	5	2	1	3	4
DC_1	2	3	1	4	5
ADC_K	4	2	1	3	5
DC^I	1	4	3	5	2
SDC_K^I	3	2	1	4	5

Figure B.5a: MA(5) for All Indices in Italy

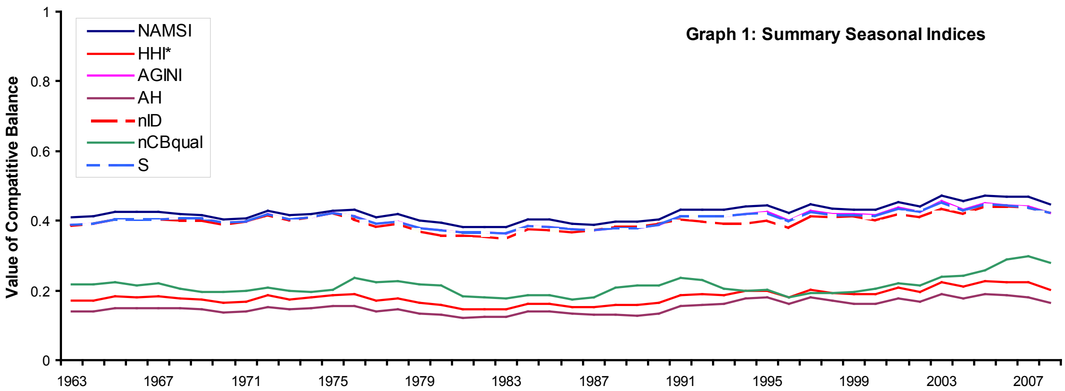
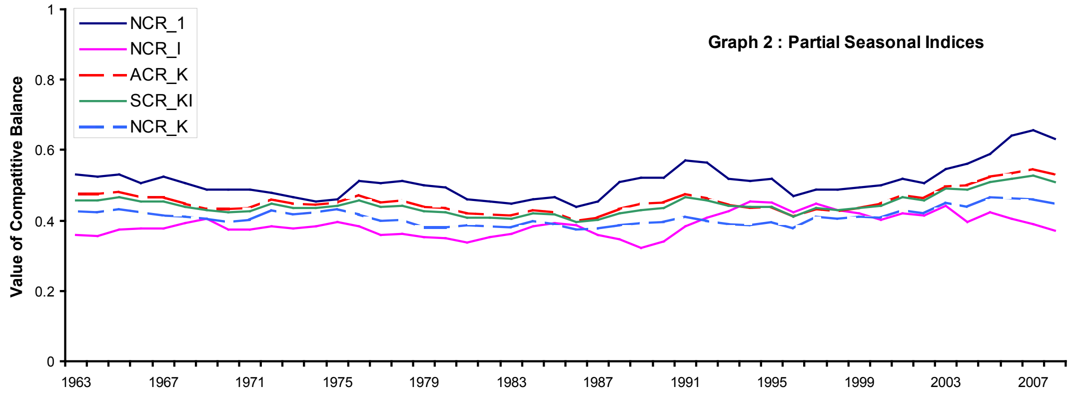
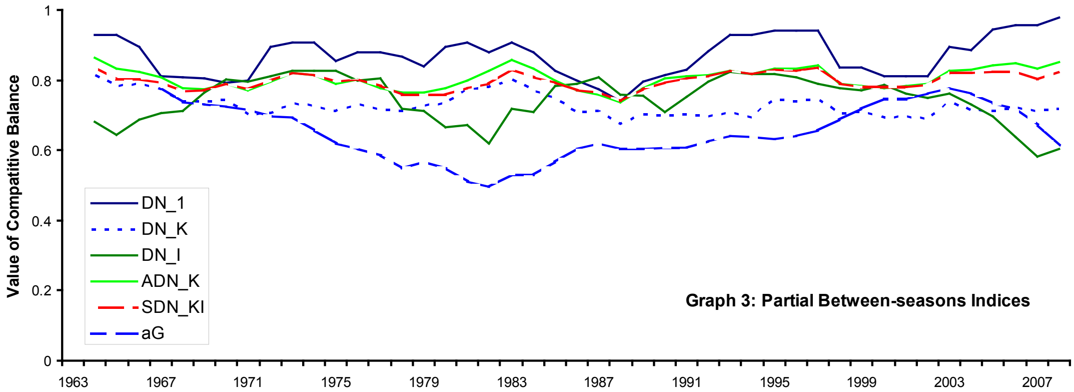
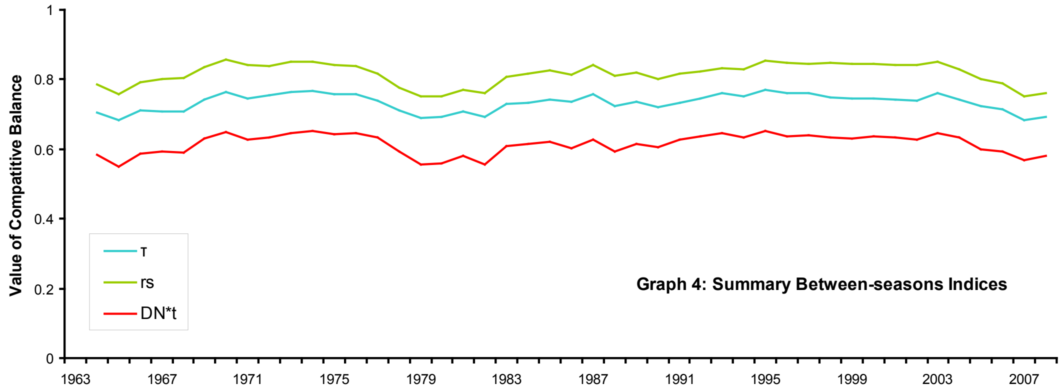
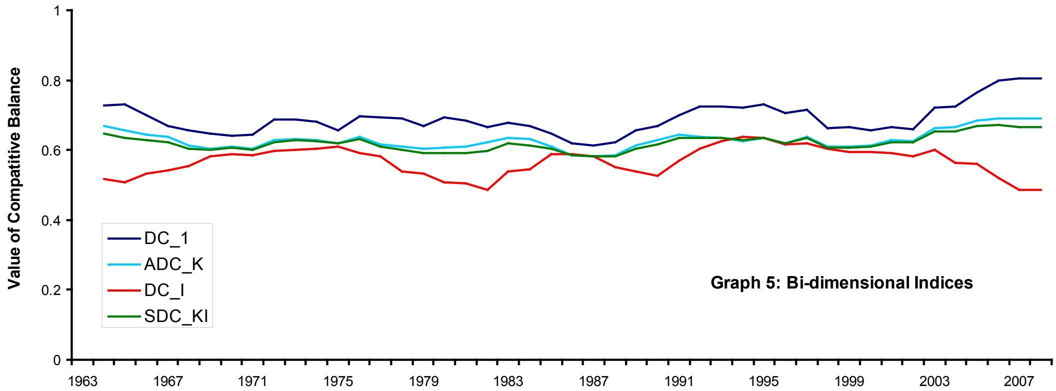


Figure B.5b: MA(5) for All Indices in Italy









An overview of the indices by type and dimension is presented in Table 6.1.

B.6. Norway

Based on the ranking results in Table B.6 an improvement of seasonal competitive balance is revealed in Norway in the last decade while the trend for the entire period is negative. On the contrary, a worsening of the between-seasons dimension is noticed in the course of the last two decades. In terms of seasonal competitive balance the best decade is that of 1979-88 while in terms of between-seasons competitive balance the best decades are the earlier two. In Figure B.6 the improvement of seasonal competitive balance is confirmed for the last few seasons (see Graph 1 & 2). Strikingly enough, a considerable gap exists between the DN_1 and the aG values, for which an interpretation similar to the above for Italy may be offered. However, we should also point out the remarkably high values of DN_1 for an extended period, which may be explained by the domination of Rosenborg. Additionally, the large difference between the NCR_1 and DN_1 indices is indicative of a great seasonal competition for the championship title combined with a between-seasons domination by a single team. In reality, this is considered as a model defined by the champion's final domination regardless of the competition for the championship title during the season.

Table B.6: Decade Ranking for All Indices in Norway

Index	*1959-1968*	*1969-1978*	*1979-1988*	*1989-1998*	*1999-2008*
$NAMSI$	3	5	1	4	2
HHI^*	3	5	1	4	2
$AGINI$	3	5	1	4	2
AH	3	5	1	4	2
nID	3	5	1	4	2
NCR_1	2	4	1	5	3
NCR_K	3	4	1	5	2
NCR^I	4	5	1	3	2
ACR_K	3	4	1	5	2
SCR_K^I	3	4	1	5	2
nCB_{qual}	3	4	1	5	2
S	3	5	1	4	2
τ	2	1	3	4	5
r_s	2	1	3	4	5
DN_t^*	2	3	1	4	5
DN_1	1	3	2	5	4
DN_K	2	1	3	5	4
DN^I	2	1	4	3	5
ADN_K	1	3	2	5	4
SDN_K^I	1	3	2	5	4
aG	4	1	3	5	2
DC_1	1	3	2	5	4
ADC_K	1	3	2	5	4
DC^I	1	4	2	3	5
SDC_K^I	1	3	2	5	4

Figure B.6a: MA(5) for All Indices in Norway

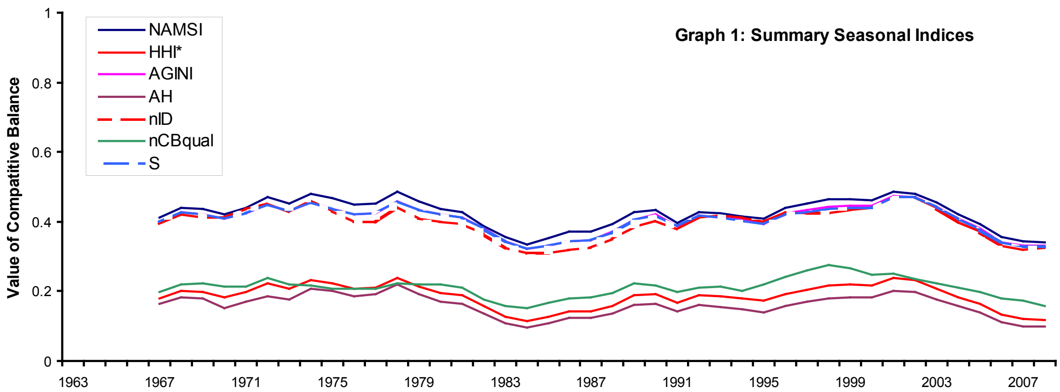
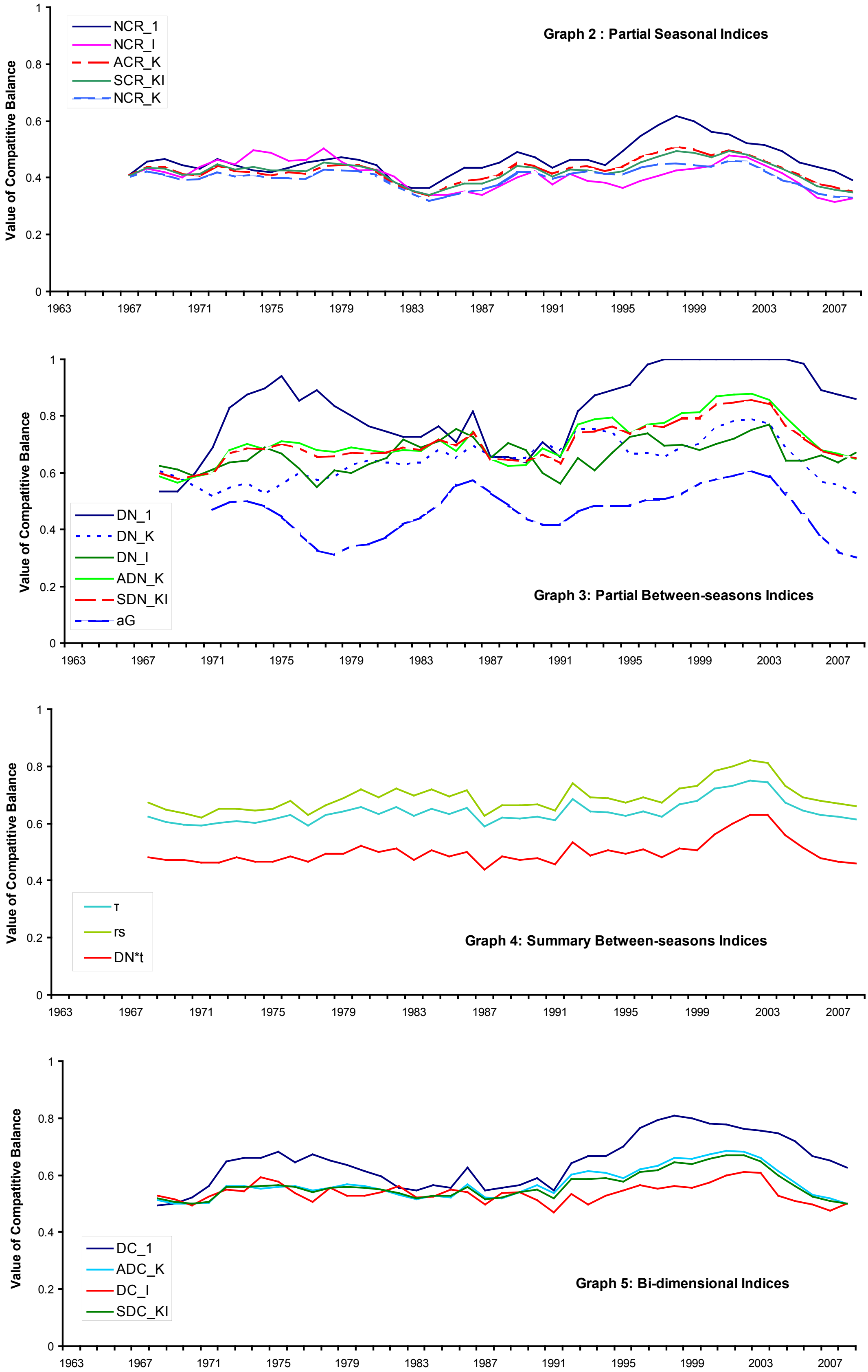


Figure B.6b: MA(5) for All Indices in Norway



An overview of the indices by type and dimension is presented in Table 6.1.

B.7. Sweden

According to the decade ranking of the indices in Table B.7, a quite unusual phenomenon emerges. More specifically, the earliest decade in Sweden (1959-68) is ranked first and last in terms of the between-seasons and the seasonal competitive balance respectively. This may be interpreted as low values of seasonal competition combined with great mobility of teams across seasons. Such a seasonally unbalanced league may not be undesirable as long as its between-seasons dimension is balanced. It should be pointed out that in the early 1960's the indices for relegation are rated higher than those of the indices for the champion, which may be interpreted as greater competition for the championship than for relegation. The unique downward seasonal trend pattern found in the analysis is verified by the MA(5) time series, which is illustrated in Figure B.7. What is also observed in Graphs 3 and 5 is a similar behaviour among the partial seasonal indices and the bi-dimensional indices respectively. That takes places especially during the last two decades, which is indicative of a comparable competition in both the top K and the bottom I positions. Additionally, what may be drawn from Graph 3 is the gradual decrease in the gap between the DN_1 and aG indices, which may be interpreted as lower domination of the champion compared with the other top K teams across seasons.

Table B.7: Decade Ranking for All Indices in Sweden

Index	*1959-1968*	*1969-1978*	*1979-1988*	*1989-1998*	*1999-2008*
NAMSI	5	2	4	1	3
HHI^*	5	2	4	1	3
AGINI	5	1	4	2	3
AH	5	1	4	2	3
nID	5	1	4	2	3
NCR_1	4	5	3	1	2
NCR_K	5	2	4	1	3
NCR^I	5	4	2	1	3
ACR_K	5	3	4	1	2
SCR_K^I	5	3	4	1	2
nCB_{qual}	5	3	4	2	1
S	5	2	4	1	3
τ	1	4	3	2	5
r_s	1	4	3	2	5
DN_t^*	1	4	3	2	5
DN_1	1	2	4	5	3
DN_K	1	5	3	2	4
DN^I	4	5	1	2	3
ADN_K	1	5	4	2	3
SDN_K^I	1	5	4	2	3
aG	1	2	3	4	5
DC_1	1	3	5	4	2
ADC_K	1	4	5	2	3
DC^I	5	4	2	1	3
SDC_K^I	1	5	4	2	3

Figure B.7a: MA(5) for All Indices in Sweden

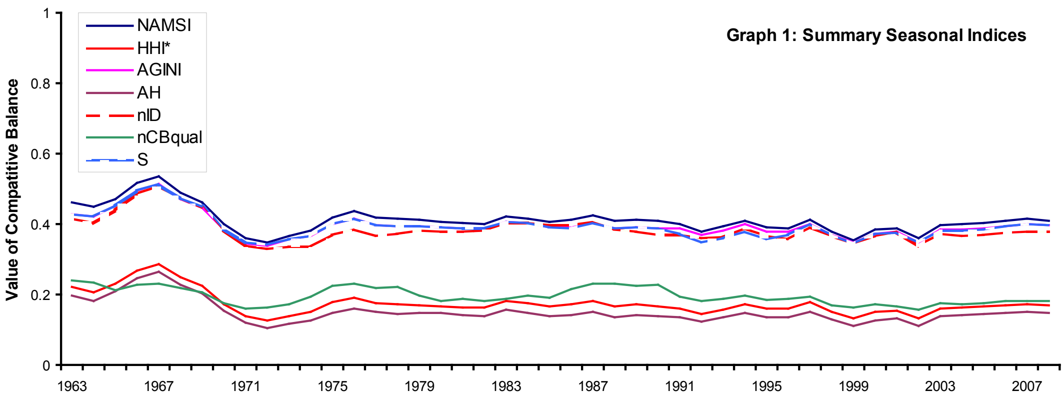
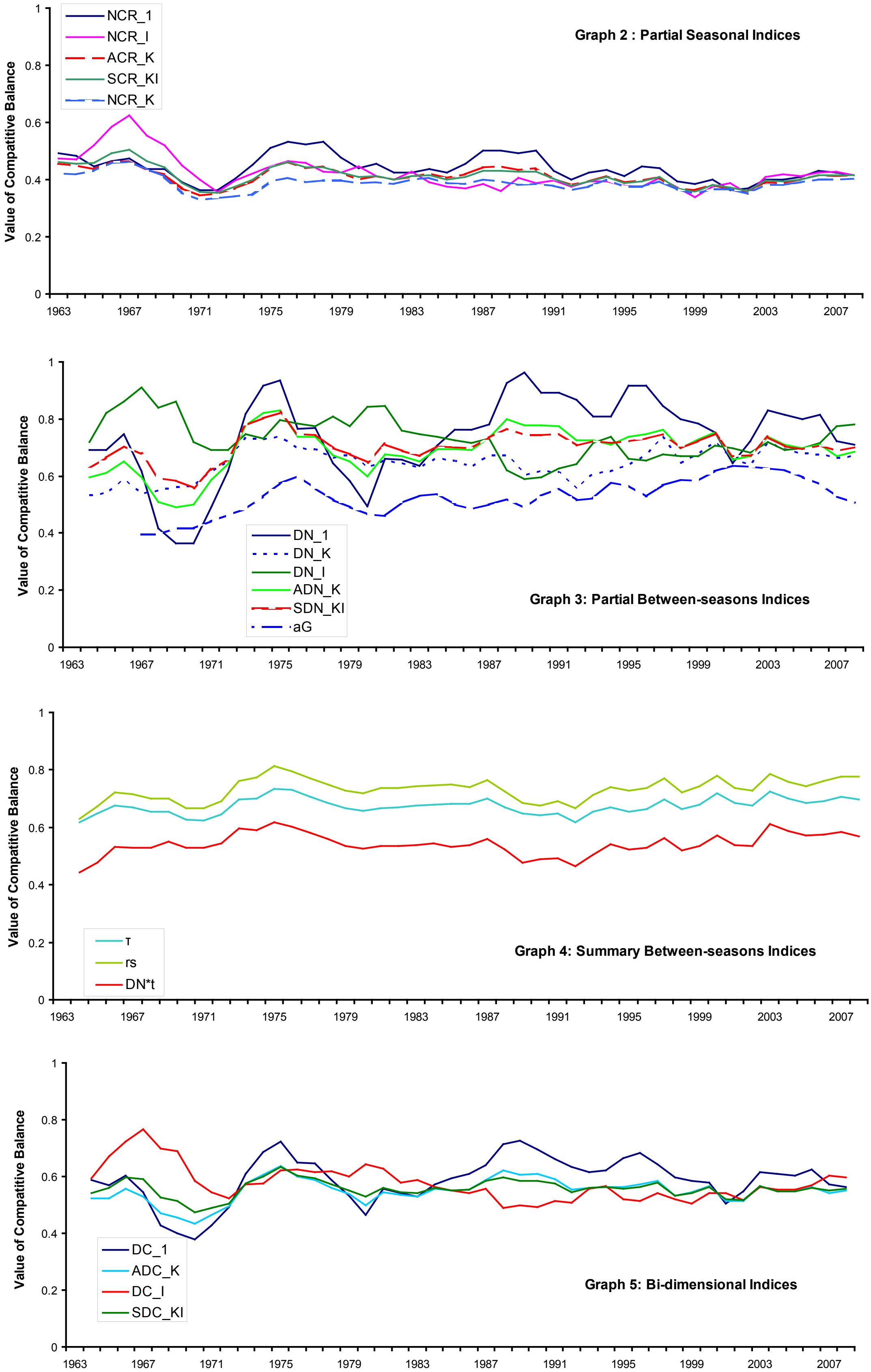


Figure B.7b: MA(5) for All Indices in Sweden



An overview of the indices by type and dimension is presented in Table 6.1.

Appendix C. Results from Econometric Model

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln_ATT_

Table C.1: Competitive Balance Index in the Model: _NAMSI_

	ln*NAMSI*	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1st lag:	-0.030 (0.036)	0.878*** (0.248)	0.077*** (0.019)	0.034*** (0.013)	-0.170*** (0.030)
Δ:	-0.079*** (0.027)	2.603* (1.429)			
1st lag of Δ:		-3.962* (2.264)			-0.081** (0.040)
	d97	*t*	t^2	*D-W*†	R^2_{adj}
	0.038** (0.019)	-0.013*** (0.003)	0.0002*** (0.000)	1.993	0.146

χ^2 *ADF-Fisher* $(p)^a$:	Constant	Constant & Trend
	201.185*** (0-2)	189.892*** (0-2)

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.947	0.901	0.416	0.824	0.640	0.908	0.398	0.398

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a] p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln_ATT_

Table C.2: Competitive Balance Index in the Model: _HHI*_

	lnHHI^*	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1^{st} lag:	-0.015 (0.018)	0.878^{***} (0.247)	0.078^{***} (0.019)	0.035^{***} (0.013)	-0.170^{***} (0.030)
Δ:	-0.039^{***} (0.013)	2.604^{*} (1.429)			
1^{st} lag of Δ:		-3.963^{*} (2.264)			-0.081^{**} (0.040)
	d97	*t*	t^2	*D-W*†	R^2_{adj}
	0.038^{**} (0.019)	-0.013^{***} (0.003)	0.0002^{***} (0.000)	1.993	0.146

χ^2 *ADF-Fisher* $(p)^a$:	Constant 201.186^{***} (0-2)	Constant & Trend 189.895^{***} (0-2)

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.263	0.947	0.901	0.415	0.824	0.640	0.908	0.398

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

$^a p$ = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln_ATT_

Table C.3: Competitive Balance Index in the Model: *AGINI*

	ln*AGINI*	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*			
1st lag:	-0.018 (0.035)	0.893*** (0.252)	0.077*** (0.019)	0.034*** (0.013)	-0.170*** (0.030)			
Δ:	-0.071*** (0.026)	2.598* (1.434)						
1st lag of Δ:		-3.937* (2.288)			-0.081** (0.039)			
	d97	*t*	t^2	*D-W*†	R^2*adj*			
	0.037* (0.019)	-0.014*** (0.003)	0.0002*** (0.000)	1.990	0.144			
χ^2 *ADF-Fisher* (*p*)[a]:	Constant 201.255*** (0-2)		Constant & Trend 190.113*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value)‡:	0.257	0.981	0.926	0.428	0.826	0.624	0.903	0.396

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.4: Competitive Balance Index in the Model: *AH*

	ln*AH*	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1st lag:	-0.007 (0.018)	0.891*** (0.249)	0.077*** (0.019)	0.034*** (0.013)	-0.170*** (0.030)
Δ:	-0.035** (0.013)	2.629* (1.439)			
1st lag of Δ:		-3.910* (2.267)			-0.080** (0.040)
	d97	*t*	t^2	*D-W*†	R^2_{adj}
	0.037* (0.019)	-0.014*** (0.003)	0.0002*** (0.000)	1.992	0.146
χ^2 *ADF-Fisher* $(p)^a$:	Constant 200.459*** (0-2)		Constant & Trend 189.209*** (0-2)		

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.254	0.966	0.930	0.450	0.830	0.610	0.890	0.394

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

$^a p$ = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln_ATT_

Table C.5: Competitive Balance Index in the Model: _nID_

	ln*nID*	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1st lag:	-0.001 (0.030)	0.905*** (0.261)	0.077*** (0.019)	0.035*** (0.013)	-0.172*** (0.031)
Δ:	-0.045* (0.024)	2.695* (1.442)			
1st lag of Δ:		-3.927* (2.297)			-0.087** (0.040)
	d97	*t*	t^2	*D-W*†	R^2_{adj}
	0.036* (0.019)	-0.014*** (0.003)	0.0002*** (0.000)	1.981	0.132

	Constant	Constant & Trend
χ^2 *ADF-Fisher* (*p*)[a]:	200.117*** (0-2)	189.253*** (0-2)

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.146	0.997	0.912	0.450	0.820	0.556	0.893	0.418

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.6: Competitive Balance Index in the Model: nCB_{qual}

	$\ln nCB_{qual}$	$\ln POP$	$\ln GNI$	$\ln Un$	$\ln ATT$
1st lag:	-0.067*** (0.022)	0.809*** (0.233)	0.082*** (0.019)	0.035*** (0.013)	-0.178*** (0.029)
Δ:	-0.088*** (0.019)	2.510* (1.343)			
1st lag of Δ:		-4.313** (2.149)			-0.090** (0.040)
	d97	*t*	t^2	*D-W*†	R^2_{adj}
	0.045** (0.018)	-0.014*** (0.003)	0.0002*** (0.000)	1.992	0.170
χ^2 *ADF-Fisher* $(p)^a$:	Constant	204.288*** (0-2)	Constant & Trend	191.348*** (0-2)	

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.328	0.592	0.803	0.390	0.713	0.954	0.971	0.463

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

$^a p$ = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

***EGLS SUR* method for Attendance Model in Europe, 1959-2008**
Dependent Variable is Δln*ATT*

Table C.7: Competitive Balance Index in the Model: *S*

	ln*S*	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1st lag:	-0.015 (0.034)	0.895*** (0.252)	0.077*** (0.019)	0.035*** (0.013)	-0.171*** (0.030)
Δ:	-0.069*** (0.026)	2.586* (1.438)			
1st lag of Δ:		-3.900* (2.285)			-0.081** (0.039)
	d97	*t*	t^2	*D-W*†	R^2adj
	0.037* (0.019)	-0.014*** (0.003)	0.0002*** (0.000)	1.990	0.146

χ^2 *ADF-Fisher* (*p*)[a]:	Constant 201.181*** (0-2)	Constant & Trend 189.955*** (0-2)

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.252	0.982	0.929	0.432	0.824	0.624	0.897	0.398

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is ΔlnATT

Table C.8: Competitive Balance Index in the Model: NCR_1

	lnNCR_1	lnPOP	lnGNI	lnUn	lnATT
1st lag:	-0.101*** (0.029)	0.824*** (0.232)	0.086*** (0.019)	0.033** (0.013)	-0.185*** (0.030)
Δ:	-0.108*** (0.023)	2.620** (1.305)			
1st lag of Δ:		-4.862** (2.147)			-0.096** (0.040)
	d97	*t*	t^2	*D-W*†	R^2_{adj}
	0.038* (0.019)	-0.014*** (0.003)	0.0002*** (0.000)	1.984	0.170

χ^2 *ADF-Fisher* (p)[a]:	Constant 203.689*** (0-2)			Constant & Trend 188.487*** (0-2)				
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value)‡:	0.360	0.548	0.790	0.535	0.678	0.899	0.976	0.577

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

***EGLS SUR* method for Attendance Model in Europe, 1959-2008**
Dependent Variable is Δln*ATT*

Table C.9: Competitive Balance Index in the Model: NCR_K

	lnNCR_K	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*			
1st lag:	-0.082** (0.033)	0.851*** (0.247)	0.085*** (0.019)	0.036** (0.013)	-0.179*** (0.030)			
Δ:	-0.089*** (0.026)	2.571* (1.459)						
1st lag of Δ:		-4.230* (2.307)			-0.090** (0.041)			
	d97	*t*	t^2	*D-W*†	R^2*adj*			
	0.040** (0.017)	-0.014*** (0.003)	0.0002*** (0.000)	1.911	0.148			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 201.071*** (0-2)		Constant & Trend 189.523*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.262	0.854	0.844	0.299	0.792	0.699	0.948	0.380

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.10: Competitive Balance Index in the Model: NCR^I

	lnNCR^I	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*			
1^{st} lag:	0.010 (0.030)	0.925^{***} (0.262)	0.076^{***} (0.019)	0.032^{**} (0.013)	-0.171^{***} (0.030)			
Δ:	-0.048^{**} (0.021)	2.740^{*} (1.448)						
1^{st} lag of Δ:		-3.825^{*} (2.197)			-0.074^{*} (0.039)			
	d97	*t*	t^2	*D-W*†	R^2_{adj}			
	0.032^{**} (0.019)	-0.014^{***} (0.003)	0.0002^{***} (0.000)	1.978	0.155			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 198.763^{***} (0-2)		Constant & Trend 187.122^{***} (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.338	0.776	0.959	0.540	0.786	0.576	0.851	0.371

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.11: Competitive Balance Index in the Model: ACR_K

	lnACR_K	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*			
1^{st} lag:	-0.118*** (0.034)	0.818*** (0.233)	0.088*** (0.019)	0.036*** (0.013)	-0.186*** (0.030)			
Δ:	-0.116*** (0.027)	2.493* (1.408)						
1^{st} lag of Δ:		-4.580** (2.212)			-0.094** (0.042)			
	d97	*t*	t^2	*D-W*†	R^2_{adj}			
	0.042** (0.017)	-0.014*** (0.003)	0.0002*** (0.000)	1.989	0.165			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 203.290*** (0-2)		Constant & Trend 189.820*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.369	0.523	0.879	0.216	0.733	0.857	0.983	0.409

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.12: Competitive Balance Index in the Model: SCR_K^I

	$\ln SCR_K^I$	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*			
1^{st} lag:	-0.104^{***} (0.036)	0.820^{***} (0.233)	0.084^{***} (0.019)	0.034^{**} (0.013)	-0.179^{***} (0.030)			
Δ:	-0.119^{***} (0.028)	2.420^{*} (1.396)						
1^{st} lag of Δ:		-4.333^{**} (2.190)			-0.089^{**} (0.040)			
	d97	*t*	t^2	*D-W*†	R^2adj			
	0.042^{**} (0.017)	-0.014^{***} (0.003)	0.0002^{***} (0.000)	1.993	0.164			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 202.693^{***} (0-2)		Constant & Trend 189.539^{***} (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.429	0.598	0.883	0.262	0.760	0.854	0.967	0.398

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

[*]Significant at α=10%; [**]significant at α=5%; [***]significant at α=1%.

[†]Durbin-Watson test statistic; [‡]Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.13: Competitive Balance index in the Model: *τ*

	ln τ	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1st lag:	-0.054 (0.047)	0.845*** (0.269)	0.077*** (0.020)	0.038*** (0.013)	-0.168*** (0.028)
Δ:	-0.099** (0.040)				
1st lag of Δ:					-0.081** (0.040)
	d97	*t*	t^2	*D-W*†	R^2*adj*
	0.044** (0.019	-0.013*** (0.003)	0.0002*** (0.000)	1.969	0.131

	Constant	Constant & Trend
χ^2 *ADF-Fisher* (*p*)^a:	203.851*** (0-2)	191.995*** (0-2)

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.117	0.970	0.960	0.487	0.746	0.385	0.847	0.514

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

$^a p$ = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.14: Competitive Balance index in the Model: r_s

	$\ln r_s$	$\ln POP$	$\ln GNI$	$\ln Un$	$\ln ATT$
1st lag:	-0.060 (0.042)	0.859*** (0.269)	0.080*** (0.020)	0.038*** (0.013)	-0.168*** (0.028)
Δ:	-0.069** (0.034)				
1st lag of Δ:					-0.088** (0.041)
	d97	*t*	t^2	*D-W*†	R^2_{adj}
	0.042** (0.019)	-0.013*** (0.003)	0.0002*** (0.000)	1.967	0.126

	Constant	Constant & Trend
χ^2 *ADF-Fisher* $(p)^a$:	202.567*** (0-2)	190.709*** (0-2)

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.135	0.968	0.959	0.505	0.759	0.327	0.852	0.534

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a] p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln_ATT_

Table C.15: Competitive Balance index in the Model: DN_t^*

	$\ln DN_t^*$	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1st lag:	-0.014 (0.029)	0.841*** (0.264)	0.075*** (0.019)	0.037*** (0.013)	-0.169*** (0.028)
Δ:	-0.067** (0.026)				
1st lag of Δ:					-0.078* (0.041)
	d97	*t*	t^2	*D-W*†	R^2adj
	0.042** (0.019)	-0.013*** (0.003)	0.0002*** (0.000)	1.980	0.136

χ^2 *ADF-Fisher* $(p)^a$:	Constant	Constant & Trend
	204.699*** (0-2)	193.164*** (0-2)

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value)‡:	0.077	0.952	0.962	0.486	0.762	0.494	0.869	0.497

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.16: Competitive Balance index in the Model: DN_1

	$\ln DN_1$		$\ln POP$		$\ln GNI$	$\ln Un$	$\ln ATT$	
1st lag:	0.001*** (0.000)		0.908*** (0.273)		0.081*** (0.020)	0.034** (0.013)	-0.178*** (0.031)	
Δ:			2.825* (1.502)					
1st lag of Δ:			-4.047* (2.326)				-0.093** (0.040)	
	d97		*t*		t^2	*D-W*†	R^2_{adj}	
	0.039** (0.019)		-0.014*** (0.003)		0.0002*** (0.000)	1.981	0.121	
χ^2 *ADF-Fisher* $(p)^a$:	Constant 199.713*** (0-2)				Constant & Trend 189.209*** (0-2)			
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value)‡:	0.135	0.949	0.941	0.677	0.782	0.507	0.895	0.518

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

$^a p$ = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln_ATT_

Table C.17: Competitive Balance index in the Model: DN_K

	lnDN_K	lnPOP	lnGNI	lnUn	lnATT
1st lag:	-0.115*** (0.028)	0.937*** (0.263)	0.091*** (0.020)	0.034** (0.013)	-0.186*** (0.031)
Δ:	-0.064** (0.026)	2.781* (1.512)			
1st lag of Δ:		-4.328* (2.399)			-0.099** (0.042)
	d97	*t*	t^2	*D-W*†	R^2_{adj}
	0.033* (0.019)	-0.015*** (0.003)	0.0002*** (0.000)	1.956	0.136
χ^2 *ADF-Fisher* $(p)^a$:	Constant 197.838*** (0-2)		Constant & Trend 182.992*** (0-2)		

Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.201	0.828	0.961	0.660	0.838	0.363	0.759	0.570

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a] p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln_ATT_

Table C.18: Competitive Balance index in the Model: DN^I

	lnDN^I	lnPOP	lnGNI	lnUn	lnATT			
1st lag:	0.013 (0.022)	0.905*** (0.273)	0.078*** (0.020)	0.034** (0.013)	-0.178*** (0.030)			
Δ:		2.761* (1.492)						
1st lag of Δ:		-4.032* (2.302)			-0.089** (0.041)			
	$d97$	t	t^2	$D\text{-}W^{\dagger}$	R^2_{adj}			
	0.035* (0.020)	-0.014*** (0.003)	0.0002*** (0.000)	1.982	0.120			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 199.429*** (0-2)		Constant & Trend 188.068*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.133	0.928	0.933	0.704	0.794	0.583	0.884	0.502

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a] p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.19: Competitive Balance index in the Model: ADN_K

	$\ln ADN_K$	$\ln POP$	$\ln GNI$	$\ln Un$	$\ln ATT$			
1^{st} lag:	-0.130*** (0.024)	0.974*** (0.271)	0.097*** (0.020)	0.028** (0.013)	-0.193*** (0.031)			
Δ:	-0.076*** (0.022)	2.757* (1.508)						
1^{st} lag of Δ:		-5.997** (2.409)			-0.099** (0.039)			
	d97	*t*	t^2	*D-W*†	R^2adj			
		-0.016*** (0.003)	0.0002*** (0.000)	1.971	0.151			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 198.858*** (0-2)		Constant & Trend 186.585*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.255	0.749	0.742	0.500	0.742	0.598	0.857	0.618

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a] p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is $\Delta \ln ATT$

Table C.20: Competitive Balance index in the Model: SDN_K^I

	$\ln SDN_K^I$	$\ln POP$	$\ln GNI$	$\ln Un$	$\ln ATT$			
1st lag:	-0.160*** (0.030)	0.922*** (0.269)	0.098*** (0.020)	0.029** (0.013)	-0.189*** (0.031)			
Δ:	-0.103*** (0.028)							
1st lag of Δ:		-3.793* (1.984)			-0.105*** (0.038)			
	d97	*t*	t^2	*D-W*†	R^2*adj*			
		-0.016*** (0.003)	0.0002*** (0.000)	1.970	0.156			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 199.981*** (0-2)		Constant & Trend 186.058*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value)‡:	0.248	0.617	0.881	0.430	0.714	0.450	0.840	0.608

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a] p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.21: Competitive Balance index in the Model: *aG*

	ln*aG*	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*
1^{st} lag:	0.004 (0.020)	1.096*** (0.288)	0.089*** (0.021)	0.032** (0.013)	-0.184*** (0.029)
Δ:					
1^{st} lag of Δ:					-0.105** (0.040)
	d97	*t*	t^2	*D-W*†	R^2*adj*
		-0.014*** (0.003)	0.0002*** (0.000)	1.976	0.126

χ^2 *ADF-Fisher* (*p*)^a:	Constant 177.413*** (0-2)			Constant & Trend 165.474*** (0-2)				
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.059	0.981	0.724	0.816	0.821	0.326	0.951	0.573

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

^{a}*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.22: Competitive Balance index in the Model: DC_1

	lnDC_1	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*			
1st lag:	-0.089*** (0.024)	0.978*** (0.268)	0.093*** (0.020)	0.030** (0.013)	-0.187*** (0.030)			
Δ:	-0.072*** (0.021)	2.869** (1.309)	0.153* (0.091)					
1st lag of Δ:		-5.727** (2.270)			-0.100** (0.041)			
	d97	*t*	t^2	*D-W*†	R^2*adj*			
		-0.015*** (0.003)	0.0002*** (0.000)	1.993	0.154			
χ^2 *ADF-Fisher* (*p*)[a]:	Constant 205.468*** (0-2)		Constant & Trend 193.530*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value)‡:	0.365	0.373	0.713	0.557	0.741	0.759	0.790	0.736

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]*p* = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.23: Competitive Balance index in the Model: DC^I

	lnDC^I	ln*POP*	ln*GNI*	ln*Un*	ln*ATT*			
1^{st} lag:	-0.007 (0.035)	0.867*** (0.267)	0.076*** (0.018)	0.035*** (0.012)	-0.167*** (0.027)			
Δ:	-0.059** (0.025)							
1^{st} lag of Δ:					-0.081** (0.040)			
	d97	*t*	t^2	*D-W*†	R^2adj			
	0.038** (0.019)	-0.013*** (0.003)	0.0002*** (0.000)	1.968	0.143			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 198.673*** (0-2)		Constant & Trend 186.120*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value)‡:	0.130	0.998	0.969	0.553	0.802	0.461	0.851	0.488

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.

EGLS SUR method for Attendance Model in Europe, 1959-2008
Dependent Variable is Δln*ATT*

Table C.24: Competitive Balance index in the Model: ADC_K

	$\ln ADC_K$	$\ln POP$	$\ln GNI$	$\ln Un$	$\ln ATT$			
1st lag:	-0.194*** (0.031)	0.910*** (0.252)	0.101*** (0.020)	0.027** (0.013)	-0.195*** (0.031)			
Δ:	-0.142*** (0.029)	2.300* (1.395)	0.148* (0.091)					
1st lag of Δ:		-5.831** (2.287)			-0.107** (0.043)			
	d97	*t*	t^2	*D-W*†	R^2_{adj}			
		-0.016*** (0.003)	0.0002*** (0.000)	1.984	0.169			
χ^2 *ADF-Fisher* $(p)^a$:	Constant 202.307*** (0-2)		Constant & Trend 191.305*** (0-2)					
Countries Eq.:	*BEL*	*ENG*	*FRA*	*GER*	*GRE*	*ITA*	*NOR*	*SWE*
JP (p-value) ‡:	0.533	0.407	0.809	0.411	0.718	0.772	0.839	0.660

A description of the variables is presented in Section 8.1 (p.198).

Numbers in parentheses are standard errors; Δ is the first difference.

[a]p = lag length in the χ^2 based *ADF-Fisher* test (the lag length is determined using the Schwartz Information Criterion).

*Significant at α=10%; **significant at α=5%; ***significant at α=1%.

†Durbin-Watson test statistic; ‡Jarque-Bera normality test.