The Anatomy of the Global Football Player Transfer Network: Club Functionalities versus Network Properties

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Abstract—Professional association football is a game of talent. The success of a professional club hinges largely on its ability of assembling the best team. Building on a dataset of player transfer records among more than 400 clubs in 24 world-wide top class leagues from 2011 to 2015, this study aims to relate a club's success to its activities in the player transfer market from a network perspective. We confirm that modern professional football is indeed a money game, in which larger investment spent on the acquisition of talented players generally yields better team performance. However, further investigation shows that professional football clubs can actually play different strategies in surviving or even excelling this game, and the success of strategies is strongly associated to their network properties in the football player transfer network.

1. Introduction

Association football, also referred to as soccer, is probably the sport that gained most global popularity since the 20th century. Professional football industry has thereby grown into a prosperous playground for wealthy investors and big name companies. It was reported that the combined revenue of the top 20 earning clubs in season 2014/15 was over 6.6 billion euros [1]. Meanwhile, the abundant football statistics gathered have attracted fans and scholars to analyze this fascinating game in a quantitative way [2]. However, the achievement of a club is ultimately decided by a squad of 30 players who play the matches through the entire season. Therefore, it is eventually the club's ability of gathering most talented players which decides about the outcome of the billion euros' investments.

Actually, talent is believed to be the most important asset in any organization. From senior executives in public companies to common laborers in a massive amount, the acquisition of talents is found to be significantly related to the accomplishment of companies or even national economics [3]. A professional football club usually acquires players from other clubs either permanently, i.e., transfer, by exchanging certain compensation, i.e., transfer fee. The football player movement has already drawn attention from the academia since decades [4]. However, few studies have addressed the relationship between the activities in the transfer market and the success of a club in a systematic way. In this paper, we try to solve this problem by employing a network perspective analysis to the global football player transfer market.

Many natural and man-made systems composed of connected components can be modeled by networks, whose properties are proven to be associated with the functionalities of the systems or their components. Scale-free structure is a common macroscopic property found in social networks. It has been shown that this property could be the cause of the unpredictability of epidemic spreading [5]. Microscopic network such as the topological properties of individual nodes and edges and are also widely used to measure the functionalities of system components. They were successfully used to characterize the importance of web pages [6] and to identify influential spreaders in social networks [7].

Building on a dataset of transfer records from 2011 to 2015 of 410 professional clubs in 24 world-wide top class leagues, our work analyzes the properties of the global football player transfer network at both macroscopic and microscopic scales. In this network, nodes are the elite clubs, and the directed edges connecting the nodes are the player transfers. Particularly, the relationship between node properties and the functionalities of professional clubs is studied. Our results show that clubs' match performance and profitability from the transfer market are strongly associated with the coreness and brokerage properties of their corresponding nodes in the player transfer network.

2. Results

2.1. Construction of the transfer network

In the 5 year period from 2011 to 2015, there were totally 8948 transfer actions among the elite clubs, constituting a player transfer network of 410 nodes connected by 6316 directed edges, where the direction of edges denotes the direction of player movements. All the nodes in the network are strongly connected except for three nodes with only outgoing edges and no incoming edges. The mean shortest distance between all nodes is 2.8 and the clustering coefficient is 0.21. The clustering coefficient is the average ratio between all directed triangles actually formed by each node and the number of all possible triangles that the node could form [8]. Comparing to the average mean shortest distance

of 2.5 and the average clustering coefficient of 0.04 in random networks of the same size and connection density, the player transfer network exhibits small-world phenomenon. Figure 1A shows the distributions of in-degree k_{in} and out-degree k_{out} of the network. Figure 1B and C show the correlation of in-degree and out-degree and the distribution of excess degree $k_{ex} = k_{in} - k_{out}$ of all nodes respectively. It is shown that the numbers of clubs that a professional club "buys from" and "sells to" are basically equal.

2.2. Club functionalities versus network properties

In this section, we will explore the relationship between the functionalities of a club and its network properties. The ultimate measure of the success of a commercial organization is its profitability, which also applies to a professional football club. Generally speaking, clubs with the highest achievements in prestigious competitions are also the ones that generate the largest revenue from various commercial activities [1]. Meanwhile, a club could also profit directly from the transfer market, by receiving more compensation from the players transferred out than it pays to acquire new players. Therefore, the club functionalities can be described either by its match performance or its transfer profit. Match performance includes the domestic and international match results. We quantify domestic performance of a club by the average game points in its domestic league matches from 2011 to 2015. On the other hand, the five year aggregate IFFHS Club World Ranking (CWR) point is employed to quantify the overall performance of a club in both domestic and international competition [9]. The ability of profiting from player transfers are defined by two measures, i.e., the average annual transfer balance and the cumulative price overflow from player transits. If a player has transferred from club A to club B then to club C, then we define that the player has transited through club B. The price overflow of this player in club B is the difference between the transfer fees payed by club C to club B and by club B to club A. The correlations between match performance and the transfer profitability are very low, so that they can be considered independent indicators of the functionalities of a professional football club.

Which factors of the transfer network properties affect the functionalities of professional football clubs? The node properties of concern include two categories of metrics that measure the coreness and brokerage of the nodes, respectively. The coreness of a node measures the richness of its connections and is usually described by the number of direct connections combined with the number of indirect connections. The coreness metrics could indicate the search breadth of the club scouts in the transfer market. In this paper, eigenvector centrality and PageRank centrality are chosen as the coreness metrics. The brokerage of a node measures the extent to which it controls the network flow. Clubs with large brokerage metrics tend to exclusively control certain transfer resources and act as brokers amongst

other clubs. In this paper, effective size [10], closeness centrality and betweenness centrality are chosen as the brokerage metrics. Table 1 shows Kendall's Tau between club functionalities and network properties. The match performance, especially international performance, of the clubs is positively correlated with the brokerage metrics, while clubs' profitability from transfers is generally weakly or not correlated with the network properties. This result suggests that the brokerage power of a club plays the most significant role in determining its match outcome, while the relationships between other network measures and club functionalities are relatively weak.

2.3. International versus domestic transfer networks

International sports labor migration shows different characteristics from domestic sports labor movements [11]. In this paper, the football player transfer network can also be separated into two subnetworks accordingly. The domestic transfer network contains only transfers within a same league and the international transfer network contains only international transfers between different leagues. Table 2 shows the correlation of network properties and club functionalities in both international and domestic transfer networks. It is shown that the node properties taking account of global network connections, i.e., eigenvector centrality, PageRank centrality, betweenness centrality and closeness centrality, are better indicators of both domestic and international match performance, while the node property taking account of local network connections, i.e., effective size, in the domestic transfer network is a better indicator of match performance.

2.4. Money leagues and farm leagues

Although that the match performance and profitability of clubs are overall weakly or not related, a closer examination shows that the clubs in different leagues exhibit different characteristics in the relationship between the two kinds of club functionalities. In some leagues, the more transfer profit a club generates, the better match performance it achieves, in other leagues it is just the opposite. We roughly classify the leagues into three categories, i.e., the leagues with negative correlation between the clubs' annual balance and average league game points with adjusted $R^2 > 0.25$ are referred to as "money leagues", as the more the clubs spend, the better match performance they achieve; the leagues with positive correlation and adjusted $R^2 > 0.25$ are referred to as "farm leagues", as the more the clubs profit from the transfer market, the better match performance they achieve. In money leagues, the clubs' performance are strongly related to their abilities in raising transfer fund. In farm leagues, the club's performances are strongly related to their abilities of profiting from player transfer.

The relationship between the node properties in the player transfer network and the functionality of clubs in
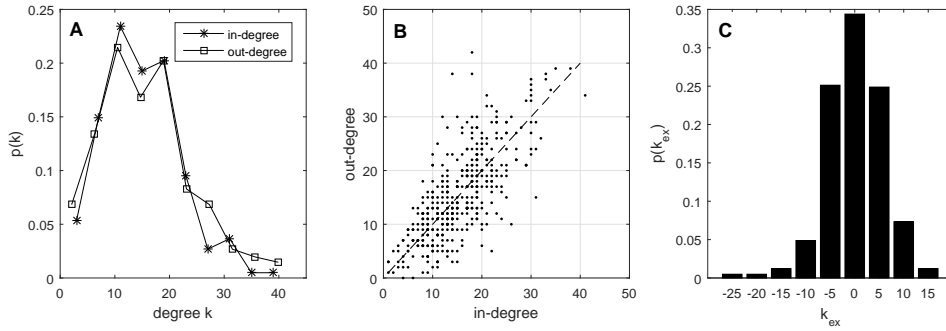
Figure 1: Degree distributions of the global football player transfer network. A: The in-degree and out-degree distributions of the network. B: The in-degree/out-degree relation for each club in the transfer network. C: The distribution of excessive degree k_{ex} of all nodes in the transfer network. The standard deviation of k_{ex} is 5.7.

Table 1: **Kendall's Tau between network properties and club functionalities in the player transfer network.**

	Eigenvector centrality	PageRank centrality	Effective size	Betweenness centrality	Closeness centrality
Avg. league pts.	0.18	0.12	**0.34**	**0.34**	**0.33**
Agg. CWR pts.	0.36	0.14	**0.48**	**0.37**	**0.49**
Balance	0.04	-0.02	0.19	0.16	0.26
Price overflow	0.04	0.04	0.06	0.06	0.07

Table 2: **Kendall's Tau between network properties and club functionalities in international and domestic transfer networks.**

		Eigenvector centrality	PageRank centrality	Effective size	Betweenness centrality	Closeness centrality
Avg. league pts.	International	**0.29**	**0.19**	0.03	**0.28**	**0.36**
	Domestic	-0.04	-0.06	**0.34**	0.04	0.15
Agg. CWR pts.	International	**0.40**	**0.24**	0.12	**0.36**	**0.48**
	Domestic	0.13	-0.05	**0.45**	0.10	0.23
Balance	International	0.05	0.04	0.11	0.15	0.23
	Domestic	0.07	0.04	0.16	0.10	0.08
Price overflow	International	0.03	0.03	0.01	0.07	0.07
	Domestic	0.02	0.04	0.06	0.01	-0.01

different league categories is shown in Table 3. The parameter correlations of clubs in "money leagues" generally agree with the average nodes in the transfer network. However, in "farm leagues", the correlation between eigenvector centrality, effective size, closeness centrality and club domestic match performance vanishes, but strong correlation emerges between node coreness and brokerage and club profitability. Especially, the brokerage of a club in the player network is strongly correlated to its annual balance. This phenomenon suggests that clubs in different financial environments actually have various strategies of achieving success, either by acquiring the best players at all costs, or by cultivating players with potential and profit from the re-selling of these valuable assets. More importantly, the successes of both strategies are strongly related to the clubs' network properties in the global player transfer network.

3. Discussion

Football is probably the most popular sports in the world. The abundance of statistics regarding teams' activities on and off the pitch has attracted extensive quantitative analysis by fans and scholars from various perspectives. However, despite of the importance of the acquisition of talented players to the success of a professional football club, previous studies rarely addressed the relationship of the clubs' functionality to their activities in the player transfer market. To do so, we have collected exhaustive transfer records among more than 400 football clubs in major professional leagues from different countries during the last 5 years. Data reveals that football is indeed a money game, in which clubs spend large amounts of money on football stars in order to achieve prestigious status and generate commercial revenue. However, in this winner-takes-all game, the finan-

Table 3: **Kendall's Tau between network properties and club functionalities in different league categories.**

		Eigenvector centrality	PageRank centrality	Effective size	Betweenness centrality	Closeness centrality
Avg. league pts.	Money Leagues	**0.25**	**0.15**	**0.33**	**0.29**	**0.34**
	Farm Leagues	**-0.01**	**0.03**	**0.06**	**0.15**	**0.04**
Agg. CWR pts.	Money Leagues	0.30	0.08	0.44	0.39	0.51
	Farm Leagues	0.43	0.25	0.53	0.41	0.51
Balance	Money Leagues	-0.13	-0.14	-0.09	-0.09	-0.03
	Farm Leagues	**0.35**	**0.20**	**0.56**	**0.46**	**0.59**
Price overflow	Money Leagues	0.03	-0.01	-0.04	-0.05	-0.03
	Farm Leagues	**0.19**	**0.14**	**0.23**	**0.17**	**0.23**

cial abilities of clubs are severely unequal. Wealthy clubs with overwhelming financial resources could spend tens or even thousands times more money than normal clubs on acquiring better players, therefore other clubs must seek different strategies to survive in this competitive industry.

Network science provides a systematic perspective and a variety of tools to quantitatively study the structure of complex systems. Particularly, the network properties of system components are found closely related to their functionalities. In this work, we have employed a network perspective of analyzing the global football player transfer market. In the transfer network, nodes are clubs linked by directed edges representing player transfers. The global football player transfer network is a small-world network with multiple loosely connected hubs. Clubs that act as hubs or brokers in the network usually achieve better domestic and international match performances. The results suggest that professional clubs should develop their scouting abilities and maintain exclusive player resources in order to achieve better match performances.

The ultimate goal of commercial organizations is to make profit. However, depending on various factors, football industry does not generate a comparable amount of revenue across the world. In some leagues, clubs could spend millions of euros on building a better team and profit from commercial activities. Yet, this strategy might not apply on clubs in leagues that attract less financial attention. Therefore, cultivating players with high potential and selling them to wealthier leagues is another viable way of generating profit for the clubs. No matter which strategy a club has to choose, in order to achieve success, the club must carefully select its position, particularly the coreness and brokerage properties, in the global player transfer network.

Meanwhile, the domestic and international movement of football players is merely a special case of the ongoing urbanization processes and global labor migration today. How the acquisition and loss of labors with different skill sets could affect the economic status of regions or nations is still an open question. We believe that the systematic perspective and network-based methods employed in this work can be further extended to study this question with a promising outcome.

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