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Abstract

Since the early 1990s, competition in the Olympic Winter Games has changed notably in terms of events contested and nations taking part. Despite, these changes, which are overseen by the International Olympic Committee (IOC), the number of medal-winning nations has remained relatively stable.

As a first attempt to illustrate this issue on a discipline by discipline basis, economic techniques are used to examine the outcome of competition between 1992 and 2014. The purpose of this paper is to measure: market size; the number of competing nations; and the balance between competitive nations in six disciplines.

Focusing on competitive balance, the Herfindahl-Hirschman Index is applied to measure the concentration of domination; while the Przeworski Index is used to quantify instability over time. Important changes are identified in biathlon (2010) and short track (2014). While the change in the former is consistent with the IOC's substantial increase in biathlon events, the latter can be attributed to athletes changing their nationality.

IOC policy-makers can benefit from this research as it provides a method by which to monitor competition in a discipline. This method provides the potential for evaluating the likely effects of governing the Olympic Games by increasing the number of events.

Keywords: Olympic winter disciplines; outcome of competition; competitive balance; static and dynamic economic indices; International Olympic Committee

INTRODUCTION

In 1992, the Olympic Winter Games were held in the same year as the Olympic Summer Games for the last time, and marked the start of a period of considerable growth in the former (e.g., Chappelet, 2002, 2014; Kempf, Weber, Renaud, & Stopper, 2014). Between the Winter Games of Albertville 1992 and Sochi 2014, the International Olympic Committee (IOC) increased the number of events by 72%, from 57 events to 98 events. Meanwhile, the number of nations taking part in the Olympic Winter Games has increased by 38% from 64 to 88. This increase is limited by the Olympic Charter to 'approximately 100 events', provided that the total number of athletes 'shall not exceed 2,900' (IOC, 2015, p. 87). As this limit was not reached at the 2014 Sochi Games, it would appear that there is further scope for the IOC to increase the programme even further.

Despite this overall growth in the number of medal-winning opportunities and the number of nations taking part, the actual number of medal winners is largely limited to a small sub-set of competitive nations that dominate the Winter Games (e.g., Andreff & Andreff, 2011; Kempf et al., 2014). The competitiveness of a nation at the Winter Games is positively correlated with macro-level factors such as GDP per capita, population size, being a (former) communist state, having a winter climate, the number of winter sports resorts, and hosting the Games (e.g., Andreff & Andreff, 2011; Johnson & Ali, 2004). At the meso-level, a nation's competitiveness is connected to its national elite sport system and policies (e.g., Bergsgard, Houlihan, Mangset, Nodland, & Rommetvedt, 2007; De Bosscher, Shibli, Westerbeek, & Van Bottenburg, 2015; Digel, Burk, & Fahrner, 2006; Houlihan & Green, 2008).

This point is well illustrated in Table 1, which shows that in the last seven editions of the Winter Games, the highest proportion of nations winning at least one medal has not exceeded one third and the number of medal-winning nations has remained relatively constant at between 24 and 26 since 1998.

Table 1
Competition at the Olympic Winter Games 1992–2014

	1992	**1994**	**1998**	**2002**	**2006**	**2010**	**2014**
Olympic Events	57	61	68	78	84	86	98
Nations participating	64	67	72	78	80	82	88
Medal-winning Nations	20	22	24	24	26	26	26
Percentages of Medal-winning Nations	31%	33%	33%	31%	33%	32%	30%

On the basis of the summary evidence in Table 1, this paper focuses on disciplines, reflecting the concern expressed by the IOC about the level of meaningful competition between nations

at the Winter Games (e.g., IOC, 2002; IOC, 2011, 2015). Since 2002, the IOC's Programme Commission has reported periodically on the global spread of excellence in each winter discipline, by analysing for example, the number of qualified nations and the number of medal-winning nations per continent within each discipline (IOC, 2012). It is therefore reasonable to argue that as the Games' governing organisation, the IOC would like to see an exciting sporting event that reflects genuine global competition in the various winter disciplines (e.g., Kempf & Lichtsteiner, 2015).

The development of managerial research into the outcome of competition at the Games with regard to the IOC's governing policy has received relatively little attention in the literature to date. To the best of our knowledge, only Baimbridge (1998) and Houlihan and Zheng (2013) have discussed the outcome of competition between nations at the Summer Games in relation to the IOC's governing policy as a mechanism to reduce domination by a minority of nations. Both sets of authors argued that the IOC, with the support of International Federations (IFs), aims to reduce nations' domination by including new sports and disciplines in the Games, and by limiting the maximum number of athletes entering the competition by nation and by discipline. These studies can be linked to the sports economics literature examining the competitive balance between teams competing in a league, in relation to the governing policies applied by the respective league's commission (e.g., Binder & Findlay, 2012; Fort & Quirk, 1995; La Croix & Kawaura, 1999; Lee & Fort, 2005, 2012). In theory, optimised competitive balance creates the conditions for increased spectator and television viewing demand and therefore increases revenues (e.g., Neale, 1964; Rottenberg, 1956). However, no index[1] commonly employed in sports economics was used to measure domination (e.g., Depken, 1999; Eckard, 2001; Humphreys, 2002; Koning, 2009; Szymanski & Késenne, 2004; Utt & Fort, 2002; Zimbalist, 2002). Baimbridge (1998) calculated the percentage of nations winning at least one Olympic medal for all the Summer Games between 1896 and 1996. Houlihan and Zheng (2013) measured the percentage of medals won by the top 10% of countries at the Summer Games since 1988. Compared with these basic ratios, recognised economic indices provide a richer analysis including the detailed performance data of all competitors as a means to measure domination.

Unlike a single-sport league like football, measuring domination at the Winter Games using economic indices is more complex because it consists of multiple disciplines, discipline-specific differences regarding the growth of events, and differences in the number of nations taking part and winning medals. The methods used to examine competition per discipline were

[1] For a fuller discussion of *indices* applied in leagues, see Owen (2013).

applied from the field of industrial economics. Economists commonly describe the outcome of competition by quantifying the structure of the industry's markets in which the firms are competing (Sutton, 2001; Tirole, 1988). Thus, the relevant market and respective competitors need to be defined first (e.g., Porter, 2008; Scherer & Ross, 1990). The market structure analysis includes information on the size of a market, the number of competitors in the market, and their respective performance. Combining this data by applying economic indices allows analysts to measure the resulting level of market domination. The results provide a basis to discuss implications for governance to enhance the efficient functioning of the market. That is, a competitive firm must be able to compete against the dominant firms in the market (e.g., Baumol, Panzar, & Willig, 1986). In this regard, economists also analysed the market entry and exit of firms to research the height of barriers to enter a specific market (e.g., Porter, 2008; Scherer & Ross, 1990).

This paper has three aims: first, to define the relevant markets and competitors in the Winter Games using selected cases to illustrate the point; second, to test different economic instruments as a proxy for examining the outcome of competition over time; and thirdly, to offer some interpretation of the evidence they provide. The economic techniques are applied to six Olympic winter disciplines over the period 1992 (Albertville) to 2014 (Sochi).

By introducing a perspective drawn from industrial economics to competition at the Olympic Winter Games and relating it to the IOC's governing policy, this research makes a novel contribution to the study of competitive balance within elite sport. Furthermore, it introduces the role of the IOC from a governing perspective to the sport management literature.

A DISCIPLINE'S MARKET SIZE

Competition in the Winter Games is determined by the Olympic programme which is based upon disciplines 'played on snow or ice' (IOC, 2015, p. 23). Within the programme, the IOC distinguishes between sports disciplines and events resulting in a ranking and an award (i.e. medals and diplomas) for top three and top eight places (IOC, 2015). For example at the 2014 Sochi Games, the alpine skiing discipline consisted of ten events in total, five for men and five for women. These events were: downhill, super-G, giant slalom, slalom and super combination (IOC, 2013a). In each event, eight diplomas were awarded by the IOC resulting in a total market size of 80 Olympic diplomas in alpine skiing. The competition format of an event differs according to the governing IF, such as the International Skiing Federation (FIS), or the International Biathlon Union (IBU). The format of an event is the specific design of the competition (e.g., Scelles, Desbordes, & Durand, 2011), which, in this context, includes for

example: distance, starting order, heats and rounds, individual start, mass start, pursuit, relay, etc. (e.g., FIS, 2012; IBU, 2012).

Governing documents of the IOC reveal that competition in each discipline is evaluated separately after the Games, to decide on the future development of the programme (e.g., IOC, 2011, 2012). According to Rule 45 of the Olympic Charter, the IOC Executive Board makes decisions on the programme of events in a discipline, after consulting with the respective IF, no later than 'three years before the Games' (IOC, 2015, p. 87). It is important to note that the IOC can implement the following three measures to adapt the discipline's programme: (a) inclusion of individual or (b) team/mixed events, and (c) replacement of an existing event. In winter discipline events, a maximum of three or four athletes per nation can take part in individual events depending on the discipline, and in team and mixed events only one team per nation can take part (e.g., FIS, 2012; IBU, 2012). Thus, the number of diplomas that can be contested by a nation is reduced to a maximum of three or four diplomas in individual events, and just one in a team or mixed event. In the case of alpine skiing at the Sochi Games, the discipline consisted of ten individual events meaning that a maximum of 40 out of 80 diplomas were contestable by any one nation.

NUMBER OF COMPETITORS IN A DISCIPLINE

Competitors at the Games are the nations as represented by their National Olympic Committees (NOCs) that have qualified or been invited to take part. Member nations of the IOC compete in the ranking table, while NOCs, after consulting with the respective National Governing Bodies, sends athletes to compete in a discipline's events.

The IOC allocates a limited number of starting places among eligible member NOCs in each discipline. The starting places per nation and discipline are related to each nation's results in qualification competitions, such as the World Championships and World Cup events, organised by the respective IF. For example in alpine skiing, 320 starting places were allocated across the 74 NOCs that qualified for the 2014 Sochi Games. The allocation of quotas per NOC followed a basic quota (i.e. one male and female athlete) for all NOCs competing with one athlete in the 2013 FIS World Cup, and a maximum quota (i.e. four athletes in every event) for NOCs with several athletes in the top 30 (FIS, 2012). After starting places are assigned, NOCs submit a list of athletes to compete in each discipline at the Games (IOC, 2015). This procedure is detailed and published separately for each discipline prior to the Games in the Rules of Qualification, proposed by the IFs and approved by the IOC (e.g., FIS, 2012; IBU, 2012). This legal basis also

includes the Rules of Competition, such as competition format, judging, and competition equipment (IOC, 2015).

According to Baimbridge (1998), this IOC policy of limiting entries per nation and supporting the participation of all eligible member NOCs suggests a likely reduction in the number of competing athletes per nation at the Games. By limiting the number of athletes from strong nations, the IOC enhances the balance of the competition between nations (Baimbridge, 1998). Szymanski (2003) agrees that the IOC influences competition, with the Rules of Qualification limiting the maximum number of athletes that are able to compete per nation. Analysing the design of a sporting contest, Szymanski (2003) described this entry quota system as a governing instrument by which the IOC handicaps dominant nations, and argued that the restriction of the number of athletes per nation has a 'significant influence on the outcome of competition' (Szymanski, 2003, p. 1149). While Szymanski (2003) underlined the attention this issue deserves, he did not provide any further evidence. More recently, Houlihan and Zheng (2013, p. 346) found 'little significant impact on the distribution of medals across competing countries", despite the inclusion of new sports or disciplines and adaptations to the quota system, as designed by some IFs and encouraged by the IOC. These governing measures have not prevented domination at the Summer Games form being relatively stable since 1988.

Hence, similar to an industry that consists of different markets (e.g., Chen, 1996), the Winter Games (i.e. the industry) are comprised of a market for awards in each discipline. In contrast to economic markets, where growth is driven by demand and production, a discipline's market growth is controlled directly by the IOC. Furthermore, the IOC governs the participation of nations at the Games with instruments, such as quotas and the legal basis of competition, showing some similarities to those applied by market governing organisations to limit the influence of dominant foreign competitors (i.e. import quotas), and to ensure fair competition (i.e. the legal basis of competition) (e.g., Scherer & Ross, 1990; Sutton, 2001).

In analysing the literature, the specifics of the market structure in a multi-discipline sporting event like the Olympic Winter Games become evident. They therefore need to be taken into account when analysing the outcome of competition.

STATIC AND DYNAMIC ECONOMIC INDICES OF COMPETITIVE BALANCE

In sports economics, several researchers have used the Herfindahl-Hirschman Index (*HHI*)[2], to analyse the competitive balance between teams in a league (e.g., Depken, 1999; Eckard, 2015;

[2] According to Scherer and Ross (1990) and Sutton (2001), the *HHI* is the most popular index used in economics.

Humphreys, 2002; La Croix & Kawaura, 1999; Owen, Ryan, & Weatherston, 2007). The *HHI* combines data on the number of teams competing and a measure of performance such as their win ratios over a season. This approach measures the concentration of teams' performances to quantify the domination of the league. Ramchandani and Wilson (2014) applied the *HHI* to the Commonwealth Games, a multi-sport competition, to quantify the domination of disciplines over time. In a similar vein, Chaplin and Mendoza (2015) applied the *HHI* to assess the competitive balance between nations in boxing at the Commonwealth Games between 1930 and 2014, while Forrest, McHale, Sanz and Tena (2016) described the domination of 15 Olympic summer disciplines between 1992 and 2014. However, Eckard (2001) was the first to point out the limitation of this conventional index in the context of sport when analysing the competitive balance across seasons. 'A key element of competitive balance is dynamic: Team positions in league standings should fluctuate from year to year. This cannot be captured by the conventional measure of competitive balance in a sports league' (Eckard, 2001, p. 223).

In line with this limitation, Buzzacchi, Szymanski, and Valletti (2003) criticised the *HHI* for being a static index that does not take into account the identity of the teams dominating competition within a sport over time. Table 2 illustrates the relevance of this argument for the current research using a fictional example of the performances of nations in a market for Olympic diplomas. Top eight places equate in most Olympic competitions a place in the final (Borden, 2014). Since diplomas are less subject to statistical noise in the data set caused by the performance of an individual athlete, and the margins between winning a medal or not are so fine; diplomas are arguably a more inclusive measure of a nation's performance over time (e.g., Johnson & Ali, 2004; Shibli, De Bosscher, & Van Bottenburg, 2013; Storm, Nielsen, & Thomsen, 2016). Consequently, in this paper, diplomas (i.e. top eight places) are preferred to medals (i.e. top three places) for analysing the development of competitive balance between nations. In Table 2 at time *t-1* as well as in *t*, the dominant diploma-winning nation wins 50% of the diplomas while the other two nations each win 25%. Hence, comparing the market concentration in *t-1*, based on the distribution of the shares of diplomas among three nations, there appears to be no difference in concentration relative to *t*. In reality, a significant variation in the competitive balance is evident. In this example, the variation between *t-1* and *t* includes a change in the most dominant nation (*A* to *B)* as well as an instance of market exit (*A*) and an instance of market entry (*D*).

Table 2
Fictional Example of Performances by Different Nations in Consecutive Events

Nation	**Event in t-1**		**Event in t**	
Identity	Performance in Diplomas	Performance in Diploma share	Performance in Diplomas	Performance in Diploma share
A	4	50%	-	-
B	2	25%	4	50%
C	2	25%	2	25%
D	-	-	2	25%
Total	8	100%	8	100%

This change in the competitive balance remains undetected by a static index like the *HHI* because it does not capture information on the identity of the diploma-winning nations over time.

To address this issue, different authors have proposed the use of a dynamic index that captures information on the identity of competitors when analysing competitive balance in a league over a time series (e.g., Buzzacchi et al., 2003; Mizak, Neral, & Stair, 2007). The key feature of a dynamic index is that it links performance to a specific team or nation when measuring differences in the competition over time.

De Bosscher, Du Bois and Heyndels (2012) as well as Truyens, De Bosscher and Heyndels (2016) applied the dynamic Hymer and Pashigian Index (*HPI*) to analyse internationalisation in athletics, notably competitive balance. The first set of authors measured the development of domination by nations in various disciplines by analysing the annual top 100 rankings from 1984 to 2006; the latter analysed the World Championships and Olympic Games between 2000 and 2015. The *HPI* respects the identity constraint and controls for the increasing number of events and competing nations in athletics. These are two important technical properties of an index for analysing a multi-discipline sporting event comparable to the Olympic Winter Games, characterised by increases in events and nations over a period. When articulating the difference between applying a dynamic or static index, De Bosscher et al. (2012) suggested that a static index gives information on the changes in internationalisation measured by a dynamic index. The authors did not state whether a static or dynamic index is more suitable to analyse internationalisation and used them simultaneously.

In summary, static and dynamic indices have been applied previously to analyse competitive balance in sport over time, but we have found no study that has developed the analysis further by investigating market structure.

METHOD

With reference to the extant literature in industrial economics (e.g., Scherer & Ross, 1990; Sutton, 2001), we propose that: Olympic diplomas and contestable diplomas define market size; while the number of nations winning diplomas reflects competitive competitors; and, the resulting competitive balance describes the market domination of nations. The respective measures are used as proxies to analyse the various disciplines' market structure and the outcome of competition. From a market governing perspective, the rationale for examining the diplomas' market is that the IOC awards and publishes top eight places with respect to the Rule of Honour in the Olympic Charter (IOC, 2015), while nations also use top eight rankings as a performance indicator and therefore recognise them as meaningful levels of achievement (e.g., DOSB, 2014; SwissOlympic, 2014; UKSport, 2016).

This study focuses on six established and diploma-rich Olympic winter disciplines contested between Albertville 1992 and Sochi 2014, namely: alpine skiing, biathlon, cross-country skiing, speed skating, freestyle skiing and short track speed skating. Every discipline is characterised by two key characteristics. First, they were all included on the Winter Games programme no later than 1992; second, they have sample sizes of at least 250 diplomas awarded over the period.

The data on the IOC quota system per discipline were derived from 42 explanatory competition books for each Games available from the online IOC library. Performance data were sourced from the online Podium Performance database managed by Infostrada Sports[3]. A total of 3,177 diplomas, out of 4,614 diplomas awarded in all 15 winter disciplines from 1988[4]–2014, were edited as follows: diplomas won by each nation in male and female individual, team, and mixed events were aggregated for all nations in each discipline analysed at every Games. Every nation winning a diploma for the first time during the period under review was considered to be a new market entrant, including the independent nations emerging after the fall of the Iron Curtain. This applies in particular to the 1992 and 1994 Games in the disciplines dominated by former communist states, such as the USSR, Yugoslavia and East Germany (i.e. alpine skiing, biathlon, cross-country skiing and speed skating).

[3] *Infostrada Sports* (now Gracenote Sports) is a company which collates sports performance data, and which controls for disqualifications after the Games. Data were retrieved in November 2015.
[4] To calculate the dynamic indices of 1992, the data from 1988 were included to establish the baselines.

Olympic events, diplomas and contestable diplomas

In this context, market size is determined by the number of Olympic diplomas awarded by the IOC for top eight places in each discipline's events. This is a significant departure from the conventional approach of analysing top three (or medal winning) performances.

The number of contestable diplomas per nation and per Games in a discipline is determined by the event-types (i.e. individual or team/mixed events), and the respective maximum quota (i.e. three/four or one).

The difference between the number of diplomas available and contestable reflects the IOC's approach of limiting dominant nations by reducing the amount of success they are able to achieve. This feature of each discipline is expressed as the percentage of contestable diplomas.

Qualified and diploma-winning nations

In this research, the number of qualified nations reflects the nations capable of qualifying an athlete or team for the Games according to the Rules of Qualification in the respective discipline.

The number of diploma-winning nations represents nations, which possess the required competitiveness to win a diploma at a point in time. The competitive balance among these nations is analysed assuming that dominant nations manage to produce athletes with genuine top eight potential consistently over time. The percentage of diploma-winning nations is used to underpin our analysis (e.g., Baimbridge, 1998). If the number of diploma-winning nations remains the same while the number of qualified nations increases, the percentage will decrease.

Herfindahl-Hirschman Index

The static Herfindahl-Hirschman Index *(HHI*) is used as a proxy for domination in a discipline's diploma market over the period under investigation. The index is based on the diploma share per nation in time *t* for a given discipline and is defined in equation (1) below:

$$(1)\quad HHI(t) = \sum_{i=1}^{K(t)} {p_i}^2(t)$$

where $K(t)$ is the number of diploma-winning nations in time period *t*, and p_i is the diploma share of the competitor $i = 1, .., K$ at time *t.* The diploma share is defined as $p_i(t) = N_i(t)/N(t)$, where $N_i(t)$ is the number of diplomas won by nation i, and $N(t) = \sum_i N_i(t)$ is the total number of diplomas awarded in *t*. By squaring the share scores, equation (1) weights large shares of dominant nations more highly than small shares of peripheral nations.

Since the *HHI* is sensitive to the number of nations included, the formula (2), proposed by Michie and Oughton (2004), corrects for such changes over time. In this context, we correct for the number of qualified nations in time *Kqal(t)* to enhance comparability[5].

$$(2)\ Corrected\ HHI(t) = \left(\frac{HHI(t)}{\left(1/Kqal(t)\right)}\right) * 100$$

In a perfectly balanced competition, the corrected *HHI* reaches the value of 100, while a decline of competitive balance is reflected by an increase of the index (Michie & Oughton, 2004).

The corrected *HHI* indicates how strongly the most competitive nations dominate the discipline at a certain point in time.

Market entry and exit indices

Accounting for market entry and exit is an additional technique for analysing market domination discussed in the economics literature (e.g., Porter, 2008; Scherer & Ross, 1990). Market entry (M_{entry}) is defined in this paper as the number of nations entering the diploma market by winning at least one diploma in time *t* and which did not win a diploma at the previous edition of the Games, *t-1*. Market exit (M_{exit}) is the number of nations exiting the market at *t* by not winning a diploma but which had won a diploma at *t-1*. M_{entry} and M_{exit} are defined per discipline and time *t* as shown in equations (3) and (4):

$$(3)\ M_{entry}(t) = \sum_{i \in s(t)} (I_i(t) - I_i(t-1))$$

$$(4)\ M_{exit}(t) = \sum_{i \in s(t-1)} (I_i(t-1) - I_i(t))$$

where *s(t)* is the set of nations winning an Olympic diploma in time *t*, and $I_i(t)$ takes the value of 1 if nation *i* won a diploma at time *t*, and 0 otherwise.

Equations (3) and (4) are sensitive to the identity of the diploma-winning nations. Equations (3) and (4) measure the 'churn' of nations by quantifying the variation in diploma-winning nations between two points in time. In line with Porter (2008), these indices provide further evidence about the height of the barriers a nation needs to overcome in order to enter a market for any given discipline. In sport, market entry barriers hinder nations from building the

[5] For further information on correcting the *HHI* see also Coulter (1989).

required competitiveness to win a diploma; while dominant nations might specialise further and thereby continue to raise the entry barriers (De Bosscher et al., 2012).

Przeworski Index

The dynamic Przeworski Index (*PI*) proposed by Coulter (1989), who compared the technical properties of the most commonly applied indices, is used in this research to measure domination of a market for diplomas over time. This index analyses market instability and is technically identical to the Hymer and Pashigian Index of market volatility applied by De Bosscher et al. (2012). The Przeworski Index is used in this paper because it offers a more intuitive interpretation of the evidence on market domination than the Hymer and Pashigian Index. In our application, the *PI* is based on the share of diplomas won by a nation in two consecutive editions of the Olympic Winter Games. *PI* at time *t* for a given discipline is shown in equation (5) as follows:

$$(5)\ (t) = \frac{1}{2}\sum_{i=1}^{K(t)} |p_i(t) - p_i(t-1)|$$

where *K(t)* is the total number of nations that won at least one diploma during the Olympic Games at time *t* or *t-1*, and $p_i(t)$ is the diploma share won by nation $i = 1, .., K(t)$ at time *t*. The diploma share is defined as $pi(t) = N_i(t)/N(t)$, where $N_i(t)$ is the number of diplomas won by nation *i* at time *t*, and $N(t) = \sum_i N_i(t)$ is the total number of diplomas awarded at time *t*. The upper boundary of the index is 1, indicating total redistribution of all diplomas to new nations compared with *t-1*. The lower boundary is 0, indicating no variation in the diploma shares won per nation between the consecutive Games of *t-1* and *t*. Equation (5) takes half of the sum of the absolute differences between the diploma shares of all nations at time *t* and *t–1* to avoid double counting of share changes.

In this paper, (5) is applied to analyse the variation in competitive balance over time, thereby allowing us to identify changes in the distribution of market share between nations, relative to the previous Games. The *PI* is interpreted as follows: the higher the index, the higher the level of variation in competitive balance compared to the previous Games, and *vice versa*.

RESULTS

The results are presented first on a sport by sport basis, before the key themes are considered more holistically in the discussion and conclusion.

Alpine Skiing

With reference to alpine skiing in Table 3, the IOC has kept the number of Olympic events, Olympic diplomas and contestable diplomas constant. The ten events have been kept constant over the period under investigation. Therefore, alpine skiing can be used as a straightforward example to illustrate the interpretation of the indices applied in this paper and the different aspects of performance data that they measure.

Table 3
Competition in Alpine Skiing 1992–2014

		1992	1994	1998	2002	2006	2010	2014
Discipline's Market Size	Olympic Events	10	10	10	10	10	10	10
	Olympic Diplomas	80	80	80	80	80	80	80
	Contestable Diplomas	40	40	40	40	40	40	40
	Percentage of Contestable Diplomas	50%	50%	50%	50%	50%	50%	50%
Discipline's Competitors	Qualified Nations	53	45	50	51	60	71	74
	Diploma-winning Nations	15	12	14	13	14	14	14
	Percentage of Diploma-winning Nations	28%	27%	28%	25%	23%	20%	19%
Static Competitive Balance	Corrected HHI	623	451	677	714	855	803	824
Dynamic Competitive Balance	M_{entry}	7	1	3	2	3	1	2
	M_{exit}	4	4	1	3	2	1	2
	PI	0.41	0.20	0.26	0.20	0.21	0.27	0.17

The increase in the number of nations qualifying to take part has caused the percentage of diploma-winning nations to decrease. The 74 competing nations in 2014 is the highest number found in all disciplines investigated. It is worth noting here that as any one nation can contest 40 out of 80 diplomas (i.e. 50%); is highly unlikely that all 74 nations taking part will win a diploma. In fact, the number of diploma-winning nations, at between 13 and 14 per edition, has been almost constant since 1998. Comparing these numbers indicates a gap in the level of competitiveness of nations qualifying for the Games and those winning an Olympic diploma. In contrast to the corrected *HHI* and the *PI*, the diploma-winning ratio does not use market shares to measure the performances of nations. Hence, this indicator describes the ratio of a discipline's competitive competitors, but is of only limited value when monitoring the competitive balance between genuinely competitive nations in a diploma market.

The corrected *HHI* index provides information on the distribution of diploma shares between the competitive nations. The highest concentration, that is the lowest competitive balance, can

be seen in 2006 (corrected *HHI* = 855). This observation was caused by Austria dominating the discipline by virtue of winning a market share of 30%.

The dynamic $M_{entry}(t)$ and $M_{exit}(t)$ scores provide further detail on the decline in the number of diploma-winning nations. For example in 1994, the decrease of three diploma-winning nations compared with 1992 was caused by Russia's entry to the market and the exit of the Unified Team of former Soviet States, Czechoslovakia, Spain and New Zealand. The overall low values of $M_{entry}(t)$ and $M_{exit}(t)$ in alpine skiing show relatively low chances of entrance to this diploma market as well as only a limited threat of new entrants replacing competitive nations.

Finally, the *PI* analyses changes in the diploma shares of nations compared with the previous Games, and includes information on changes in concentration and entry to and exit from the market. After high instability in 1992 caused by significant market entry (7) and exit (4) of nations, Table 3 shows that the domination of nations remained relatively stable from 1994, with two small peaks in 1998 and 2010. Each peak marks an increase of instability, followed by stabilisation of domination at the next Games. These two peaks mark the beginning and end of the period of strong Austrian domination. The peaks are caused by Austria increasing its diploma share in 1998 (p_i = 26%) compared with 1994 (p_i = 11%), which it improved steadily until a peak in 2006 (p_i = 30%) before relative decline in 2010 (p_i = 21%) and 2014 (p_i = 20%). The dynamic indices reinforce the earlier finding, suggesting high entry barriers for new nations. Most newly qualified nations for alpine skiing events since 2006 have not been competitive enough to challenge the established nations.

In summary, competition in alpine skiing is characterised by: first, strong domination of a few nations; and second, seemingly high barriers to entry for new nations. The corrected *HHI* allows us to indicate whether the distribution of diploma share won by nations has become more concentrated, while the *PI* monitors the fluctuation of diploma shares between nations in successive Games. The interpretation of the second assertion, concerning market entry and exit, is supported by M_{entry} and M_{exit}, as proxies for market barriers.

Freestyle Skiing

Since freestyle skiing became an Olympic discipline in 1992, the market size data in Table 4 highlights a significant increase in diplomas due to the inclusion of male and female individual events: aerials (1994), ski cross (2010), and half pipe and slope style skiing (2014). As the IOC aims to achieve parity between male and female individual events, it is not surprising to see the number of events increase by multiples of two and therefore the number of diplomas increase

by multiples of eight. These changes resulted in stability in the percentage of contestable diplomas (50% throughout the period).

Table 4
Competition in Freestyle Skiing 1992–2014

		1992	1994	1998	2002	2006	2010	2014
Discipline's Market Size	Olympic Events	2	4	4	4	4	6	10
	Olympic Diplomas	16	32	32	32	32	48	80
	Contestable Diplomas	8	16	16	16	16	24	40
	Percentage of Contestable Diplomas	50%	50%	50%	50%	50%	50%	50%
Discipline's Competitors	Qualified Nations	21	21	25	21	22	27	30
	Diploma-winning Nations	8	11	15	12	13	13	20
	Percentage of Diploma-winning Nations	38%	52%	60%	57%	59%	48%	67%
Static Competitive Balance	Corrected HHI	328	304	244	279	236	312	290
Dynamic Competitive Balance	M_{entry}		5	6	1	2	2	7
	M_{exit}		2	2	4	1	2	0
	PI		0.34	0.44	0.28	0.31	0.24	0.28

The corrected *HHI* monitors a decrease of concentration from 1992 to 1998, between 2002 and 2006, and between 2010 and 2014, caused by an increase of diploma-winning nations in these periods. The $M_{entry}(t)$ and $M_{exit}(t)$ indices show a high fluctuation of diploma-winning nations in 1994, 1998, and 2014, indicating seemingly low entry barriers for new nations in these years, which is an interesting counterpoint to alpine skiing for example. The results show the relevant market entry of five nations in 1994 (i.e. Australia, Russia, Switzerland, Ukraine, and Uzbekistan), six nations in 1998 (i.e. Austria, Belarus, China, Czech Republic, Finland, and Japan), and seven nations in 2014 (i.e. Finland, Germany, Great Britain, Italy, Kazakhstan, New Zealand and Ukraine). This significant influx of nations to the market occurred in the same edition as the introduction of aerial events (1994) and four years later; as well as in the same edition that half pipe and slope style events were introduced (2014). Nevertheless, the increase in diplomas did not prevent the competitive balance from becoming more stable from its peak in 1998 ($PI = 0.44$), as demonstrated by substantially lower scores thereafter ($PI = 0.24 – 0.31$). This peak is caused by fluctuations in market shares compared with 1994 (i.e. market instability) due to the market entry of the six nations listed above for 1998. These nations won high levels of market share for new entrants as reflected in the decrease in concentration measured by the corrected *HHI*.

Speed Skating

Comparing the total number of diplomas available to the contestable diplomas in Table 5 illustrates how for speed skating, different quotas per individual event determine the number of competing athletes per nation, which in turn handicaps strong nations. While the FIS and IBU proposed to the IOC a maximum of four athletes per nation in individual events, the respective quotas in the disciplines of the International Skating Union (ISU) differ.

For example, at the 2014 Sochi Games, the IOC awarded 96 diplomas in 12 speed skating events. The IOC followed the ISU's proposal by allowing four athletes per nation in each male and female individual event with distances up to 1,500 metres, and three athletes in each individual event with longer distances (IOC, 2013b). The IOC and the ISU included male and female team pursuit events in 2006, allowing eight different nations to qualify thereby reducing the overall percentage of contestable diplomas to 40% since then. In this way, the IOC has reduced diploma-winning possibilities for a potentially dominant nation like the Netherlands.

Table 5
Competition in Speed Skating 1992–2014

		1992	1994	1998	2002	2006	2010	2014
Discipline's Market Size	Olympic Events	10	10	10	10	12	12	12
	Olympic Diplomas	80	80	80	80	96	96	96
	Contestable Diplomas	36	36	36	36	38	38	38
	Percentage of Contestable Diplomas	45%	45%	45%	45%	40%	40%	40%
Discipline's Competitors	Qualified Nations	23	21	25	23	19	24	23
	Diploma-winning Nations	12	16	10	11	12	15	15
	Percentage of Diploma-winning Nations	52%	76%	40%	48%	63%	63%	65%
Static Competitive Balance	Corrected HHI	367	217	411	380	222	261	353
Dynamic Competitive Balance	M_{entry}	4	5	1	3	3	3	3
	M_{exit}	5	1	7	2	2	0	3
	PI	0.65	0.33	0.34	0.16	0.26	0.18	0.31

The number of diploma-winning nations increased in 1994 and 2006, and concentration was significantly diminished in 1994 (corrected *HHI* = 217) compared with the 1992 Games (corrected *HHI* = 367), and in 2006 (corrected *HHI* = 222) compared with 2002 (corrected *HHI* = 380). The increase of instability in 2014 (*PI* = 0.31) was caused by an increase of domination (corrected *HHI* = 353) when the Netherlands increased its market share from 21% (2010) to 32% (2014) and the fluctuation of diploma-winning nations when Belgium, Kazakhstan and New Zealand entered the market, and Finland, Italy and Sweden left the market. Overall, speed

skating shows the greatest fluctuations in market share scores for all disciplines analysed with *PI* values between 1992 and 2002 ranging from 0.65 to 0.16. This suggests that apart from the Netherlands, other traditional diploma-winning nations in this discipline like Germany did not manage to defend their dominant position in the longer term. In fact, Germany won the greatest market share of 19% (1998), which decreased continuously to 6% (2010), and then increased again to 10% (2014); whereas Canada decreased from 15% (2006) to 4% (2014).

Short Track

Short Track was introduced to the Olympic programme in 1992 consisting of a male and female individual event with a maximum quota of three athletes per nation and male and female team event. Compared with speed skating, the IOC and the ISU have applied stricter quotas in all individual short track events (Table 6). Hence, the inclusion of two additional events in both 1994 and 2002 resulted in just six more diplomas available to be contested on each occasion. In effect, the IOC increased the percentage of contestable diplomas for already dominant nations.

Table 6
Competition in Short Track 1992–2014

		1992	1994	1998	2002	2006	2010	2014
Discipline's Market Size	Olympic Events	4	6	6	8	8	8	8
	Olympic Diplomas	32	48	48	64	64	64	64
	Contestable Diplomas	8	14	14	20	20	20	20
	Percentage of Contestable Diplomas	25%	29%	29%	31%	31%	31%	31%
Discipline's Competitors	Qualified Nations	16	19	18	26	24	23	25
	Diploma-winning Nations	14	14	11	12	14	13	12
	Percentage of Diploma-winning Nations	88%	74%	61%	46%	58%	57%	48%
Static Competitive Balance	Corrected HHI	148	266	256	332	290	374	332
Dynamic Competitive Balance	M_{entry}		3	2	3	3	1	2
	M_{exit}		3	5	2	1	2	3
	PI		0.34	0.22	0.20	0.19	0.17	0.34

The competition in short track is characterised by strong nations protecting their positions successfully since 1992. After 1994, the number of diploma-winning nations decreased, despite the IOC's efforts outlined above, with 2006 being the only exception. Participating nations were offered more diploma-winning possibilities, but it was the most competitive nations that took advantage to strengthen their domination, which lasted until 2010. The concentration score reached its highest value in 2010 (corrected *HHI* = 374) when South Korea achieved a market

share of 25% and Canada 22%. Meanwhile, the fluctuation of diploma-winning nations decreased after 1998, reaching its lowest values in 2010, suggesting increasing barriers to market entry. The IOC and ISU increasing the percentage of contestable diplomas for strong nations by including individual events only, contributed towards this development in market dynamics. It is worth noting that short track shows an important variation of instability in competitive balance. It increased notably in 2014 (*PI* = 0.34), after decreasing continuously from 1998 and reaching its most stable market situation in 2010 (*PI* = 0.17). Prior to the Sochi Games, Russia had never won a diploma in short track speed skating. However, its very successful market entry (p_i = 11%) diminished the concentration in 2014 (corrected *HHI* = 332), and explains the change in the observed competitive balance. Looking in more depth at the data, Russia's success in 2014 was caused by nationalising foreign athletes with genuine diploma-winning capability. Viktor Ahn and Vladimir Grigorev, who had previously competed for South Korea and Ukraine respectively, won five of Russia's seven short track diplomas.

Biathlon

The key characteristic of the market structure in biathlon (Table 7) is an important increase in diplomas. The IOC introduced two male and female individual events developed by the IBU with new competition formats, namely pursuit (2002) and mass start (2006); and furthermore the mixed team relay (2014). The latter event decreased the percentage of contestable diplomas and thereby further handicapped the dominant nations.

Table 7
Competition in Biathlon 1992–2014

		1992	**1994**	**1998**	**2002**	**2006**	**2010**	**2014**
Discipline's Market Size	Olympic Events	6	6	6	8	10	10	11
	Olympic Diplomas	48	48	48	64	80	80	88
	Contestable Diplomas	18	18	18	26	34	34	35
	Percentage of Contestable Diplomas	38%	38%	38%	40%	43%	43%	40%
Discipline's Competitors	Qualified Nations	28	28	30	34	36	32	36
	Diploma-winning Nations	10	16	16	12	18	15	17
	Percentage of Diploma-winning Nations	36%	57%	53%	35%	50%	47%	47%
Static Competitive Balance	Corrected HHI	348	360	284	511	433	308	302
Dynamic Competitive Balance	M_{entry}	5	10	5	2	6	3	4
	M_{exit}	4	4	5	6	0	6	2
	PI	0.69	0.54	0.46	0.35	0.25	0.26	0.31

In 2002, there was a decrease in the number of diploma-winning nations, while in 2006, six nations entered the diploma market (i.e. China, Finland, Italy, Latvia, Moldavia, and Poland), and no nation exited. The changes observed in competitive balance from 2006 onwards suggests that the governing interventions of the IOC and IBU achieved the desired effect. The concentration of domination decreased notably in 2010 (corrected *HHI* = 308), and 2014 (corrected *HHI* = 302); due to strong nations like Germany (-10%) and Norway (-4%) losing some market share in 2010, and in 2014 Germany made further losses (-8%) and Sweden suffered a significant reversal (-5%). Meanwhile, instability increased in 2010 (*PI* = 0.26) and 2014 (*PI* = 0.31), leading to a more balanced and unpredictable competition after 2006.

Cross-Country Skiing

The case of cross-country skiing (Table 8) shows that in addition to increasing the number of events, the IOC and the respective IF can also replace events. In 2002, the IOC and the FIS introduced a new male and female individual event, the Olympic sprint. Between 2002 and 2006, they replaced the male (2 x 10km) and female (2 x 5km) individual pursuit events with male and female team sprint events. In this way, the IOC and the FIS limited the potential dominance of certain nations more effectively in 2006 (38% contestable diplomas) than in 2002 (44% contestable diplomas), as the number of Olympic diplomas remained fixed, and both the corrected *HHI* and *PI* decreased.

Table 8

Competition in Cross-Country Skiing 1992–2014

		1992	**1994**	**1998**	**2002**	**2006**	**2010**	**2014**
Discipline's Market Size	Olympic Events	10	10	10	12	12	12	12
	Olympic Diplomas	80	80	80	96	96	96	96
	Contestable Diplomas	34	34	34	42	36	36	36
	Percentage of Contestable Diplomas	43%	43%	43%	44%	38%	38%	38%
Discipline's Competitors	Qualified Nations	39	33	35	32	46	50	54
	Diploma-winning Nations	9	11	13	17	18	16	15
	Percentage of Diploma-winning Nations	23%	33%	37%	53%	39%	32%	28%
Static Competitive Balance	Corrected HHI	640	562	497	369	396	533	657
Dynamic Competitive Balance	M_{entry}	4	6	4	5	3	1	2
	M_{exit}	5	4	2	1	2	3	3
	PI	0.49	0.43	0.15	0.25	0.19	0.25	0.21

The data show rapidly decreasing diploma-winning percentages from 2002, caused by an increase in competing nations and a decrease in diploma-winning nations. At the 2002 Games,

it is noteworthy that five nations entered the market (i.e. Belarus, Canada, France, Slovenia, and United States), and at the same time the lowest concentration (corrected *HHI* = 369) was recorded. Market domination deceased significantly until 2002, while, the dominant nations increased their market shares again at the following Games in 2006 (corrected *HHI* = 396), in 2010 (corrected *HHI* = 533) and 2014 (corrected *HHI* = 657). More nations left the market in 2010 (Austria, Slovakia and Ukraine) and 2014 (Canada, Estonia and Japan), than entered it: the United States in 2010; and Austria and Belarus in 2014, which in turn led to the concentration scores rising again in these years. This change in the concentration of domination as well as the variability of market entry and exit causes the fluctuating development of competitive balance measured by the *PI*. Only in 1998 did the diploma-winning nations perform similarly to the previous Games, reaching the lowest value of instability of all the disciplines analysed (*PI* = 0.15).

Summarising the results, the market governing measures applied vary in each discipline. Meanwhile, dynamic and static indices provide different information on the competitive balance between nations to be identified: the first measures concentration of domination between competitive nations; while the second measures respective instability compared with the previous Games. The results indicate some effects on the balance of the outcome of competition triggered by the IOC with the support of the relevant IFs.

DISCUSSION

While most studies tend to analyse the Games as one event (e.g., Andreff & Andreff, 2011; Chappelet, 2002, 2014; Kempf et al., 2014), in this paper, we quantified the outcome of competition for diplomas between nations in six Olympic winter disciplines.

All disciplines examined, except alpine skiing, show an increase in terms of number of diplomas awarded and the subset of these that are actually contestable.

Every discipline shows an increase in the number of competitors as defined by nations qualified, except speed skating, where the number remained constant at 23 in both 1992 and 2014. In terms of competitive competitors, the number of diploma-winning nations increased in all disciplines except in alpine skiing and short track, which decreased by one nation and two nations respectively.

Benchmarking the corrected *HHI*-values between the disciplines reviewed, reveals that the lowest concentration of domination was found in speed skating (corrected *HHI* = 217) at the 1992 Albertville Games, while the highest values, i.e. the most unbalanced competition, was found in alpine skiing (corrected *HHI* = 855) at the 2006 Turin Games.

Comparing the development of instability in competitive balance between diploma-winning nations (*PI*) over the period 1992 to 2014, reveals that alpine skiing became more stable; biathlon stabilized until 2006; freestyle skiing and short track became more stable until 2010; while no general trend in the market dynamics of speed skating and cross-country skiing was identified. However, the instability values monitored in 1992 and 1994 were the highest found in all disciplines, except for short track in 2014, despite the change of market structure described. The fall of the Iron Curtain in 1992 was an unusual political event that had a material impact on the outcome of competition in disciplines dominated by former communist countries. The break-up of the USSR and Yugoslavia led to an increase in the number of nations with genuine diploma-winning capability. For example, Belarus, Kazakhstan, Ukraine, and Uzbekistan, who competed in 1992 in the Unified Team with Russia, qualified independently for the 1994 Games and each of them subsequently won diplomas. Thus, peaks in instability were observed in alpine skiing, speed skating, biathlon, cross-country in 1992; as well as in short track and cross country in 1994. Referring back to the argument that dominant nations build-up market entry barriers by further specializing in a discipline (De Bosscher et al., 2012), the general trend of diminishing market entries and instability after 1994 supports this reasoning. Most new nations qualified in the aftermath of these unusual political events were not competitive enough to overcome the barriers to entry of the market for diplomas.

While developments such as this are outside the managerial control of the IOC, adapting a discipline's programme of events, as well as the Rules of Qualification (i.e. quota) and the Rules of Competition (i.e. legal basis), are within its control. However, the effects on the outcome of competition in the disciplines examined are shown to be limited. This finding is consistent with mainstream business contexts, where economists have argued that market growth does not necessarily increase the number of successful competitors because dominant firms might protect and even enhance their position and thereby prevent new firms from entering the market (e.g., Porter, 2008; Sutton, 2001). For example, with reference to the Dutch domination in the pre-Sochi 2014 speed skating qualification competitions, the outcome indicates that the IOC did not manage to legislate effectively against the Netherlands' predictable domination at the 2014 Games (p_i = 32%).

Nevertheless, this study demonstrates that discipline-specific effects on competitive balance can occur in the short term, triggered by the IOC's adjustment of the Olympic programme with endorsement from the respective IF. We illustrate that the IOC adjusts a discipline's winter programme predominantly by adding different event categories, including quota limitations, and not by adapting the quota system as suggested by other authors researching the Summer

Games (e.g., Houlihan & Zheng, 2013). For example, the results show an increase in market entry in freestyle skiing (1994 and 2014) caused by the IOC and the FIS introducing new events like aerials (1994), and half pipe and slopestyle (both 2014), and thereby offering nations more opportunities to win diplomas. However, this index reveals no such change in 2010, when ski cross events were introduced, and resulted in a less balanced outcome of competition (corrected *HHI*-index). In other words, adding male and female individual ski cross did not have the same effect on market entry, possibly because these events are more similar to alpine skiing and therefore entry barriers are already high. The ski cross events, as all alpine skiing events, are racing events. In these events, ranking is based on time, while in the other freestyle events, performance is subjectively scored and rankings are awarded on the basis of judges' interpretation of performance. Meanwhile, adding individual events to the programme does not seem to have created more instability in the outcome of competition between the diploma-winning nations in freestyle skiing over time (*PI*-index). A similar effect is identified in cross-county skiing (2002), when market entry and market concentration increased, in response to the IOC and the FIS applying governing measure (a) (i.e. the inclusion of an individual event). Market concentration decreased only in 2006, when the two governing organisations implemented governing measure (c) (i.e. the replacement of an existing event), and thereby decreased the percentage of contestable diplomas.

While sport is characterised by some variation in the outcome of competition, the important changes measured in competitive balance in biathlon since 2006 and in short track at the 2014 Games provide fertile ground for more in-depth discussion. The evidence in biathlon supports the interpretation that the massive increase in events brought about by applying governing measures type (a) and (b) (i.e. the inclusion of team/mixed events), and (c), has enabled the IOC and the IBU to engineer a decrease in concentration, and an increase in market entry leading to more variable levels of domination. The growth in market size created the conditions for more balanced competition after 2006. The few diploma-winning nations that traditionally dominated the discipline were unable to protect their positions because of the intervention of the two governing organisations (amongst other factors). This outcome can be argued to be a condition necessary to improve uncertainty of outcome and thereby increase interest in an event. Applying a similar analysis to short track in 2014, the observed change in competitive balance was not the outcome of any governing measure. Referring to Chen (1996), such a change must therefore have been caused by significant increases in competitiveness amongst the discipline's contestants. In practice, Russia nationalised foreign short track athletes to increase its competitiveness at the expense of rival competitors. Whether this approach will be sustainable

in the longer run is questionable. Nevertheless, in accordance with rule 41 of the IOC (2015, p. 80) on the 'Nationality of Competitors', the IOC and IF policymakers could learn from this measure for increasing competitive balance. However, as in any competition, applying market governing measures is debatable and competitive balance should not be reached at any expense and should be consistent with widely accepted principles of fair play in sport (i.e. CIFP, 2016).

This research is limited to examining the outcome of competition for diplomas, including the various governing measures applied by the IOC to increase market size and to restrict the dominance of nations over time. It does not permit any causality analysis or further interpretation at this stage. Reflecting further on the difference between the competition for medals and diplomas (e.g., De Bosscher et al., 2015), we assume that the IOC's governing measures to limit the number of competitors per nation impact more on the competition for diplomas than medals. The impact on the competition for medals[6] is small, because a maximum of three to four athletes per nation can compete for the three medals available in individual events, which in turn results in 100% of contestable medals, while only a maximum of 50% of contestable diplomas. Since most winter disciplines consist mainly of individual events, the percentages of contestable medals per discipline are higher than the percentages of contestable diplomas. It is quite understandable that the IOC cannot interfere in the competition for medals, because this would adversely affect the integrity of the Games. Meanwhile, consistent with the literature, most nations which qualified for the Winter Games for the first time after 1994 are generally not competitive enough to win Olympic awards (e.g., Andreff & Andreff, 2011).

As the increase of competitive nations after the fall of the Iron Curtain and Russia's competitiveness at the Sochi Games shows, the development of competitive balance in a discipline is also determined by factors outside the governing control of the IOC. Amongst those outlined in the literature are: the home nation effect which is a unique competitive advantage for nations when hosting the Games (e.g., Balmer, Nevill, & Williams, 2001; Forrest et al., 2016; Shibli, Gratton, & Bingham, 2012); and, nations applying successful elite sport policies to increase their competitiveness (e.g., Bergsgard et al., 2007; De Bosscher et al., 2015). Given its focus, such an analysis per discipline, although certainly valid, is beyond the scope of this article.

Finally, these findings point to future directions for further research on the impact of governing measures on competitive balance commonly applied in professional leagues (e.g., Binder & Findlay, 2012; Lee & Fort, 2012), to Olympic disciplines. Since the difficulty of applying economic indices lies mainly in their interpretation (Coulter, 1989), the distinction

[6] Results for medals instead of diplomas are available upon request.

between analysing the concentration of competitive balance at a point in time and instability over time makes a useful contribution to the literature (e.g., Buzzacchi et al., 2003; Eckard, 2001). We argue that the latter index indicates the extent to which a discipline's dominant nations can be competed against meaningfully in practice. Economists have reasoned that a monopoly is not inefficient *per se*, but that an efficient market of any type has to be contestable. That is, any competitive firm must be able to compete against the dominant firms in the market (e.g., Baumol et al., 1986). This is relevant when examining the outcome of competition as a distinction should be made between whether a discipline is always dominated by the same nations, or whether dominance changes over time. In line with Scelles, Durand, Bah and Rioult (2011), as well as Cabaud, Scelles François and Morrow (2016), the analysis could be extended in the future to examine intra-event competition and the discussion of event-specific governing measures such as: starting order, heats and rounds, etc. (e.g., FIS, 2012; IBU, 2012). Reflecting further on the contestability of an efficient market (e.g., Baumol et al., 1986), an analysis of this type might provide new directions for analysing demand by spectators and television viewers related to the measures of contestability demonstrated in this paper.

CONCLUSION

The proposed measures offer decision-makers in the IOC and the IFs an instrument to analyse the peculiar dynamics of the competitive environment in an Olympic discipline more accurately and objectively. This new insight may enable governing measures to be implemented that are based on sound empirical evidence. However, our analysis indicates that the governing measures used thus far are limited and that incidents outside the management control can have a far more material impact on the outcome of competition between nations.

In addition to developing the application of economic indices to the analysis of competition in sport, this paper also introduces context-specific interpretation of the various measures derived from a time series data set.

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