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Soccer Labour Market Equilibrium and Efficient Training of Talents

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Abstract

This paper develops a two-period model of the soccer labour market. The first period is devoted to the selection of talents and training, while the second period corresponds to the beginning of the players' professional career. Between the two periods, players can be hit by idiosyncratic shocks, thus generating mismatches between players and clubs. Some players are transferred in exchange for the payment of a transfer fee by the poaching club to the training club, while others may renegotiate their wages. Our model emphasises the key allocation role played by transfer fees: a training club may benefit from training, even if the player moves to another club at the end of the training period. Using the simulated method of moments, we estimate the impact of transfer fees on training, capitalising on an original data set on the Big-5 European soccer leagues. We show that the presence of transfer fees allows the selection and training of talents to get closer to the efficient allocation. Counterfactual experiments then highlight that a significant share of talents would not have been trained in the absence of transfer fees.

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1 Introduction

Since the seminal contribution of Rottenberg (1956), it is widely recognised that sport represents an interesting laboratory for analysing labour market issues. In addition to providing a theoretical framework for analysing specific public policies or contracts, sport also offers rich open data that have no equivalent in standard empirical studies of the labour market, which allows researchers to answer longstanding unsolved questions. In this paper, we investigate the soccer labour market to analyse the effects of the transfer fee system on human capital investment.

Human capital is a fundamental element of the labour market. Workers that accumulate human capital are more productive (Chevalier et al., 2004), have a lower risk of unemployment (Mincer, 1991; Cairo and Cajner, 2018), and receive higher wages (Bagger et al., 2014; Menzio et al., 2016). This is visible in the significant effort devoted by governments and public policies to promote training.

The human capital theory developed by Becker (1962) introduced a crucial distinction between specific and general human capital. While specific human capital only increases the worker's productivity in the training firm, general human capital increases it equally in all firms. In Becker's view, firms and workers share the costs and returns of investments in specific human capital. However, in a competitive labour market, firms do not invest in general human capital because workers can reap all the returns of training. This prediction is not consistent with the empirical literature, which suggests that firms contribute to the financing of general training (Acemoglu and Pischke, 1998). Acemoglu (1997) and Acemoglu and Pischke (1999b,a) show that market imperfections (e.g., asymmetric information or search frictions) may provide an incentive for firms to invest in general training. However, firms' investment in general training is sub-optimal. As firms do not internalise the impact of training on workers' productivity in future jobs (poaching externality), they under-invest in training compared to the socially optimal level. Acemoglu (1997) suggests that efficiency could be restored through appropriate contracts (while he underlines that such contracts would be very difficult to implement, and hard to enforce):

> "There are two types of contracts [...] which would help with the inefficiency. The first, contract 1, would involve the firm and the worker writing in their contract that if in the second period the worker has a new employer, this new employer has to pay a certain amount, to the initial firm, otherwise the worker is not allowed to work. The second, contract 2, works similarly, but requires the new employer of the worker to pay a certain wage to the worker. [...] However, both types of contracts are very difficult to implement precisely because they impose obligations on a party who is not part of the contract, and are thus not legally enforceable. [...] It is also interesting to note that an example of contract 1 was actually used in the market for European football players. This contract which required a new team to pay a transfer fee to the player's previous club has been recently challenged and declared unlawful in European courts precisely on such grounds (the Bosman Case, September, 1995). Overall, it is safe to presume that such contracts are not possible and that there will therefore be underinvestment in training."

Acemoglu (1997)'s intuition was right. A complete contract can restore efficiency. However, Acemoglu (1997) was probably too pessimistic about the possibility of implementing such contracts. The transfer system still exists, and the volume of transfers has increased continuously over the last two decades (FIFA, 2021b). While the Bosman case[1] has been a source of major concern for the transfer system and the future of the European soccer leagues, it has also contributed to restore a balance in terms of contracts and to ensure the long-term sustainability of the transfer fee system. The Judgement of the European Court of Justice in 1995 has forced European soccer authorities to reform the transfer system. Among others, a club can no longer claim a transfer fee after the expiry of the contract, restrictions on the number of foreign players from EU member states have been lifted, and compensation for training clubs [up to the age of 23] has been introduced. Overall, these reforms mark the beginning of the transfer system as we know it today.

This paper proposes a stylised two-period model to analyse human capital investments in the labour market of soccer players. We focus on young players who are yet to become professionals. These are players who train during the first period and have the opportunity to be offered a professional contract in the second period. At the beginning of the first period, clubs select the more

[1] See Simmons (1997) for a description of the Bosman case and its implication on the soccer transfer market.

(exogenously) talented players and train them. At this stage, information is perfect and there is no friction, hence the matching is optimal. At the end of the first period, some players can be hit by a productivity or talent shock and possibly move to another club at the beginning of the second period, while others either become mismatched, because they wish to move but cannot, or are efficiently matched, due to the absence of a productivity shock, with their current club. The cornerstone of our model is that the efficient assortative matching between a player and the training club is captured by a production function that features complementarity effects between players and club characteristics. In this respect, we also characterise the wage of the second period as the transfer fee (if relevant) that the poaching club has to pay to incumbent clubs. In so doing, we assume that the three parties (i.e. the selling club, the buying club and the player) enter in a (static) Nash-bargaining process in the event of a transfer while mismatched or well-matched players turn to a two-agent Nash-bargaining game with their current club. This allows us to derive the optimal equilibrium bargaining conditions.

By defining a training policy as the endogenous choice of the minimal talent required of a player to be trained, we determine the efficient threshold from the point of view of a social planner, as well as the equilibrium training cut off in the presence of transfer fees, and finally in the counterfactual absence of a transfer fee system. In the latter, trained players can move to poaching clubs without any compensation for the incumbent club, and the second period wage is then determined through a Bertrand competition between clubs or a standard Nash-bargaining process between the player and the poaching club. This allows for comparing the different outcomes and quantifying the impact of the transfer fee system on training policy.

Such a quantitative assessment is based on an estimation of our model. Capitalising on a new and original data set regarding individual player performances, salaries and transfers in the Big-5 European soccer leagues (i.e. Bundesliga in Germany, La Liga in Spain, Ligue 1 in France, Premier League in the United Kingdom, and Serie A in Italy) over the period 2013-2020, we estimate the distribution of talents, the distribution of the productivity shock, the structural parameters of the production function and the bargaining power of the selling club, the poaching club and the player. Using the simulated method of moments, our empirical results provide support that our model accurately reproduces relative wage differences according to the player's type (movers, mismatched stayers, and well-matched stayers), and the ratio of average transfer fee to average wage. Importantly, the bargaining power of the poaching club is found to be about 75%, while it is around 20% for the selling club and 5% for the player. Such predominant bargaining power of the poaching club is consistent with the existence of a poaching externality (Acemoglu, 1997), and thus, it opens the door for inefficient training outcomes.

Using these structural estimates, we then estimate the talent's threshold (i.e. the training policy) in the presence/absence of transfer fees and compare them to the optimal training policy. Our results show that the transfer fee system mitigates the negative impact of poaching and protects clubs' investment in general training. The equilibrium allocation in the presence of transfers, as measured by the percentage of players excluded from training, is close to the optimal allocation of a social planner. Furthermore, counterfactual experiments show that a significant share of players would have not been trained in the absence of transfer fees: this share is, at least, greater than 10%, and even 30% in our benchmark simulation.

Two conclusions can be drawn. First, the poaching externality is large, and in the absence of an appropriate tool, the equilibrium allocation is very far from the efficient allocation. Second, the transfer system allows restoring efficiency, at least for young players. This result is of major importance for policymakers. Contrary to other policies that could help restore efficiency such as training subsidies (Chéron and Terriau, 2018), the transfer system does not imply any public cost.

The rest of the paper is organised as follows: Section 2 presents the model and derives the labour market equilibrium of professional soccer players. Section 3 describes the database and presents the strategy used to estimate the structural parameters of the model. Section 4 determines the clubs' training policy in the presence/absence of transfer fees, and compares it to the optimal training policy. In Section 5, we run counterfactual experiments to illustrate and quantify the allocation role played by the transfer system. The final section concludes the study.

2 Soccer labour market and the equilibrium distribution of wages and transfer fees

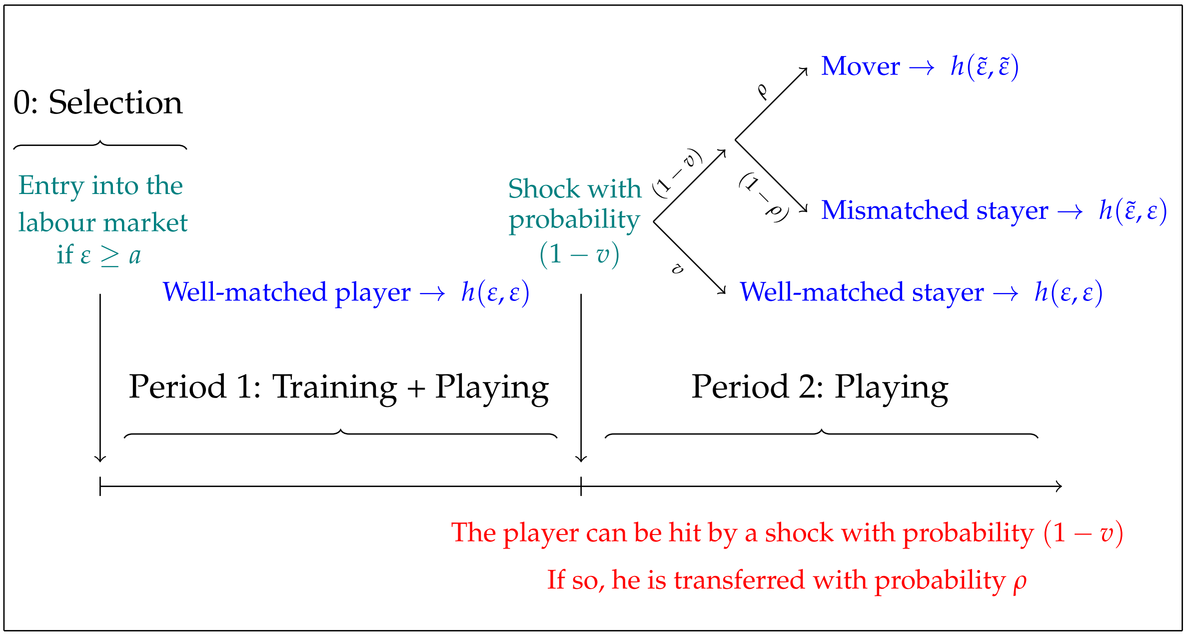
2.1 Model environment

Timing of events. The model is populated by a continuous measure 1 of football players and a large continuum of football clubs and jobs. Each player is endowed with an initial ability ε that is (continuously) distributed across players and observable by all agents. The economy lasts for two periods.

The first period is devoted to selection, training, and playing. At the beginning of the first period, clubs select the more talented players and train them. The minimum talent required to be trained is denoted by a. If the player's talent is high enough, that is if $\varepsilon \geq a$, the player is trained and starts playing. At this stage, information is perfect and there is no friction, hence the matching is optimal. At the end of the first period, the player can be hit by a shock, with probability $1 - v$. If the shock occurs, the player has an incentive to move to a club that better matches his new ability. With probability ρ he can move to another club (he is considered as a "mover"), while with probability $1 - \rho$ he cannot move and stays in his training club (he is considered as a "mismatched stayer"). If the shock does not occur, the player will have no incentive to move and thus will stay in his training club (he is considered as a "well-matched stayer"). The timing of events is detailed in Figure 1.

We first characterise the distribution of wages by player type (movers, mismatched stayers, and well-matched stayers), and the distribution of transfer fees at period 2. The firms' selection and training policy will be analysed in Section 4.

Figure 1: Timing of events



Talents At this stage, we do not analyse the selection of players that occurs at the beginning of the first period. The minimal threshold required to be trained, denoted by a, is thus considered as given. Accordingly, the initial distribution of talents is assumed to be exogenous, and $\psi(\varepsilon)$ is the related probability density function, with support $[a;\varepsilon_{\text{max}}]$. Each club/job is characterised by an attribute p, observable by all agents. In the first period, there is no friction and information is perfect, so that each player is matched to the club that best matches his ability.

Assumption (A1): Production function

A player contributes $h(\varepsilon, p)$ to the club's production. The production function belongs to a general class of functional forms such that:

$$\underset{p}{\operatorname{argmax}}\, h(\varepsilon, p) = \varepsilon.$$

where $h(\varepsilon, \varepsilon)$ is strictly increasing with ε.

Several points are worth emphasising. First, for sake of simplicity, we abstract from the endogenous link between p and the sum of all abilities (externalities) of all individual players within the team. We specify only the flow of output generated by the match between a type-ε player and a type-p club. Second, we make no distinction between the various positions on the field, that is we assume that all positions are equally important in the team and thus what matters is the contribution of the player irrespective of the position. Third, Assumption (A1) implies that a maximum is reached at $p = \varepsilon$. Accordingly, Assumption (A1) will account for a form of efficient assortative matching: players get incentives to search for a club/job-type p that leads to the highest production of a player-club pair, hence being consistent with $p = \varepsilon$ and $h(\varepsilon, \varepsilon) > h(\varepsilon, p)\ \forall \varepsilon \neq p$. Fourth, in the case of perfectly matched players, a more talented player generates more output than a less talented one and it can be interpreted as an *absolute comparative advantage* (within the team).[2]

Shocks. We assume that the job/club's attribute is permanent, but players' ability is subject to idiosyncratic shocks. Specifically, at the end of period 1, every player's talent ε is subject to a multiplicative shock λ, which is defined by the following stochastic process:

$$\lambda(\mu, \sigma) = \begin{cases} 1 & \text{with probability } v \\ X(\mu, \sigma) & \text{with probability } 1 - v \end{cases} \tag{1}$$

where $X(\mu, \sigma)$ follows a log-normal distribution with μ and σ the mean and standard deviation of the underlying normal distribution. Meanwhile, with probability v the player's ability does not change. Finally, with probability $1 - v$, the player is hit by a productivity shock and his new ability is defined by $\tilde{\varepsilon} = \varepsilon x$, where x is some realisation of the log-normal random variable X.

Search frictions and matching. Taking Assumption (A1), we consider that each initial match between a type-ε player and a type-p job/club is an optimal match, which produces $h(\varepsilon, \varepsilon)$ from $p = \varepsilon$. Once the player is hit by a shock

[2]We shall emphasise that the functional form used during the quantitative analysis will also allow for *complementarity effects* between players and club characteristics. Hence being matched with the most productive club will not necessarily imply a maximum output.

and his ability switches to $\tilde{\varepsilon}$, two cases are considered. First, with probability ρ, the player can move and mobility features efficient assortative matching. Indeed, when the player is hit by a shock, he will move, at equilibrium, to a poaching club with type $q = \tilde{\varepsilon}$ and produce $h(\tilde{\varepsilon}, \tilde{\varepsilon})$.[3] In other words, we assume that a player hit by a shock will always move and find a club that allows for an efficient match. Second, with probability $1 - \rho$ the player cannot search for a new job/club (e.g., the market is not open) and is mismatched with his current club. His output is then $h(\tilde{\varepsilon}, p) = h(\tilde{\varepsilon}, \varepsilon) < h(\tilde{\varepsilon}, \tilde{\varepsilon})$.

2.2 Bargaining of wages and transfer fees

We are now in a position to define the second period wages, as well as transfer fees that poaching clubs have to pay to incumbent clubs in the event of a transfer. We suppose that wages are negotiated at the beginning of the second period, once the new ability is revealed. We need to distinguish three cases: i) the player is hit by a shock and can move, with probability $(1 - v)\rho$; ii) the player is hit by a shock but cannot move, with probability $(1 - v)(1 - \rho)$; iii) the player is not hit by a shock, with probability v.

Bargaining for movers. We first consider case (i). When a player is hit by a shock, and thus his ability ε switches to $\tilde{\varepsilon} = x\varepsilon$ according to a given draw x, he moves and gets a new wage contract, denoted by w^m. In line with FIFA regulation, such a move requires the payment of a transfer fee from the buying club (poaching club) to the selling club (training club). We assume that the three parties (the selling club, the buying club, and the player) have a right of veto on the transfer. Following Thomson et al. (2006), the corresponding wage and transfer fees are solutions of a three-agent Nash-bargaining, with bargaining powers α, β and γ for the selling club, the buying club, and the player, respectively.[4]

In so doing, we assume that the player's outside option is the period-2 wage, denoted by $w^r(\tilde{\varepsilon}, p)$, which he would have obtained by renegotiating

[3] All clubs are aware of a possible mismatch and can try to poach the player. Therefore, we rule out a significant search or informational frictions.

[4] Thomson et al. (2006) show such a representation of the asymmetric Nash solution with N agents.

his contract with his current club according to his new productivity. In this respect, the selling club's outside option is then $h(\tilde{\varepsilon}, p) - w^r(\tilde{\varepsilon}, p)$. Finally, the buying job/club of type q has an outside option of 0. This implies that the wage of a moving player, denoted by $\tilde{w}^m$, and the transfer fee, denoted by T, jointly solve:

$$\arg\max_{w^m, T} \Big(\underbrace{T}_{\substack{\text{Tranfer}\\ \text{fees}}} - \underbrace{[h(\tilde{\varepsilon}, p) - w^r(\tilde{\varepsilon}, p)]}_{\substack{\text{Selling club's}\\ \text{outside option}}} \Big)^{\alpha} \Big(\Big[\underbrace{h(\tilde{\varepsilon}, q) - w^m - T}_{\substack{\text{Buying club's surplus}\\ \text{if the transfer occurs}}} \Big] - 0 \Big)^{\beta} \Big(\underbrace{w^m}_{\text{Wage}} - \underbrace{w^r(\tilde{\varepsilon}, p)}_{\substack{\text{Player's}\\ \text{outside option}}} \Big)^{\gamma}$$

with $\alpha + \beta + \gamma = 1$. This problem is thus a weighted average of the respective net surplus of the transfer for both clubs and the player. Each party trades off the benefit of a transfer against the *status quo*. Note that we consider a "signing premium" (if any) as being part of the bargained wage, and thus assume the player does not value the transfer fee. The solution of this three-agent Nash-bargaining is given by:

$$w^m = w^r(\tilde{\varepsilon}, p) + \gamma \left[h(\tilde{\varepsilon}, q) - h(\tilde{\varepsilon}, p) \right] \quad (2)$$

$$T = h(\tilde{\varepsilon}, p) - w^r(\tilde{\varepsilon}, p) + \alpha \left[h(\tilde{\varepsilon}, q) - h(\tilde{\varepsilon}, p) \right] \quad (3)$$

The bargained wage $\tilde{w}^m$ corresponds to the player's outside option (the wage he could expect by staying in his current club) plus a share γ of the net surplus of the transfer. Similarly, the bargained transfer fee corresponds to the selling club's outside option plus a share α of the net surplus of the transfer. Note that the bargained transfer fee T is only determined by α (i.e. the bargaining power of the selling club) or, equivalently, by the sum $\beta + \gamma$, but not by the relative importance of β versus α. Likewise, the bargained wage is only determined by γ (i.e. the bargaining power of the player). In other words, how much the player is able to extract from the surplus generated by the transfer $[h(\tilde{\varepsilon}, q) - h(\tilde{\varepsilon}, p)]$ is independent from the transfer price itself. These results arise as that the player only cares about the negotiated wage, and will thus "fight with" the poaching club to lower the current club's share of the net surplus (i.e. the transfer fee). Furthermore, because contract duration is not specified in our model, the link between the contract duration (including the breach of the actual contract) and the size of the transfer fee is not accounted for, and the same transfer fee is thus predicted no matter the number of seasons left on a player's contract.[5] With the aim of controlling such contract duration effects in our estimation and simulation strategy (see Section 3 and further), the transfer fee is scaled by the number of years of the new contract so that both wages and transfer fees have the same unit of time (yearly frequency). To some extent, it is consistent with a financial accounting perspective in which a transfer is considered as an intangible asset amortised over several years.

Bargaining for stayers. The first situation (case ii) in which a player is considered as a stayer occurs when there is no transfer opportunity after the productivity shock at the expense of a mismatch with his current club. The shock can be either positive or negative, but even in the latter case we argue the player has no incentive for negotiations to fail, that is, the club has sufficient (unmodelled) threats to convince the player to renegotiate although his contract is still ongoing.[6]

Let $w^r(\tilde{\varepsilon}, p)$ denote the wage the player could get in his current club if he cannot move despite the shock. In this case, the wage bargaining involves only two agents: the player and the current club. Noticing that $\gamma/(\gamma+\alpha)$ now represents the player's relative bargaining power within the two-agent Nash-bargaining game, w^r is the solution of the following problem:

$$\arg\max_{w^r} \quad \left(h(\tilde{\varepsilon}, p) - w^r\right)^{\frac{\alpha}{\alpha+\gamma}} \left(w^r\right)^{\frac{\gamma}{\alpha+\gamma}}$$

$$w^r = \frac{\gamma}{\alpha+\gamma} h(\tilde{\varepsilon}, p) \tag{4}$$

A second situation (case iii) in which player is considered as a stayer occurs when a player is not hit by a productivity shock and thus stays in the same club as an efficient match. Let $w(\varepsilon, p)$ denote the corresponding wage: it is again

[5] The model would then tend to overestimate the transfer fee of players with few years left on their contract, and underestimate that of players holding a long-term contract (of no more than 5 years according to the regulation).

[6] For example, the club can threaten to place a player on the substitutes' bench or in the club's reserve team, if he does not renegotiate his contract. Given the highly competitive nature of European top division soccer, losing such visibility can be very detrimental to a soccer player's career.

defined as a standard two-agent Nash-bargaining problem between the player and the club, and the solution is given by:

$$w = \frac{\gamma}{\alpha + \gamma} h(\varepsilon, p). \tag{5}$$

2.3 Equilibrium bargaining conditions

We can now characterise the period-2 equilibrium of the labour market of (young) soccer players when they sign a professional contract. Thanks to efficient assortative matching, if a transfer occurs following a shock, the player will move from his training club of type $p = \varepsilon$ to a poaching club of type $q = \tilde{\varepsilon}$ with $\tilde{\varepsilon} = x\varepsilon$. Accordingly, our model features only one-state variable ε and the multiplicative (productivity) shock x. Taking some draws, ε and x, of both the initial distribution of talents $\psi(\varepsilon)$, $\forall \varepsilon \in [a, \varepsilon_{max}]$ and the log-normal distribution of (productivity) shocks $X(\mu, \sigma)$, the labour market equilibrium is characterised by the tuple $\{w^m(x,\varepsilon), w^r(x,\varepsilon), w(\varepsilon), T(x,\varepsilon), \ \forall(\varepsilon, x) \quad \text{with} \quad \varepsilon \geq a\}$ such that

$$w^m(x,\varepsilon) = \gamma h(x\varepsilon, x\varepsilon) + \frac{\gamma\beta}{1-\beta} h(x\varepsilon, \varepsilon) \tag{6}$$

$$w^r(x,\varepsilon) = \frac{\gamma}{1-\beta} h(x\varepsilon, \varepsilon) \tag{7}$$

$$w(\varepsilon) = \frac{\gamma}{1-\beta} h(\varepsilon, \varepsilon) \tag{8}$$

$$T(x,\varepsilon) = \alpha h(x\varepsilon, x\varepsilon) + \frac{\alpha\beta}{1-\beta} h(x\varepsilon, \varepsilon) \tag{9}$$

At this stage, according to Assumption (A1), we can shed light on some equilibrium properties:

- $w^m(x,\varepsilon) > w^r(x,\varepsilon), \forall x$

Due to assortative matching, once he faces a shock, a player always expects a higher wage by moving to another club. In contrast, the wage gap of mismatched stayers (respectively, movers) with respect to $w(\varepsilon)$ cannot be signed unambiguously since it depends on both the magnitude of the productivity shock, x, and the difference $h(x\varepsilon, \varepsilon) - h(\varepsilon, \varepsilon)$, which captures the production cost of being mismatched after a productivity shock. We further discuss these wage gap in the light of our structural estimation in Section 3.

- $T(x, \varepsilon)/w^m(x, \varepsilon) = \alpha/\gamma$

Finally, the ratio between the transfer fee and the wage is constant and given by the ratio between the bargaining power of the training club (α) and that of the player (γ). Accordingly, one would expect that $\gamma << \alpha$ since the amount of a transfer (excluding a free transfer or loan) is substantially greater than the wage offered for a first professional contract.

Taking some functional specification of h and some (empirical) distributions for the talent and the productivity shock, we make use of these four equations to construct theoretical moments of our model and to match them with their empirical counterparts through the lens of the simulated method of moments.

3 Model estimation

3.1 Data

We collect information from various online sources to construct a new database that tracks players of the "Big-5" European soccer leagues (Premier League, Serie A, La Liga, Bundesliga, and Ligue 1) over the period 2013-2020.[7] We thus obtain unique matched employer-employee data with full information on individual performances, wages, mobility, and transfer fees.

To determine the talent/ability of each player, we use the SoFIFA's index database that provides an overall rating (henceforth, OVA) of each player in real-time. This index, which is based on a large number of variables (among others, dribbling, passing, finishing, acceleration, jumping, and mentality), summarises the skills of the player.[8] The choice of such an *observable* talent variable is motivated by two points. First, the OVA index has been developed historically by the video games industry to reproduce the performances of the players as closely as possible, and to ensure that players who perform the best on the field also perform the best in the video games. In this respect, it provides a well-founded proxy of the player's talent. Second, since talent is a

[7] A full description of the database is provided in Appendix A.

[8] See SoFIFA for more details.

latent variable, we assess the reliability of this index to mitigate some possible error-in-variable issues. We check the consistency of our talent ranking with those of several rankings based on the grades of specialised newspapers, the UEFA ranking for each field position and the FIFA index.[9]

Meanwhile, individual gross annual wages are collected from the Capology's salary database. The selection of this database is motivated by two points. First, this data set was built to help professional soccer teams and players' agents to improve scouting operations and contract negotiations, and thus it can be seen as a valuable source of information on the remuneration of players. Second, we evaluate the reliability of the wage variable along two dimensions. We first check whether these salaries are consistent with those provided by other sources, and, more specifically, the wages reported by (sport) newspapers and specialised magazines such as (*L'Equipe* and *France Football* in France, *Kicker* in Germany, *the Guardian* or the *BBC* in England, *Gazzetta dello Sport* in Italy, and *Diario* in Spain), as well as some other data sets (e.g., the International Centre for Sports Studies). Then we compare our summary statistics with those of related UEFA and FIFA publications, as well as other reports (e.g., the annual review of football finance by Deloitte). Putting together these two dimensions, we find a strong data consistency by cross-checking our main source with a large array of sources and statistics.

Finally, we use the German website Transfermarkt that reports all transfers in European soccer leagues.[10] Several points are worth discussing. First, *Transfermarkt* defines, by default, the transfer fee as the market value of a player, and thus attributes a transfer fee to out-of-contract footballers who are free to sign for another team without transfer indemnity payment or to free loans across teams. In contrast, following FIFA's regulation, we consider that a *transfer* occurs when a player under contract moves to another club, in exchange for the payment of a transfer fee by the buying club to the selling club. Therefore, loans or free-agent signings are ruled out from our empirical analysis. Second, we cross-check these data with traditional newspapers and well-established sources (e.g., International Centre for Sports Studies, club balance sheets). In

[9] A detailed and complete analysis for the Serie A in Italy and Ligue 1 in France is available upon request.

[10] Almost all empirical studies on soccer transfer fees rely on the reference website Transfermarkt.

the latter case, since official figures regarding transfer fees are published by clubs listed on stock markets (Juventus, Olympique Lyonnais, etc.), the transfer fees can be easily checked for a minority of all Big-5 clubs. Moreover, we also make use of the various publications by FIFA TMS (Transfer Matching System) after each transfer window, and, in particular, to the aggregate transfer fee figures per league (when a transfer occurs between clubs located in different national associations). This allows us to reach a good level of accuracy and to get a good predictor of the true fee value without significant bias. Third, to account for the expiration date of a player's contract in case of a breach or the duration of the new contract, transfer fees are scaled by the remaining number of years in the player's contract (including the new contract). We thus abstract from differences in the contract length and facilitate comparisons with annual gross wages.

Since this paper focuses on labour market outcomes around the training period and, as per FIFA regulations, player's training takes place until the age of 23 (FIFA, 2021a), we restrict our sample to players aged 23 or less.[11] Then we keep all players for whom we have at least two consecutive observations over the sample period. The first observation refers to period 1 (the training period) while the second observation refers to period 2 (signature of the first professional contract). Accordingly, our final sample contains 2379 observations distributed in the five leagues (546 in Premier League, 418 in Serie A, 269 in La Liga, 609 in Bundesliga, and 537 in Ligue 1).

Finally, from an empirical point of view, we define the three types of players as follows. A *mover* is a player who is not in the same club between two consecutive years ($club_{t-1} \neq club_t$) and does not have the same level of performance from one year to the next ($OVA_{t-1} \neq OVA_t$). A *mismatched stayer* or a *well-matched stayer* is a player who stays in the same club over two consecutive years but the former does not have the same level of performance from one year to the next ($OVA_{t-1} \neq OVA_t$) whereas the latter maintains the same productivity ($OVA_{t-1} = OVA_t$).[12]

[11] It is obvious that some life-cycle specificities shall affect wage and transfer fees. But here our focus is more on the way the wage determination process interacts with the training policy, hence considering only players 23 years old or less to estimate the key parameters of the model seems consistent.

[12] Since measurement errors on the talent variable cannot be ruled out, we also relax, as a robustness analysis, the narrow definition of a *well-matched stayer* player, as well as the two

Table 1 displays some summary statistics for: i) the overall distribution of wages (column (1)); ii) the distribution of wages by player's type (columns (2)-(4)); iii) the distribution of transfer fees (column (5)), and iv) the ratio of transfer fee to wages of movers (column (6)). We report similar empirical moments for each league in Appendix C.

Several points are worth commenting on. First, the wage and transfer distribution are positively skewed. In particular, the median (gross) salary is around 1.2 million euros and median transfer fees amounts to 4 million euros, while their respective means are 2 million euros for wages and 6.3 million euros for transfer fees.[13] Moreover, the interquartile range of the transfer fees ($\simeq$ 6 million euros) is two times that of wages. Second, well-matched stayers represent 15% of all players, whereas mismatched stayers and movers represent 69% and 16%, respectively. This provides support for high player mobility and turnover. Third, the descriptive statistics by player type are also consistent with what we observe on the overall distribution of transfer fees and wages. Moreover, the indicators of central tendency (mean), position (quantiles) and (relative) dispersion (interquartile range and unreported coefficient of variation) are generally higher for movers than well-matched and mismatched stayers. The evidence is less clear cut when comparing the two types of stayers and there is no substantial difference, with the exception of the bottom of their respective wage distributions (first decile and quartile). Fourth, column (6) indicates that the transfer fee is on average two times greater than the wage of a mover. Importantly, this ratio is roughly constant over the distribution, which provides support to our model's predictions (see Equation (9)). Fifth, looking at the same statistics for each national association, we do observe some country-specific heterogeneity on the level variables (see Appendix C). However, controlling for wage and transfer fee outliers in the top and bottom part of the distributions, it is interesting to note that the ratios, w_{Q1}/w_{Q2}, w_{Q3}/w_{Q2}, $\bar{w}^r/\bar{w}$, $\bar{w}^m/\bar{w}^r$, and $\bar{T}/\bar{w}^m$—where w_{Q1}, w_{Q2}, and w_{Q3} are the three quartiles of the wage of well-matched players, $\bar{w}$, $\bar{w}^r$, and $\bar{w}^m$ are respectively the average wage of well-matched, mismatched, and moving players, and $\bar{T}$ is the average

other player-types by introducing a maximum threshold for the difference of the overall rating between the two periods. Our results remain robust.

[13] Note that players join better, equivalent or worst clubs (after ranking club into three tiers according to their results at the end of the season) in the event of a transfer.

transfer fee, and all are roughly of the same magnitude across the Big-5.[14] We precisely use these ratios as our targeted moments in Section 3.

Table 1: Moments of the wage/transfer distribution

	(1) All players	(2) Well-matched stayers	(3) Mismatched stayers	(4) Movers	(5) Transfer fees	(6) (5)/(4)
Mean	2028193	1841223	1931081	2642450	6298021	2.38
Q1	523914	460000	480000	878108	1675000	1.91
Q2	1215109	1110000	1118585	1915629	4000000	2.09
Q3	2638606	2760990	2423582	3595665	7475000	2.08
D1	215613	150267	200000	553695	833333	1.51
D9	4705903	4545992	4507725	5725662	13750000	2.40
Min	20000	20000	20000	103186	25000	
Max	32090000	18180000	32090000	18731834	145000000	
%	100	15	69	16		

Source: Capology & Transfermarkt. See Appendix A.

Notes: 1. The sample period is 2013-2020.

2. Q_1, Q_2, and Q_3 denote the 1rst, 2nd and 3rd quartile, respectively.

3. D_1, D_9 denote the 1rst and 9th decile, respectively.

4. Wages (Columns (1)-(4)) and Transfer fees (Column (5)) are expressed in euros.

3.2 Estimation strategy

The estimation of the structural model is conducted as follows. First, we proceed with the estimation of the distribution of talent and the distribution of the multiplicative productivity shock. Second, we specify a functional form for the production function, which captures the match between the player and the training club. Third, the structural parameters are estimated using the simulated method of moments.

Distribution of initial talent and productivity shock. We first estimate the distribution of initial talent using period-1 data. As discussed before, the talent is captured by the overall rating (OVA) variable, which is scaled by 10^{-2} and

[14] Indeed, the minimum wage of well-matched stayers, mismatched stayers or movers is rather low (respectively, high) in the Bundesliga (respectively, in Serie A). At the same time, the maximum transfer fee in Germany and France is low with respect to other leagues.

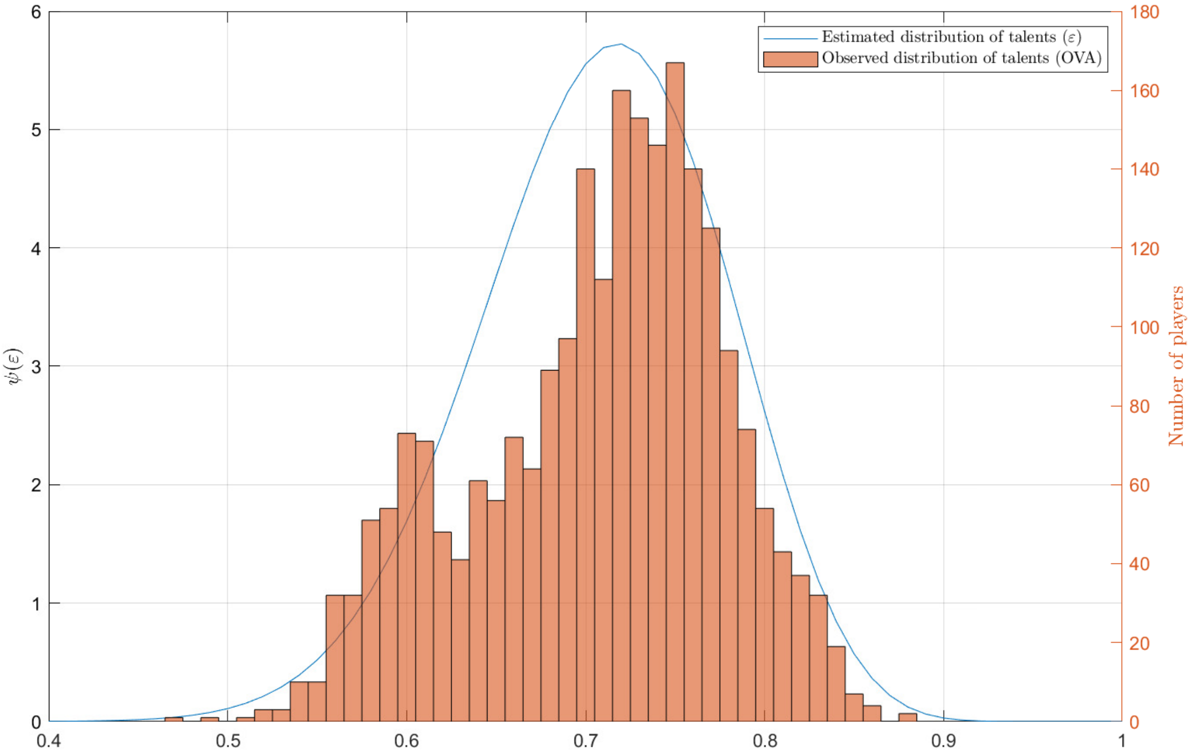
thus takes its values on the unit interval. We assume that the initial talent is drawn from a Beta distribution:

$$f(\varepsilon) = \frac{\varepsilon^{z-1}\,(1-\varepsilon)^{zz-1}}{B(z,zz)},$$

where $z, zz \in (0,\infty)$ and $B(z,zz)$ is the beta function. This parametric distribution is particularly meaningful here, at least, for two reasons. First, it naturally covers the range of values $[0,1]$ which is of particular interest in our application. Second, the Beta distribution can reproduce a very wide range of distribution shapes. For $z = zz = 1$, we have a uniform distribution. For $0 < z < 1 < zz$, the distribution is continuously decreasing, while for $0 < zz < 1 < z$, it is continuously increasing. For $0 < z, zz < 1$, the distribution is U-shaped. For $1 < z < zz$, the distribution is rightward asymmetric bell-shaped, while for $1 < zz < z$, the asymmetry is leftward. Using a maximum likelihood estimation, Table 2 reports the estimates of the Beta distribution parameters z_ε and zz_ε, denoted $\widehat{z}_\varepsilon$ and $\widehat{zz}_\varepsilon$. Both are statistically significant with p-value below 1%, and $\widehat{z}_\varepsilon$ (respectively, $\widehat{zz}_\varepsilon$) is around 30.01 (respectively, 12.41). Since $\widehat{z}_\varepsilon > \widehat{zz}_\varepsilon > 1$, the estimated distribution is leftward asymmetric bell-shaped. Moreover, the maximum likelihood estimates of z_ε and zz_ϵ imply that the estimate of the average talent is $\widehat{z}_\varepsilon/(\widehat{z}_\varepsilon + \widehat{zz}_\varepsilon) \simeq 0.707$ close to the sample value of 0.708.[15] Figure 2 plots the estimated distribution and the empirical histogram (using constant bins).

[15]In the same respect, the estimate of the standard deviation, skewness, and excess kurtosis of talent implied by the maximum likelihood estimation of the Beta distribution are respectively given by 0.069, -0.271 and -0.025 whereas the sample values are 0.070, -0.429 and -0.442, respectively.

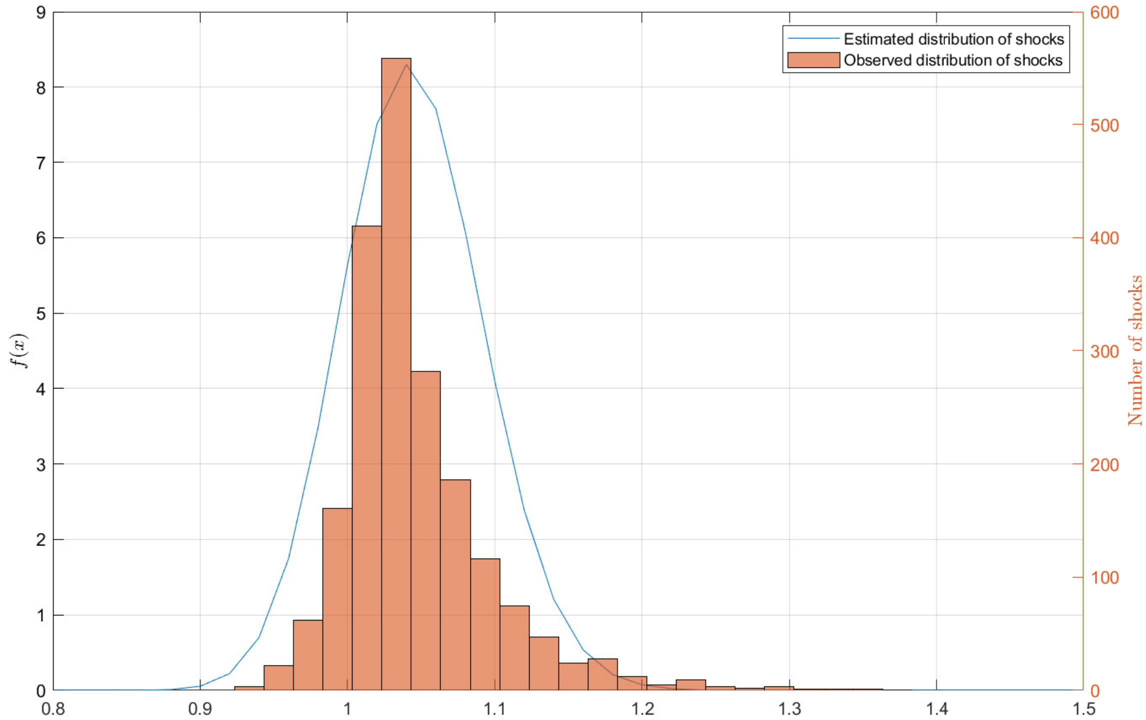
Figure 2: Probability density function of talents



Notes: 1. The right scale displays the number of players for the histogram of observed talents using the overall rating variable. 2. The left scale displays the estimated distribution of the talent variable.

We now turn to the distribution of shocks. We consider that a player is hit by a shock if his overall rating (OVA) varies between two consecutive years, that is if $OVA_{t-1} \neq OVA_t$. The shock is multiplicative and equivalent to OVA_t/OVA_{t-1}. Using the maximum likelihood principle, we estimate the two parameters μ and σ of the log-normal distribution. Both estimates are statistically significant with p-value below 1%. Taking the estimate of μ (Table 2), the estimate of the sample mean of the productivity shock is around 1.042, meaning that, the player's talent increases by 4.2% on average following a positive shock, and is quite close to the observed mean of the productivity shock (1.045). Meanwhile, the estimate of σ is also consistent with its empirical counterpart (0.050). Inspecting Figure 3, which plots the observed distribution of shocks (using an histogram with constant bins) and the related LN-distribution, supports the hypothesis that the observed multiplicative shocks are very well captured by our distribution specification.

Figure 3: Probability density function of shocks



Notes: 1. The right scale displays the number of shocks regarding the histogram of observed multiplicative shocks defined by $OVA_{t-1} \neq OVA_t$. 2. The left scale displays the estimated LN-distribution of the shocks.

Table 2: Estimation of the initial talent and productivity shock distributions

Description	Parameter	Estimate
First parameter of the *Beta*-distribution of talents	z_ε	30.0113
Second parameter of the *Beta*-distribution of talents	zz_ε	12.4109
Mean of the *LN*-distribution of shocks	μ	0.0427
Standard deviation of the *LN*-distribution of shocks	σ	0.0461

Specification of the production function. Before proceeding with the structural estimation of our model, we now specify the production function h using Assumption (A2).

Assumption (A2): Production function

$$h(\varepsilon,p) = \max\{j(\varepsilon,p);0\}, \text{ with } j(\varepsilon,p) = \varepsilon^{\kappa} - \delta^{\kappa}|\varepsilon - p|^{\kappa}$$

with $\kappa, \delta \geq 0$.

The j function contrasts the power function ε^{κ} with a penalty term that measures a "distance" between the talent of the player, ε, and the club type, p. Notably,

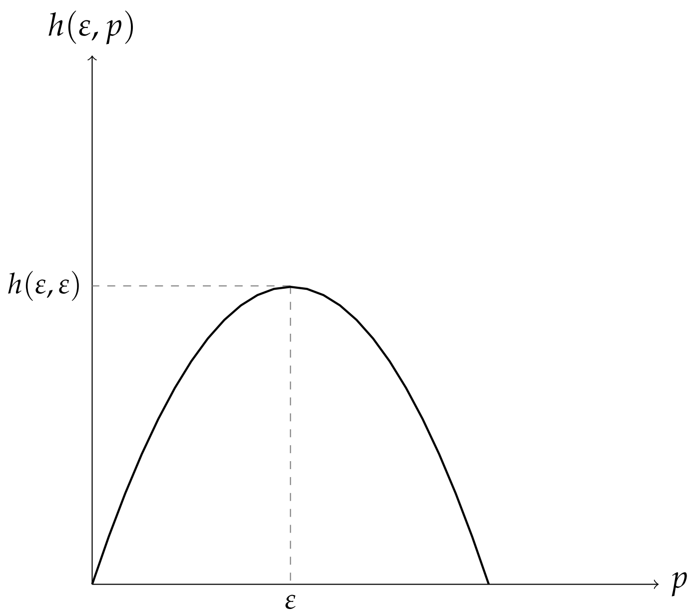
$$j(\varepsilon,p) = \begin{cases} \varepsilon^{\kappa} - \tilde{\delta}(\varepsilon - p)^{\kappa} & \text{if } \varepsilon \geq p \\ \varepsilon^{\kappa} - \tilde{\delta}(p - \varepsilon)^{\kappa} & \text{otherwise.} \end{cases}$$

where $\tilde{\delta} = \delta^{\kappa}$. This function introduces two parameters κ and δ that determine respectively how talent affects the productivity of the match, and how mismatch reduces the latter, and thus wages. Such specification is consistent with Assumption (A1) (since $\underset{p}{\operatorname{argmax}}\, h(\varepsilon,p) = \varepsilon$ and $h(\varepsilon,\varepsilon)$ is strictly increasing with ε) and related wage equilibrium properties. This function h is particularly meaningful as it allows for complementarity effects between players and club characteristics. As depicted in Figure 4, the highest surplus of a player-club match is reached when $p = \varepsilon$. Hence, being matched with the most productive club does not necessarily imply a maximum output.[16] Additionally, depending on δ, this specification introduces a production cost of being mismatched after a productivity shock x, which is given by the related gap $h(x\varepsilon,\varepsilon) - h(\varepsilon,\varepsilon) = \varepsilon^{\kappa}[x^{\kappa} - \delta^{\kappa}|x-1|^{\kappa}]$.[17] Function h is also in line with the literature on sorting. Indeed, as argued in Eeckhout and Kircher (2011), the highest compensation arises when the correct match is formed. We do consider efficient assortative matching, but once a player's talent is shocked, he can only search for a new club with a probability ρ.

[16]Big market clubs are therefore not willing to acquire any players, as it would be the case with a multiplicative matching function such as $p\varepsilon$. Instead, these clubs will only be interested in very talented players (i.e. with an ability level close to club's productivity).

[17]Similarly, Marimon and Zilibotti (1999), consider a matching function where an employed worker's productivity decreases with the distance between him and the firm. But as it is defined along a circle, it appears less appropriated to deal with player's mobility over best or worst clubs.

Figure 4: Function $h(\varepsilon, p)$



Last, according to efficient assortative matching at equilibrium, we have $p = \varepsilon$ and $q = \tilde{\varepsilon} = x\varepsilon$, and thus:

$$h(\tilde{\varepsilon}, \tilde{\varepsilon}) = (x\varepsilon)^{\kappa} \quad \text{(movers)}$$
$$h(\tilde{\varepsilon}, \varepsilon) = \varepsilon^{\kappa} \max\{x^{\kappa} - \delta^{\kappa}|x-1|^{\kappa}; 0\} \quad \text{(mismatched stayers)}$$
$$h(\varepsilon, \varepsilon) = \varepsilon^{\kappa} \quad \text{(well-matched stayers)}$$

Plugging this production technology into the bargaining Equations (6)-(9) leads to the following equilibrium wages and transfer fees:

$$w^m(x, \varepsilon) = \frac{\gamma}{1-\beta} \varepsilon^{\kappa}[(1-\beta)x^{\kappa} + \beta \max(x^{\kappa} - \delta^{\kappa}|x-1|^{\kappa}; 0)] \tag{10}$$
$$w^r(x, \varepsilon) = \frac{\gamma}{1-\beta} \varepsilon^{\kappa} \max(x^{\kappa} - \delta^{\kappa}|x-1|^{\kappa}; 0) \tag{11}$$
$$w(\varepsilon) = \frac{\gamma}{1-\beta} \varepsilon^{\kappa} \tag{12}$$
$$T(x, \varepsilon) = \frac{\alpha}{1-\beta} \varepsilon^{\kappa}[(1-\beta)x^{\kappa} + \beta \max(x^{\kappa} - \delta^{\kappa}|x-1|^{\kappa}; 0)] \tag{13}$$

where $\alpha = 1 - \beta - \gamma$.

Simulated method of moments. Our structural model is estimated using the Method of Simulated Moments (MSM). As proposed by McFadden (1989), the objective is to find a vector of structural parameters, denoted by $\theta = (\kappa, \delta, \beta, \gamma)$ and $\alpha = 1 - \gamma - \beta$, that leads to simulated model-predicted moments that look like (as measured by a GMM-based criterion function) the ones from the data. In so doing, the data sample allows to compute a vector of empirical moments for wages and transfer fees, denoted by $\widehat{m}_N = \frac{1}{N}\sum_{i=1}^{N} m_i$ where $\widehat{m}_N$ are some functionals of the mean, the median, the first and third quartiles of the movers' and stayers' wages, and the transfer fees.[18] Given a value of θ, we simulate S alternative samples of wage and transfer (fee) trajectories, and compute the corresponding model-predicted moments for each sample. This yields the vector of average simulated moments $\widehat{m}_S^M(\theta) = \frac{1}{S}\sum_{s=1}^{S} m_s^S(\theta)$ where M stands for a model-predicted quantity. Assuming $\boldsymbol{W}_N$ is the optimal weighting matrix, the minimised criterion function (up to a proportional factor) is:

$$Q(\theta) \;=\; \min_{\theta} \left(\widehat{m}_N - \widehat{m}_S^M(\theta)\right)^{\top} \boldsymbol{W}_N \left(\widehat{m}_N - \widehat{m}_S^M(\theta)\right). \tag{14}$$

Under suitable regularity conditions (McFadden, 1989; Pakes and Pollard, 1989; Duffie and Singleton, 1993), it can be shown that the optimal weighting matrix is the inverse of the variance-covariance matrix of the moment conditions, and the MSM estimator is both consistent and asymptotically normally distributed. To compute $\boldsymbol{W}_N$, we use the inverse of the variance-covariance matrix of the empirical moments using a bootstrapping procedure.[19]

We now turn to the selection of the (simulated) theoretical moments and adopt the following strategy. A first set of moments makes use of relative wage variations according to talent. Starting from the distribution of talent and using Equation (12), it is straightforward to get the wage distribution of well-matched stayers (i.e., players that are not hit by a productivity shock), and

[18] Note that higher-order empirical moments are not computed, due to the number of observations in our sample, especially for transfer fees.

[19] Note that the asymptotically efficient weighting matrix arises when it converges to the inverse of the variance-covariance matrix of the data moments. Even though this matrix is asymptotically efficient, it might be biased in small samples (Altonji and Segal, 1996). As a robustness analysis, we also make use of a diagonal weighting matrix (Pischke, 1995). All in all, this weighting matrix delivers parameters roughly similar to our benchmark estimates.

then to determine the quartiles. Since (theoretical) quantiles can be written as moment conditions (Manski, 1988; Powell, 1994; Buchinsky, 1998), our first set of moments conditions is given by the two ratios $\frac{w_{Q1}}{w_{Q2}}$ and $\frac{w_{Q3}}{w_{Q2}}$ where w_{Q_i} denotes the ith wage quartile of well-matched stayers, or, equivalently, by:

$$\frac{w_{Q1}}{w_{Q2}} := \frac{E\left[\mathrm{I}_{w \leq F_W^{-1}(0.25)}\right]}{E\left[\mathrm{I}_{w \leq F_W^{-1}(0.5)}\right]} \tag{15}$$

$$\frac{w_{Q3}}{w_{Q2}} := \frac{E\left[\mathrm{I}_{w \leq F_W^{-1}(0.75)}\right]}{E\left[\mathrm{I}_{w \leq F_W^{-1}(0.5)}\right]} \tag{16}$$

where the cumulative distribution function of the wage of well-matched players, F_W, depends on Ψ_ε.

Note that our aim is to capture the relative variation of the first and third quartile relative to the median, and not the difference between the first quartile (respectively, third quartile) and the median. We also pursue this strategy for the second set of moment conditions by using ratios of (unconditional) expectations (e.g., average wage or average transfer fee). A first motivation for those theoretical moment specifications is that the estimate of κ will be invariant to the scale of the talent variable, which is an index (the overall rating performance) without a unit of measure. Using a proportionality factor for the talent variable so as to fit the observed wages of well-matched stayers (respectively, mismatched stayers and movers) will not change the relative variation of the corresponding quartiles and the expectation-based ratios. This stems from the homogeneity of the four equilibrium conditions (Equations (10)-(13)) with respect to ε^κ.[20] A second motivation comes from descriptive statistics. Notably, while country-specific heterogeneity cannot be ruled out for level variables, we control this issue by using moment-based ratios, which are roughly constant across national associations when outliers of the wage and transfer fee distribution are disregarded, particularly in France (Ligue 1) and Germany (Bundesliga).

[20] In contrast, using a Box-Cox transformation of the talent variable will not change the relative variation for the expectation-based ratios. However, the quartiles of the transformed variable will be obviously different from those of the initial talent variable and there is no one-to-one relationship between the ratio of quartiles of the transformed and initial talent variable.

A second set of moments captures the average impact of shocks and mobility on wages and transfer fees. We can indeed compute the three following ratios $E(w^m)/E(w^r)$, $E(w^r)/E(w)$, and $E(T)/E(w^m)$ where the expected values $E(w^m)$, $E(w^r)$, $E(w)$ and $E(T)$ are derived from Equations (10)-(13):

$$\frac{E(w^r)}{E(w)} = \int_{\underline{x}}^{\overline{x}} \left(x^\kappa - \delta^\kappa \left|x-1\right|^\kappa\right) f(x)dx \tag{17}$$

$$\frac{E(w^m)}{E(w^r)} = (1-\beta)\frac{\int_x x^\kappa f(x)dx}{\int_{\underline{x}}^{\overline{x}} \left(x^\kappa - \delta^\kappa \left|x-1\right|^\kappa\right) f(x)dx} + \beta \tag{18}$$

$$\frac{E(T)}{E(w^m)} = \frac{1-\gamma-\beta}{\gamma} \tag{19}$$

where the shock thresholds $\underline{x}$ and $\overline{x}$ are defined such that $\forall x \in [\underline{x}, \overline{x}]$,

$$\max(x^\kappa - \delta^\kappa |x-1|^\kappa; 0) = x^\kappa - \delta^\kappa |x-1|^\kappa.$$

Accordingly, for a given θ, the vector of theoretical moments $\widehat{m}_S^M(\theta)$ is given by Equations (15)-(19) and $\widehat{m}_N$ is the empirical counterpart of those moments. Whereas the first two moments mainly identify the technology parameter κ, the last three moment conditions helps identifying the scale factor of the penalty term δ, and the two bargaining parameters β and γ. Taking the constraint on the bargaining parameters $\alpha = 1-\beta-\gamma$, this leads to an overidentified system of (simulated) moment conditions.

3.3 Estimation results

Table 3 reports the values of the estimated parameters. All parameter estimates are statistically significant at conventional level. Our structural estimation reveals, in particular, that the bargaining power of the poaching club ($\beta = 77\%$) is relatively high, compared with the bargaining powers of the player ($\gamma = 5\%$) and the selling club ($\alpha = 18\%$).

Table 3: Estimated parameters

Description	Parameter	Estimates
Production technology	κ	16.514
Production penalty when mismatched	δ	15.020
Bargaining power of poaching club	β	0.770
Bargaining power of player	γ	0.052
Bargaining power of selling club*	α	0.178

Notes: 1. All estimates are statistically significant at the 1% level, using a bootstrapping procedure with 1′000 replications. 2. The first step estimation makes use of the identity matrix as a weight matrix, whereas the second-step estimation computes the optimal weight matrix as the inverse of the variance-covariance matrix of the empirical moments using a bootstrapping procedure with 1′000 replications. 3. The estimate of α is derived from the constraint of the bargaining parameters $\alpha = 1 - \beta - \gamma$.

Table 4 displays the moments generated by the model with those observed in the data. As can be seen, our model reproduces the targeted moments remarkably well. First, our model perfectly captures the relative wage variations by player type. Given the estimates provided in Section 3.2, suppose that the player's ability increases on average by $exp(\mu) = 4.4\%$ in case of a productivity shock. Then the impact on wages depends on the outcome of the transfer: if the player stays in his current club, he can expect on average a wage increase of 5%, while the average wage progression is 37% if he moves to a poaching club (Table 4). Second, the wage gap between stayers and movers is consistent with our assumptions regarding the production function and the wage bargaining that imply a wage penalty for mismatched players. Third, our empirical estimates suggest that the bargaining power of the selling club is about four time greater than that of the player. This is also consistent with the predictions of our model that underlines the selling club may extract a larger share of the net surplus provided that transfer fees are much larger than wages. Fourth, looking at the wage distribution characteristics of well-matched stayers, we reproduce the large relative variation between the observed first and third quartiles, e.g. a proportionality factor around 8, thanks to a relatively high value of the

Table 4: Estimated moments: model vs. data

Moment	$\frac{E(w^r)}{E(w)}$	$\frac{E(w^m)}{E(w^r)}$	$\frac{E(T)}{E(w)}$	$\frac{w_{Q_1}}{w_{Q_2}}$	$\frac{w_{Q_3}}{w_{Q_2}}$
Data	1.049	1.368	3.421	0.414	2.487
Model	1.049	1.362	3.420	0.300	2.468

Source: Capology & Transfermarkt; Period: 2013-2020.

technological parameter κ.[21] Fifth, using Table 4, we can easily derive a scale and skewness measure of the wage distribution of well-matched stayers. Using the quartile ratios, it is common to define a scale measure as $\frac{w_{Q3}-w_{Q1}}{w_{Q3}+w_{Q1}}$ and a skewness measure as $\frac{w_{Q3}+w_{Q1}-2w_{Q2}}{w_{Q3}-w_{Q1}}$. In both cases, our estimates of these two measures are quite close to the observed ones, the two estimates are respectively given by 0.783 (scale) and 0.354 (skewness) whereas the observed measures are respectively 0.715 and 0.434.

4 Training of talents: equilibrium *versus* efficient outcomes

This section discusses the firms' training policy at the first period. We first define a training policy as a minimal talent determination, and then derive the equilibrium threshold talent in our model. In particular, the training policy depends on the expected value at period 1 from giving access to a professional contract at period 2, and the threshold value depends on the impact of shocks on the player's ability, and the sharing of the surplus occurring at period 2. With the aim of quantifying the impact of the transfer fee system, we then present how to determine the threshold talent in the absence of a such a system by considering either a Bertrand competition between employers or a standard Nash-bargaining between the player and his current club. Finally, all these solutions are contrasted with the one of a social planner.

[21] It also provides support for our Assumption (A1) in the sense that having more talented players leads to higher production than having less talented players (within a team).

4.1 Training condition and equilibrium threshold talent

We do not deal with wage determination during the training period, which may reflect specific rules. The training policy, which consists of choosing the minimal talent required to be trained, does not rely on wage determination during the first period, but rather on the expected surplus from the match between the player and the training club.[22] At the same time, our model features some training costs that depend on players' talent. Let $c(\varepsilon)$ denote a function that characterises the cost *per* player supported by the training club.

Our goal is to determine the minimal talent, denoted by a, required to be trained at the start of period 1. This threshold depends on the match surplus net of the training costs, which has to be non-negative for the player to be trained. Since players are assumed to be efficiently matched at the initial period, we focus on the surplus $S_1(\varepsilon, \varepsilon) - c(\varepsilon)$ where

$$\begin{aligned} S_1(\varepsilon, \varepsilon) &= h(\varepsilon, \varepsilon) + \varsigma v h(\varepsilon, \varepsilon) + \varsigma(1-v)(1-\rho) \int_x h(x\varepsilon, \varepsilon) f(x) dx \\ &\quad + \varsigma(1-v)\rho \int_x \{T(x\varepsilon, \varepsilon) + w^m(x\varepsilon, \varepsilon)\} f(x) dx \end{aligned} \qquad (20)$$

where ς is the discount factor. The surplus is defined as the sum of four terms. The first right-hand side term corresponds to the current production of well-matched young players. In the absence of a productivity shock between the two periods with a probability v, the young player can be offered a first professional contract and thus the second right-hand side term is the discounted value of the player-club match (production). In contrast, in the event of a productivity shock with a probability $1 - v$, there are two possible outcomes. The player cannot move with probability $1 - \rho$ and there is some mismatch (since $h(x\varepsilon, \varepsilon) < h(x\varepsilon, x\varepsilon)$). The corresponding discounted expected value is then captured by the third right-hand side term. In contrast, the player can move to another club with probability ρ so that the production value of the match between the player and the poaching club is $h(x\varepsilon, x\varepsilon)$. Accordingly, from the point of view of the surplus between the player and the incumbent club, this value is then given by the sum of the player's new wage and the transfer fee paid by the poaching club to the incumbent one and this leads to the last right-

[22]The wage determination for an apprentice (not yet professional) follows some specific rules that are defined by FIFA and UEFA.

hand side term.

The initial club chooses to train the player at time $t = 1$ if $S_1(\varepsilon, p) \geq c(\varepsilon)$, i.e. if the surplus of the match at least compensates for the training cost. Accordingly, the threshold a must satisfy $S_1(a, a) = c(a)$. In contrast, players whose talent ε is below a do not enter the soccer labour market. Therefore, the talent threshold is characterised by the following condition:

$$\begin{aligned} c(a) &= h(a,a)(1+\varsigma v) + \varsigma(1-v)(1-\rho)\int_x h(xa,a)f(x)dx \\ &\quad +\varsigma(1-v)\rho\int_x \{T(xa,a) + w^m(xa,a)\} f(x)dx \\ &= h(a,a)(1+\varsigma v) + \varsigma(1-v)(1-\rho)\int_x h(xa,a)f(x)dx \\ &\quad +\varsigma(1-v)\rho\int_x \Big\{h(xa,xa) - \beta\Big[h(xa,xa) - h(xa,a)\Big]\Big\} f(x)dx \end{aligned} \tag{21}$$

where the cost function, c, is left unspecified at this stage (see Section 5).

4.2 Training without transfer fees

We now proceed with a counterfactual analysis to quantify the impact of the transfer fee system. Following an idiosyncratic shock, we assume that the labour market regulation would not allow the payment of a transfer fee to the selling club. In other words, the transfer system does not exist, and trained workers can move to poaching clubs without any compensation from poaching clubs to training clubs.[23] Let w^{m0} denote the wage of a mover with 0 transfer fee. The surplus of the period-1 match between the player and the training club is now given by:

$$S_1(\varepsilon, p) = h(\varepsilon,\varepsilon)(1+\varsigma v) + \varsigma(1-v)(1-\rho)\int_x h(x\varepsilon,\varepsilon)f(x)dx \tag{22}$$

$$+\varsigma(1-v)\rho\int_x w^{m0}(x\varepsilon,\varepsilon)f(x)dx \tag{23}$$

Compared to Equation (20), the main difference regards the last right-hand side term. The surplus no longer features a transfer fee for the incumbent club

[23] This counterfactual scenario indeed corresponds to the standard labour market, in which training compensation generally does not exist.

in the event of productivity shock, and the player can move. Additionally, the bargained wage, $w^{m0}(x\varepsilon, \varepsilon)$, needs to be revisited. In the absence of a transfer fee system, there are, at least two ways to determine wages. First, when bargaining with the poaching club, the outside option of the player could be the wage that he would bargain for after staying in his current club and becoming mismatched. Second, in the spirit of Cahuc et al. (2006) in which there is a Bertrand competition between employers, the outside option of the player can be defined as the highest wage he could get by staying in his current club, i.e. the mismatched productivity. In both cases the training surplus is reduced relative to the bargaining with transfer fees. We discuss these two cases subsequently.

Bertrand competition case. We first consider a Bertrand competition between employers. In so doing, the outside option of the player is the highest wage he could get by staying in his current club, that is, mismatched productivity. In other words, we focus on the situation where the outside opportunity of the player is $h(x\varepsilon, \varepsilon)$, so w^{m0} solves the following problem:

$$\arg\max_{w^{m0}} \left(h(x\varepsilon, x\varepsilon) - w^{m0}\right)^{\frac{\beta}{\beta+\gamma}} \left(w^{m0} - h(x\varepsilon, \varepsilon)\right)^{\frac{\gamma}{\beta+\gamma}}$$

The equilibrium wage w^{m0} is then given by:

$$w^{m0}(x\varepsilon, \varepsilon) = h(x\varepsilon, \varepsilon) + \frac{\gamma}{\gamma+\beta}\left[h(x\varepsilon, x\varepsilon) - h(x\varepsilon, \varepsilon)\right],$$

and the threshold talent for training, a_0, satisfies:

$$\begin{aligned} c(a_0) &= h(a_0, a_0)(1+\varsigma v) + \varsigma(1-v)(1-\rho)\int_x h(xa_0, a_0) f(x)dx \\ &\quad + \varsigma(1-v)\rho \int_x \left\{ h(xa_0, xa_0) - \frac{\beta}{\gamma+\beta}\left[h(xa_0, xa_0) - h(xa_0, a_0)\right]\right\} f(x)dx. \end{aligned}$$

where $\gamma + \beta = 1 - \alpha$, hence $\gamma \in (0, 1 - \alpha - \beta)$. It is worth emphasising that the expected surplus of training for the match between the player and the training club is higher with transfer fees (20) than without. Furthermore, the lower the player's bargaining power γ is, the lower is the expected surplus of the match between the player and the incumbent club, because the poaching club gets a higher share of the production value of the new match. Therefore, not only does the incumbent club not pick up any transfer fee, but the player also gets a lower wage.

Standard Nash-bargaining case. In turn, if the outside option of the player is the wage he would bargain for after staying in his current club and becoming mismatched, we therefore have:

$$\arg\max_{w^{m0}} \quad \Big(h(x\varepsilon, x\varepsilon) - w^{m0}\Big)^{\frac{\beta}{\gamma+\beta}} \Big(w^{m0} - w^{r}(x\varepsilon, \varepsilon)\Big)^{\frac{\gamma}{\gamma+\beta}}$$

It is straightforward to show that the wage for movers is given by:

$$\begin{aligned} w^{m0} &= \frac{\gamma h(x\varepsilon, x\varepsilon) + \beta w^{r}(x\varepsilon, \varepsilon)}{\gamma+\beta} \\ &= \frac{\gamma}{\gamma+\beta}\left\{h(x\varepsilon, x\varepsilon) + \frac{\beta}{1-\beta}h(x\varepsilon, \varepsilon)\right\} \equiv w^{m0}(x\varepsilon, \varepsilon) \end{aligned}$$

So the lowest talent that is trained, denoted $\tilde{a}_0$, solves:

$$c(\tilde{a}_0) = h(\tilde{a}_0, \tilde{a}_0)(1+\varsigma v) + \varsigma(1-v)(1-\rho)\int_x h(x\tilde{a}_0, \tilde{a}_0)f(x)dx + \varsigma(1-v)\rho \times$$
$$\int_x \left\{h(x\tilde{a}_0, x\tilde{a}_0) - \frac{\beta}{\gamma+\beta}\Big[h(x\tilde{a}_0, x\tilde{a}_0) - h(x\tilde{a}_0, \tilde{a}_0)\Big] - \frac{\beta}{1-\beta}\Big[\frac{1}{\gamma+\beta} - 1\Big]h(x\tilde{a}_0, \tilde{a}_0)\right\} f(x)dx$$

Compared to the Bertrand competition case, this already suggests that the expected overall surplus of training is relatively lower, due to the last right-hand side term. This term is as much higher as the bargaining power of the player is lower. Indeed, during the bargaining process with the poaching club, the outside option of the player is no longer given by the maximum wage he can get by staying mismatched with the incumbent club, $h(x\varepsilon, \varepsilon)$, but it now depends on $w^{r}(x\varepsilon, \varepsilon)$, and thus on player's bargaining power. Therefore if γ is low, the gap $h(x\varepsilon, \varepsilon) - w^{r}(x\varepsilon, \varepsilon)$ will be high, and the player will get a lower wage w^{m0} (by switching to the poaching club much lower). The surplus related to the initial match between the player with the incumbent club is relatively lower, which also means that the value of training is relatively lower.

4.3 Efficient training and the role of transfer fees

From the point of view of a social planner, the intertemporal value of training at period 1 is given by:

$$S_1^\star(\varepsilon,\varepsilon) \;=\; h(\varepsilon,\varepsilon)(1+\varsigma v)+\varsigma(1-v)\int_x \{\rho h(xa^\star,xa^\star)+(1-\rho)h(xa^\star,a^\star)\}\, f(x)dx$$

so the lowest talent that should be trained, denoted $a^\star$, solves:

$$c(a^\star) \;=\; h(a^\star,a^\star)(1+\varsigma v)+\varsigma(1-v)\int_x \{\rho h(xa^\star,xa^\star)+(1-\rho)h(xa^\star,a^\star)\}\, f(x)dx$$

The surplus associated to the training policy now takes into account the overall expected production value, and in particular the total value of the new match if the player moves to another club following a productivity shock (with probability $(1-v)\rho$).

Discussion. We can therefore compare the efficient training policy ($a^\star$), to the equilibrium training policy with a transfer fee (a) or without a transfer fee (a_0 or $\tilde{a}_0$, respectively). The four training policies can be summarised by $s=\{a^\star,a,a_0,\tilde{a}_0\}$ and the talent thresholds are solutions of

$$\begin{aligned} c(s) \;=\;& h(s,s)(1+\varsigma v)+\varsigma(1-v)(1-\rho)\int_x h(xs,s)f(x)dx \\ &+\varsigma(1-v)\rho\int_x \Big\{h(xs,xs)-\lambda\Big[h(xs,xs)-h(xs,s)\Big]-\tilde{\lambda}h(xs,s)\Big\}\, f(x)dx \end{aligned}$$

where

- At the optimum

$$\{\lambda=0,\tilde{\lambda}=0\};\;\; \text{with } s=a^\star$$

- At equilibrium in the presence of a transfer fee system

$$\{\lambda=\beta,\tilde{\lambda}=0\};\;\; \text{with } s=a$$

- At equilibrium in the absence of a transfer fee system

$$\{\lambda = \frac{\beta}{1-\alpha}, \tilde{\lambda} = 0\}; \text{ with } s = a_0 \text{ (Bertrand competition)}$$
$$\{\lambda = \frac{\beta}{1-\alpha}, \tilde{\lambda} = \frac{\alpha\beta}{(1-\alpha)(1-\beta)}\}; \text{ with } s = \tilde{a}_0 \text{ (Nash-bargaining).}$$

It is straightforward to see that if $\delta = 0$, there is no mismatch, i.e. $h(x\varepsilon, x\varepsilon) = h(x\varepsilon, \varepsilon)$, and the equilibrium training is efficient not only with transfer fees but also without transfer fees, when considering a Bertrand competition configuration for the player's outside option, that is $a^\star = a = a_0$. This is no longer the case if we consider that the outside option of the player is the wage he would bargain for by staying in his current club and becoming mismatched (Nash-bargaining case without transfer fees). In the Bertrand case, the outside option of the player is only the share $\gamma/(\alpha+\gamma)$ of his new productivity. This means that in period 2 the poaching club extracts part of the extra-rent generated by the productivity shock, and neither the selling club through the transfer fee system nor the player through his outside opportunity are able to capture the entire extra-rent. So, there is still a room for inefficiency in this case, that is, $a_0 > a^\star$. In turn, when $\delta > 0$, staying mismatched leads to a production penalty, and the bargaining with transfer fees allows us to get closer to efficiency even with respect to the Bertrand competition case.

Finally, according to the technology specification (A2), the training policy rule can be more specifically written as follows:

$$\begin{aligned} g(s) \quad &= \quad 1 + \varsigma v + \varsigma(1-v)\rho(1-\lambda) \int_x x^\kappa f(x) dx \\ &\quad + \varsigma(1-v)[1-\rho(1-\lambda-\tilde{\lambda})] \int_{\underline{x}}^{\overline{x}} \{x^\kappa - \delta^\kappa |x-1|^\kappa\} f(x) dx \end{aligned} \tag{24}$$

with $g(s) = c(s)/s^\kappa$. Therefore, we unambiguously have that $a^\star < a < a_0$ as long as $g'(\varepsilon) < 0$, which means that the productivity impact of talent is relatively higher than its cost impact. In this case, the threshold talent to become a professional player is decreasing with λ and $\tilde{\lambda}$.

5 The quantitative impact of transfer fees system on training (in)efficiency

We now run some numerical experiments to quantify the impact of poaching on firms' training policy and to illustrate the allocation role played by the transfer fee system.

5.1 Calibration of training parameters

Training cost function. The functional specification of the training cost is given by Assumption (A3).

Assumption (A3): Training cost function

$$c(\varepsilon) = \varepsilon^{\phi}$$

with $\phi \geq 0$ and $\kappa > \phi$.

The training cost function is a power function of the talent, and is strictly convex as $\phi > 1$. Importantly, $\kappa > \phi$ is a sufficient condition for $g'(\varepsilon) < 0$ (see Equation (24)), so that the threshold talent to become a professional player does decrease with λ and $\tilde{\lambda}$.[24]

Our strategy to calibrate the training cost function is to find the value of ϕ that implies the talent threshold observed in data.[25] More precisely, we determine the lowest observed talent needed for a player aged less than 23 to get a contract with a professional club from the Big-5.[26] This minimal talent required to become a professional player represents the empirical counterpart of a.

[24] As explained below, note that the calibration strategy is always consistent with $\kappa > \phi$ irrespective of the value of ρ.

[25] In practise, the threshold is a latent variable as other dimensions than just the talent ought to be considered (e.g., whether the young player is often injured during his training period). We assume that each club values only the productivity that the player can bring to the team, and thus the observed talent is a sufficient statistic to determine the threshold.

[26] To remove outliers, which are generally due to serious injuries, we drop the bottom 5% of the distribution of OVA.

We then determine the expected surplus of training for the match between the player and the training club at period 1:

$$\begin{aligned} ES(\lambda,\tilde{\lambda}) \quad \equiv \quad & 1+\varsigma v+\varsigma(1-v)\rho(1-\lambda)\int_{x} x^{\kappa} f(x)dx \qquad (25) \\ & +\varsigma(1-v)[1-\rho(1-\lambda-\tilde{\lambda})]\int_{\underline{x}}^{\overline{x}}(x^{\kappa}-\delta^{\kappa}|x-1|^{\kappa})f(x)dx \end{aligned}$$

We can then find the threshold talent s from the following condition:

$$s^{\phi-\kappa} = ES(\lambda,\tilde{\lambda}) \qquad (26)$$

which implies $s = s(\lambda,\tilde{\lambda})$. Finally, using the observed lowest value of talent in the absence of transfers, $s(\beta,0) = 0.58$, the cost function parameter ϕ is set to:

$$\phi = \kappa + \frac{\log(ES(\beta,0))}{\log(0.58)}$$

where $\log(ES(\beta,0))$ is determined by Equation (25) using parameters whose calibration is detailed hereafter (see Table 5).[27]

Shocks and transitions. We further need to calibrate the probability for the player to be hit by a shock $(1-v)$ and the probability to be transferred following a shock (ρ), both probabilities driving the expected surplus of training. It is clear that the training return embodies some dynamical aspects, i.e. the time over which to recoup investment, that our model does not directly deal with. However, we choose to use external information from our data set and run sensitivity analysis to help capture the horizon effect over which the training investment is valued. Based on our definition of productivity shocks and player's types, 84% of the players get variations in their SoFIFA index between two successive observations. Then, there is the issue of the (legal) possibility to move to another club, which also relies on our parameter ρ. As a limit case, we consider that $\rho = 100\%$, i.e. all players shall be able to move in the long-run since contract duration is limited and there is a large turnover in Big-5 cham-

[27]Since ϕ depends on the estimation of the structural parameters as well as the lowest observed value of talent. Subsequently we conduct sensitivity analysis. The main conclusions reported in this section remain robust. Results are available upon request.

pionships. However, using our data set, we do observe that 18% of young players move to another club between two successive observations. Accordingly, we choose to run our counterfactual experiments by considering four alternative values for $\rho = \{0.15, 0.25, 0.5, 1\}$, that encompass 18% and consider 15% (100%) as the lowest (highest) admissible value. Our calibration strategy therefore leads to compute $\phi(\rho)$ as implied by Equation (26) to be consistent with observed equilibrium threshold talent $s = 0.58$. Table 5 then reports the parameters that are specific to the training period. In particular, we show the relationship between ϕ and ρ is consistent with our calibration strategy.

Table 5: Period-1 parameters

Prob. to be transferred following a shock	ρ	0.15	0.25	0.5	1
Cost function parameter	ϕ	15.171	15.144	15.077	14.950
Discount factor	ς	0.9615			
Prob. to be hit by a shock	$1-v$	0.8462			

5.2 Counterfactual experiments

We can now investigate how crucial the transfer fee system is, by considering how the training policy depends on $(\lambda, \tilde{\lambda})$, for different values of the player's probability to be transferred at the end of the training period (ρ).

Using estimated parameters of the model, we can determine the minimal talent required to be trained at equilibrium with/without transfer fees, and compare it to the efficient allocation. Table 6 reports the threshold values implied by our model under the different scenarios either in the presence of a transfer fee system (social planner, $a^\star$, and equilibrium, a) or in the absence of such a system (Bertrand competition, a_0, and Nash-bargaining, $\tilde{a}_0$) for distinct values of ρ. Thanks to our estimation of the probability density function of the initial talent variable, it also provides the fraction of players that are not trained (and thus do not get a professional contract), $\int^{\overline{a}} d\psi(\epsilon)$ with $\overline{a} = a^\star$, a, a_0 or $\tilde{a}_0$.

At the optimum, very few players are not trained. According to ρ, this share is at most less than 2% of talents. Then, as expected, the transfer fees system allows getting closer to the optimal allocation. In the presence of transfer fees, only 4% of the players are not trained,[28] whereas without transfer fees it reaches for instance 7% in the Bertrand competition case when $\rho = 0.5$, and even more than 30% with standard Nash-bargaining. Indeed, in this latter case, when a player is shocked and moves to another club, not only does the training club not get some transfer fees, but the player's outside option when negotiating with the poaching club is also not as high as in the Bertrand situation. Therefore, his new wage in the poaching club is smaller, which reduces the expected overall surplus related to training at period 1. As our estimation of the bargaining power of the poaching club is high ($\beta = 0.77$), this effect is strong and leads us to exclude a significant share of talents with respect to the optimum and the situation with transfer fees.

Table 6: Simulated training policies

Prob. of Transfer	Thresholds				Workers excluded from training			
ρ	$a^\star$	a	a_0	$\tilde{a}_0$	$\int^{a^\star} d\psi(\varepsilon)$	$\int^{a} d\psi(\varepsilon)$	$\int^{a_0} d\psi(\varepsilon)$	$\int^{\tilde{a}_0} d\psi(\varepsilon)$
0.15	0.549	0.58	0.59	0.609	1.6%	4.0%	4.8%	8.4%
0.25	0.531	0.58	0.592	0.628	0.9%	4.0%	5.5%	12.9%
0.50	0.498	0.58	0.602	0.677	0.3%	4.0%	7.1%	31.8%
1.00	0.456	0.58	0.62	0.779	$\approx$ 0%	4.0%	10.8%	84.9%

Reading: For $\rho = 0.5$ the minimal talent required to be trained at optimum is 0.498, compared to 0.58 at equilibrium with transfer fees. At equilibrium with transfer fees 4% of the total players' population has a talent below 0.58.

Overall, our simulations therefore suggest that, in the absence of transfer fees, the equilibrium allocation is very far from the efficient allocation and the transfer system is a useful tool to get closer to the efficient allocation. Furthermore, while it is obvious that we could reach efficiency by implementing some subsidies (Chéron and Terriau, 2018), it is worth emphasising that transfer fees do not imply any public cost.

[28] This share does not vary with ρ as our calibration strategy implies to re-calibrate consistently the parameter value of the training cost function, ϕ, to be consistent with observed minimum talents at equilibrium with transfer fees.

6 Conclusion

In this paper, we analyse the effects of transfer fees on clubs' training policy in the Big-5 European soccer leagues. We develop a two-period model that reproduces the main features of the soccer labour market: selection of talents and training, wage bargaining, and transfers.

Capitalising on a unique data set and a structural estimation, we focus on the clubs' training policy. In standard labour markets, firms' investment in general human capital is generally sub-optimal, due to the existence of a poaching externality (Acemoglu, 1997). However, in the soccer labour market, the existence of a transfer system may theoretically help to restore efficiency: when a player under contract moves to another club, the poaching club has to pay a compensation to the training club that generally increases with the player's performance. This system mitigates the negative impact of poaching and protects clubs' investments in general training. Our results highlight the allocation role played by transfer fees. We show that the selection and training of talents is significantly closer to the efficient allocation with transfer fees than without, since at least 10% the players would not have been trained in the context of a standard Nash-bargaining of wages without fees.

This paper provides interesting results for researchers and policymakers. To get closer to the efficient allocation, some countries invest massively in vocational training,[29] particularly through training subsidies. In this paper, we show that there is another way, that is, the implementation of transfer fees, that allows restoring efficiency without any public cost.

While this paper opens up new perspectives, some questions still remain. Is the transfer system implementable in the standard labour market? What would be the effects of such a policy in the presence of frictions and asymmetric information? What would be the effects on life-cycle trajectories? Further research is needed to answer these questions. This is on our agenda.

[29] For example, France and Germany spend roughly 0.25% of the GDP on vocational training (Source: OECD)

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Appendix

A Data description

In our study, we take advantage of three datasets:

i) The SoFIFA's index database, that provides an overall rating of each player at a given date.

ii) The Capology's salary database, that provides information on a player's gross annual salary.

iii) The Transfermarkt's transfer database, that reports all transfers in European soccer leagues.

The following appendix provides a full description of each dataset.

A.1 Sample

Our initial sample consists of individuals playing in one of the Big-5 European soccer leagues (Premier League, Serie A, La Liga, Bundesliga, and Ligue 1) over the period 2013-2020.

We focus on the Big-5 for two reasons:

- It allows us to collect detailed and reliable data on players' trajectories.
- It limits attrition issues, as the vast majority of players trained in the Big-5 spend their career in the Big-5.

We then restrict our sample to players aged 23 or less for two reasons:

- Our model focus on the beginning of a player's career.
- According to the FIFA regulation, a player's training lasts until the age of 23.

Our final sample contains 2379 observations (546 in Premier League, 418 in Serie A, 269 in La Liga, 609 in Bundesliga, and 537 in Ligue 1).

A.2 SoFIFA's index database

A.2.1 Description

The SoFIFA's index database is a longitudinal database that tracks players over time and provides a player's overall rating at a given date.

A.2.2 Variables

- *surname*: This variable identifies the player's surname.
- *initial*: This variable identifies the first letter of the player's name.
- *year*: This variable corresponds to the observation year.
- *league*: This variable indicates the league in which the individual plays.
- *age*: This variable indicates the player's age.
- *OVA*: This variable indicates the player's overall rating. This allows us to measure the level of performance of a player at a given date.
- *contract length*: This variable indicates the remaining number of years in the player's contract.

A.3 Capology's salary database

A.3.1 Description

The Capology's salary database is a longitudinal database that tracks players over time and provides information on a player's gross annual salary.

A.3.2 Variables

- *surname*: This variable identifies the player's surname.
- *initial*: This variable identifies the first letter of the player's name.
- *year*: This variable corresponds to the observation year.
- *league*: This variable indicates the league in which the individual plays.
- *wage*: This variable indicates the player's annual gross salary (in 2021 euros).

A.4 Transfermarkt's transfer database

A.4.1 Description

The Transfermarkt's transfer database is a longitudinal database that tracks players over time and reports all transfers in European soccer leagues.

A.4.2 Variables

- *surname*: This variable identifies the player's surname.
- *initial*: This variable identifies the first letter of the player's name.
- *year*: This variable corresponds to the observation year.
- *league*: This variable indicates the league in which the individual plays.
- *previous club*: This variable indicates the player's former club (before transfer).
- *club*: This variable indicates the player's current club (after transfer).
- *transfer fees*: This variable reports the amount of compensation paid by the current club to the former club for the transfer of the player (in 2021 euros).

A.5 Final database

A.5.1 Description

We merge the three databases described above based on the surname, initial, year, and league of the player. We use this final database to estimate the structural parameters of the model.

A.5.2 Variables

- *id*: This variable uniquely identifies the player accross clubs and time.
- *surname*: This variable identifies the player's surname.
- *initial*: This variable identifies the first letter of the player's name.
- *year*: This variable corresponds to the observation year.
- *league*: This variable indicates the league in which the individual plays.
- *age*: This variable indicates the player's age.
- *EPS*: This variable (based on *OVA*) indicates the player's ability (ε in our model).
- *W*: This variable (based on *wage*) indicates the player's wage (in 2021 euros).
- *T*: This variable (based on *transfer fees*) reports the amount of compensation paid by the current club to the former club for the transfer of the player, if any. We divide the transfer fees by the remaining number of years in the player's contract to abstract from differences in the contract length. This allows us to measure wages and transfer fees on a yearly basis (in 2021 euros).

B Player's types

We distinguish 3 types of players:

- *movers (w^m):* players who are not in the same club between two consecutive years ($club_{t-1} \neq club_t$) and do not have the same level of performance from one year to the next ($OVA_{t-1} \neq OVA_t$).
- *mismatched stayers (w^r):* players who are in the same club over two consecutive years ($club_{t-1} = club_t$) but do not have the same level of performance from one year to the next ($OVA_{t-1} \neq OVA_t$).
- *well-matched stayers (w):* players who are in the same club between two consecutive years ($club_{t-1} = club_t$) and who maintain the same productivity ($OVA_{t-1} = OVA_t$).

In our model, we consider that players can be transferred only if they are hit by a shock. We thus implicitly exclude from the analysis players that are not hit by a shock but move. Note that such transfers are extremely scarce. Over the period 2013-2020, only 63 players have been transferred without any change in their ability ($OVA_{t-1} = OVA_t$). This justifies the model's assumption that transfers only occur when players are hit by a shock.

C Wages and transfer fees by league

C.1 Big-5 (Premier League, Serie A, La Liga, Bundesliga, Ligue 1)

	(1) All players	(2) Well-matched stayers	(3) Mismatched stayers	(4) Movers	(5) Transfer fees
Mean	2028193	1841223	1931081	2642450	6298021
Q1	523914	460000	480000	878108	1675000
Q2	1215109	1110000	1118585	1915629	4000000
Q3	2638606	2760990	2423582	3595665	7475000
D1	215613	150267	200000	553695	833333
D9	4705903	4545992	4507725	5725662	13750000
Min	20000	20000	20000	103186	25000
Max	32090000	18180000	32090000	18731834	145000000

Source: Capology & Transfermarkt. See Appendix A.

Notes: 1. The sample period is 2013-2020.

2. Q_1, Q_2, and Q_3 denote the 1rst, 2nd and 3rd quartile, respectively.

3. D_1, D_9 denote the 1rst and 9th decile, respectively.

4. Wages (Columns (1)-(4)) and Transfer fees (Column (5)) are expressed in euros.

C.2 Premier League

	(1) All players	(2) Well-matched stayers	(3) Mismatched stayers	(4) Movers	(5) Transfer fees
Mean	3222654	3000279	2992250	4296403	7884635
Q1	1309751	1211520	1218115	1984438	3391667
Q2	2454264	2733995	2234901	3745383	6202500
Q3	4252881	4288885	3904755	5746888	11500000
D1	524428	523900	455666	1421970	2006667
D9	6683099	6242305	6545098	7607013	14990000
Min	51575	98231	51575	364533	500000
Max	18517751	11694565	18226633	18517751	28233334

Source: Capology & Transfermarkt. See Appendix A.

Notes: 1. The sample period is 2013-2020.

2. Q_1, Q_2, and Q_3 denote the 1rst, 2nd and 3rd quartile, respectively.

3. D_1, D_9 denote the 1rst and 9th decile, respectively.

4. Wages (Columns (1)-(4)) and Transfer fees (Column (5)) are expressed in euros.

C.3 Serie A

	(1) All players	(2) Well-matched stayers	(3) Mismatched stayers	(4) Movers	(5) Transfer fees
Mean	1989026	1520362	2066926	2158691	7538975
Q1	739980	647108	739980	900314	2000000
Q2	1371066	1110000	1300000	1912889	4090000
Q3	2589429	2040000	2341223	2780000	9500000
D1	447248	356927	446001	537813	1328000
D9	4617333	3687297	4630000	4125362	20050000
Min	36949	36949	38614	103186	733333
Max	12945149	5293005	12945149	6410000	43000000

Source: Capology & Transfermarkt. See Appendix A.

Notes: 1. The sample period is 2013-2020.

2. Q_1, Q_2, and Q_3 denote the 1rst, 2nd and 3rd quartile, respectively.

3. D_1, D_9 denote the 1rst and 9th decile, respectively.

4. Wages (Columns (1)-(4)) and Transfer fees (Column (5)) are expressed in euros.

C.4 La Liga

	(1) All players	(2) Well-matched stayers	(3) Mismatched stayers	(4) Movers	(5) Transfer fees
Mean	2401843	2351754	2319273	2806360	7280233
Q1	656347	427500	654408	843715	2762500
Q2	1290821	1350000	1200115	1646144	5000000
Q3	2981628	3585877	2547720	4631577	8500000
D1	300000	225345	276509	601038	746667
D9	6021353	6405990	6000000	6069780	19200000
Min	30000	74766	30000	160000	133333
Max	20000000	9160000	20000000	11930526	40000000

Source: Capology & Transfermarkt. See Appendix A.

Notes: 1. The sample period is 2013-2020.

2. Q_1, Q_2, and Q_3 denote the 1rst, 2nd and 3rd quartile, respectively.

3. D_1, D_9 denote the 1rst and 9th decile, respectively.

4. Wages (Columns (1)-(4)) and Transfer fees (Column (5)) are expressed in euros.

C.5 Bundesliga

	(1) All players	(2) Well-matched stayers	(3) Mismatched stayers	(4) Movers	(5) Transfer fees
Mean	1588999	1596313	1485079	2106626	3884667
Q1	500000	230000	438760	861322	1393750
Q2	1000000	894772	909451	1515121	2000000
Q3	2010772	2100000	1817941	2975696	5062500
D1	149853	68396	149755	681412	750000
D9	3976288	4020268	3200000	4020268	7500000
Min	20000	20000	25931	434854	125000
Max	13000000	10450785	13000000	8079285	26500000

Source: Capology & Transfermarkt. See Appendix A.

Notes: 1. The sample period is 2013-2020.

2. Q_1, Q_2, and Q_3 denote the 1rst, 2nd and 3rd quartile, respectively.

3. D_1, D_9 denote the 1rst and 9th decile, respectively.

4. Wages (Columns (1)-(4)) and Transfer fees (Column (5)) are expressed in euros.

C.6 Ligue 1

	(1) All players	(2) Well-matched stayers	(3) Mismatched stayers	(4) Movers	(5) Transfer fees
Mean	1155108	1135221	1095897	1485132	5185068
Q1	299222	230000	275440	469583	1000000
Q2	516077	489543	481537	775679	2500000
Q3	1169660	1150000	1082950	1584227	4400000
D1	112230	70484	101124	353018	500000
D9	2406014	2679703	2165900	3130000	6640000
Min	20000	20000	20000	120000	25000
Max	32090000	18180000	32090000	18731834	145000000

Source: Capology & Transfermarkt. See Appendix A.

Notes: 1. The sample period is 2013-2020.

2. Q_1, Q_2, and Q_3 denote the 1rst, 2nd and 3rd quartile, respectively.

3. D_1, D_9 denote the 1rst and 9th decile, respectively.

4. Wages (Columns (1)-(4)) and Transfer fees (Column (5)) are expressed in euros.

D Equilibrium distribution of wages and transfer fees

Distributions of wages depend both on players' talent and shocks. We let $a_r(W,x)$ be the highest talent value such that a player who faced a shock x but could not move is paid W or less at period 2. It solves $w^r(x,a_r) = W$, hence:

$$a_r(W,x) \equiv \left\{ \frac{W(1-\beta)/\gamma}{x^\kappa - \delta^\kappa |x-1|^\kappa} \right\}^{\frac{1}{\kappa}}$$

Accordingly, the distribution of wages among this type of players is given by

$$G_r(W) = 1 - F(\overline{x}) + F(\underline{x}) + \int_{\underline{x}}^{\overline{x}} \int_{a}^{a_r(W,x)} \psi(\varepsilon) f(x) d\varepsilon dx$$

Similarly, for movers we can also define $a_m(W,x)$ that solves $w^m(x,a_m) = W$:

$$a_m(W,x) \equiv \left\{ \frac{W(1-\beta)/\gamma}{x^\kappa - \beta\delta^\kappa |x-1|^\kappa} \right\}^{\frac{1}{\kappa}}$$

But we need also to define $a_{m0}(W) \equiv (W/\gamma)^{\frac{1}{\kappa}}$, so we get

$$G_m(W) = [1 - F(\overline{x}) + F(\underline{x})] \int_a^{a_{m0}(W)} \psi(\varepsilon) d\varepsilon + \int_{\underline{x}}^{\overline{x}} \int_a^{a_m(W,x)} \psi(\varepsilon) f(x) d\varepsilon dx$$

Lastly, for the players that do not face any shock, it is obvious that the distribution of wages is directly derived from the distribution of talents (a property that was used to computed related wage deciles in Table 4). We can simply let define $a_s(W)$ which solves $w(a_s) = W$ from Equation (8), which is therefore given by $a_s(W) = [W(1-\beta)/\gamma]^{\frac{1}{\kappa}}$, and then:

$$G_s(W) = \int_a^{a_s(W)} \psi(\varepsilon) d\varepsilon$$

Lastly, as shocks are iid, the aggregate cumulative distribution of wages, $G(W)$, can be defined as follows:

$$G(W) = vG_s(W) + (1-v)(1-\rho)G_r(W) + (1-v)\rho G_m(W)$$

In turn, we can compute the distribution of transfer fees, which is defined over the subset of mover players. Using a similar approach as for wages, we let define $a_{T0}(T) \equiv (T/\alpha)^{\frac{1}{\kappa}}$ and $a_T(T,x)$ such that $T(x, a_T) = T$,

$$a_T(T,x) = \left\{ \frac{(1-\beta)T}{(1-\beta-\gamma)[x^\kappa - \beta\delta^\kappa |x-1|^\kappa]} \right\}^{\frac{1}{\kappa}}$$

so the distribution of transfer fees, $Z(T)$ is given by:

$$Z(T) = [1 - F(\overline{x}) + F(\underline{x})] \int_a^{a_{T0}(T)} \psi(\varepsilon) d\varepsilon + \int_{\underline{x}}^{\overline{x}} \int_a^{a_T(T,x)} \psi(\varepsilon) d\varepsilon f(x) dx$$

Lastly, we shall notice that without transfer fee, the threshold f$a_m(W, x)$ shall be restated as follows at the Bertrand equilibrium:

$$a_m(W,x) = \begin{cases} \left\{ \frac{(1-\beta)W}{\gamma x^\kappa - \gamma\beta\delta^\kappa |x-1|^\kappa} \right\}^{\frac{1}{\kappa}} & \text{in the presence of transfer fees} \\ \left\{ \frac{(1-\alpha)W}{(1-\alpha)x^\kappa - \beta\delta^\kappa |x-1|^\kappa} \right\}^{\frac{1}{\kappa}} & \text{in the absence of transfer fees (Bertrand)} \end{cases}$$

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