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ABSTRACT

On-the-Job Learning and Earnings: Comparative Evidence from Morocco and Senegal*

In this paper, we consider a model of on-the-job learning where workers learn informally by watching and imitating colleagues. We estimate the rate of knowledge diffusion inside the firm using two matched worker-firm data sets from Morocco and Senegal. We rely on non-linear least squares to estimate the structural parameters of the informal learning model and account for firm heterogeneity using firm factors derived from a principal component analysis. We find that the rate of knowledge diffusion is around 7 percent in Morocco and Senegal, but part of the learning-by-watching returns stems from firm heterogeneity. Informal training significantly affects the shape of returns to tenure in these two countries. Finally, we estimate an extended model with both learning-by-watching and learning-by-doing and find significant benefits from imitating colleagues in Morocco.

JEL Classification: J24, J31, O12

Keywords: earnings functions, informal training, learning-by-watching, learning-by-doing, returns to tenure, Morocco, Senegal

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1. Introduction

Within the academic literature in sociology, there has been a growing interest in workplaces as learning environments and the importance of on-the-job learning in skill formation processes (Garrick, 1998, Boud and Garrick, 1999). In particular, many workplace learning processes are variously described as 'informal' or 'nonformal' (Billett, 2001, Colley et alii, 2003, Hayward and James, 2004). The perceived importance of informal processes in workplace learning is captured by Coffield's image of the learning iceberg (2000, p. 1): "If all learning were to be represented by an iceberg, then the section above the surface of the water would be sufficient to cover formal learning, but the submerged two thirds of the structure would be needed to convey the much greater importance of informal learning".

It is important to appreciate that interest in workplace learning, through both formal and informal processes, is still a relatively recent phenomenon and that evidence about effective practices is still relatively scarce (Battu et alii, 2003). Research on workplace learning in economics is still in late infancy at best, albeit Mincer (1989) was claiming years ago that informal training may constitute the essential part of training provided by firms. If workplace learning, and in particular informal training, is as important in developing vocational knowledge and skills as research is beginning to suggest, then it is also important to understand the ways in which (and of course the extent to which) skill formation resulting from situated learning affects workers' productivity and wages.

While the benefits of investments in human capital are clearly established in the economic profession, the accurate calculation of rates of return to informal training remains complex. One reason is that the usual on-the-job training variables are often affected by measurement errors. Some authors have shown that these errors are likely to bias the estimates of the rates of return to training (Barron et alii, 1997, Loewenstein and Spletzer, 1999, Frazis and Loewenstein, 2005). Moreover, for reasons that are inherent in the very nature of informal training, the few direct measures of informal training available today in data sets are even more imperfect (see the discussion in Barron et alii, 1997, Loewenstein and Spletzer, 1999). Finally, informal training appears inextricably part of the employee's productive activity (Brown, 1990). The modeling of a process of informal learning susceptible to be submitted to an empirical test requires the availability of micro data containing information both on workers and on their firm.

In this contribution, we rely on two matched worker-firm data sets for Morocco and Senegal to study informal training in Africa. With a method similar to that of Mincer (1974),

our approach consists in estimating the returns to informal training using the individual earnings profiles. For that purpose, a structural model of on-the-job learning is developed to conform to the structure of our data[1]. The model accounts for on-the-job learning. Workers learn informally on the job by watching others performing their tasks[2]. They may also learn by themselves, i.e. by a sort of learning-by-doing process. Structural parameters of the model are estimated using non-linear least squares.

We extend the previous results on the learning model in the following way. First, we structurally take into account a flexible form of the returns to schooling. Indeed, the previous estimated model did not consider the possibility of convex returns to education (Destré et alii, 2008). Yet, constant rates of return to education are more and more challenged in developed and developing countries (Card, 1999), especially in Africa[3]. Second, we introduce controls for the firm's heterogeneity component using a factor analysis of the firms' characteristics and show the impact of these firm factors on the structural parameters of the model. Finally, our estimates are innovative in the context of developing countries.

The issue of informal training is especially important among African countries. Mechanisms for closing the skill gap across categories of workers in Africa have long been articulated in terms of supply-side reforms. There is a recent recognition among policy makers that the demand side of the skills equation also needs attention. More effort needs to be directed towards the development of the skills of the existing workforce, in addition to improving the educational outcomes of learners in schools, colleges and higher education. This is all the more important given that public vocational education and training systems have generally failed in providing young workers, which are massively found in the informal sector, with the necessary human capital to access stable and decent jobs in the formal sector. Johanson and Adams (2004) show that in Sub-Saharan Africa training by traditional learning (mostly informal) is the most frequent form of training in the informal sector. Traditional learning probably makes a far greater contribution to develop the workers' skills than all the training providers taken together. It is then interesting to gauge the informal training potential of the formal private sector in these economies as well.

Our empirical results suggest that informal learning may be of importance in African firms. We find that the rate of knowledge diffusion is around 7% in the Moroccan and

[1] The first presentation of the model appears in the original work of Lévy-Garboua (1994). It has been extended and successively estimated by Chennouf et alii (1997), Nordman (2000), Destré and Nordman (2002), Destré (2003) and Destré et alii (2008).
[2] Employees who are getting informal training may not always be conscious that they are doing so.
[3] See Bigsten et alii (2000), Schultz (2004), Söderbom et alii (2006) and Kuepie et alii (2009).

Senegalese firms of our samples. However, part of the learning-by-watching returns stems from firm heterogeneity. The remainder of this paper proceeds as follows. In section 2, we present the on-the-job learning model. Section 3 describes the two matched worker-firm surveys together with the information collected from workers and firms respectively for Morocco and Senegal. In Section 4, we present the econometric strategy to recover the structural parameters of the model. Our results are discussed in Section 5. Section 6 concludes.

2. A model of learning-by-watching

Workers may improve their skills by learning informally, simply while being in their firm and watching other workers performing their tasks. Unlike formal training, this knowledge acquisition process seems not really costly as a firm does not have to provide specific resources for it. More productive workers may not necessarily devote time to explain other workers how to improve their own productivity. All the training effort remains informal, in the sense that less productive workers are simply expected to watch those who have more knowledge and experience, and then to replicate what they have observed. This imitation process acts as a positive externality whose benefits extend over time[4].

In what follows, we draw on the model of learning-by-watching first described in Lévy-Garboua (1994) and extended in Destré et alii (2008). Consider a competitive industry where wage rates are equal to the true marginal product of labour, so that earnings reflect pure human capital. Using a discrete-time framework, we denote by h_t the amount of human capital for a worker at date t. Assume that the worker enters the firm at date 0, so that t corresponds to tenure. Then, h_0 is the value of the worker's human capital when starting his activity in the firm. Each individual has presumably accumulated some experience while working in previous firms. Let x be the number of working years spent outside the current firm, so that individual total experience is $x+t$.

In the firm, each worker is supposed to learn from colleagues who have more human capital than him/her. Let H_t be the highest level of human capital embodied in colleagues. We assume that the firm's knowledge is invariant, meaning that $H_t = H$. Owing to the imitation process, a worker's human capital is expected to increase over time by learning

[4] Workers receiving at a given time some informal training from others will be later in a supply position, showing in turn informally to new incumbents how they can enhance their own productivity.

from others. The following equation describes the dynamics of human capital formation for a worker (see Lévy-Garboua, 1994):

$$h_t - h_{t-1} = \frac{n}{1+n}\left(H - h_{t-1}\right) \tag{1}$$

where n is the rate of knowledge diffusion inside the firm. The rate of learning-by-watching is the same for each worker and is time-invariant. For a given n, human capital will increase faster when the worker has a lot to learn from the most qualified worker. Hence, at the period t, the level of human capital is a weighted sum of human capital in $t-1$ and of human capital of the most capable worker:

$$h_t = \frac{n}{1+n}H + \frac{1}{1+n}h_{t-1} \tag{2}$$

From the recurrence equation (2), we get the following solution for h_t:

$$h_t = \left[1 - \frac{1}{(1+n)^t}\right]H + \frac{1}{(1+n)^t}h_0 \tag{3}$$

which we can also be expressed as:

$$h_t = h_0\left[1 + \left(1 - \frac{1}{(1+n)^t}\right)\left(\frac{H}{h_0} - 1\right)\right] \tag{4}$$

The human capital of a worker depends on the number of periods spent within the firm ($\partial h_t / \partial t > 0$). Also, as time goes by, the individual level of human capital converges towards the firm's job-specific knowledge ($\lim_{t\to\infty} h_t = H$). In this model, the central interest lies in the estimation of the parameter n.

From (2), all the job-specific information is learnt from colleagues and the highest level of human capital remains constant. A more realistic framework, considered in Destré et alii (2008) and estimated in Destré and Nordman (2002), is to assume that workers learn both by themselves through their own experience and by watching others[5]. In such setting, the human capital of a worker is both increasing with tenure and it converges towards the firm's job-specific knowledge. However, the latter component is no longer fixed within the firm. Since all workers are expected to learn by themselves, the level of human capital of the most qualified worker is continuously growing.

Let g be a measure of the impact of self-learning. The dynamics of human capital formation may be expressed as:

[5] By repeating tasks within the firm, a worker is expected to improve his/her own productivity and hence human capital.

$$h_t - h_{t-1} = g\, h_{t-1} + \frac{n}{1+n}\left(H_{t-1} - h_{t-1}\right) \quad (5)$$

By definition, there is no learning-by-watching for the most capable worker, meaning that the highest level of human capital will increase inside the firm only owing to self-learning. This implies that $H_t = (1+g)H_{t-1}$. Using (5) and after some calculations, we finally deduce the following value for h_t (Destré et alii, 2008):

$$h_t = (1+g)^t \left\{ \left(\frac{1+g(1+n)}{(1+g)(1+n)} \right)^t h_0 + \left[1 - \left(\frac{1+g(1+n)}{(1+g)(1+n)} \right)^t \right] H_0 \right\} \quad (6)$$

When $g = 0$, equation (6) is equivalent to (3), which is the pure learning-by-watching case. Two comments are in order. First, it is unclear whether the firm's job specific knowledge H_t may really be seen as a moving target, increasing at steady state. Imagine a manufacturing firm, with a young worker and a very experienced, older worker. In a context where the technology remains fixed, the latter has certainly nothing more to learn even by him/herself[6]. As a consequence, we estimate first the learning-by-watching model in our empirical analysis and then examine the consequences of self-learning. Second, as shown by (4) and (6), the expression of h_t is a non-linear function of both g and n. A non-linear estimation is hence needed to estimate the structural parameters of informal training.

3. Data and descriptive statistics

3.1. The matched worker-firm data

We estimate the previous theoretical model in a comparative context with matched employer-employee data collected in Morocco and Senegal. The data for Morocco come from the Firm Analysis and Competitiveness Survey (FACS) conducted in 2000 by the World Bank and the Moroccan Ministry of Trade and Industry. The data for Senegal stem from the Investment Climate Assessment (ICA) survey conducted by the World Bank in 2003-2004 in the framework of the Africa Regional Program on Enterprise Development (RPED).

These two surveys are based on the notion that the workplace is the microdata unit where labour supply and demand are resolved. In that spirit, the ICA and FACS surveys collected data both on the firm characteristics and on a sample of employees in each workplace. The survey instrument was then a written questionnaire addressed to both

[6] In fact, the worker may even become less productive as time goes by, and could thus be concerned by a decrease in earnings. We rule out this possibility by assuming that there exists some downward wage rigidity.

employers and employees. The questionnaires are specifically tailored for each country, but they enable cross-country comparisons as they are made of very similar questions.

In Senegal, the firms have been randomly selected among the population of formal establishments and belong to the following ten sectors of production: agro-industry, chemicals and paints, construction materials, food, furniture, metal, paper and publishing, plastics, textile and leather and wood industry. There is no constraint on the size of the firms which were selected in the sample. Conversely, in Morocco, the focus is restricted to formal companies which have at least ten employees. The selected firms are in seven industries: electronics, textiles, garments, food, pharmaceuticals, leather and shoes products, and plastics. Clearly, there is less heterogeneity in the firm sample of Morocco.

Let us describe more precisely the two samples[7]. In Senegal, a sample of 262 manufacturing firms has been surveyed based on a sampling plan made of 1645 formal companies. These firms have been randomly selected using a stratification based on sector, size and localisation and represented 59.6% of the formal manufacturing firms in 2003 and 68.9% of its formal permanent jobs. For Morocco, the Moroccan Census of Manufactures was used as the establishment sampling frame, with 1933 formal firms of more than ten employees in the seven sectors mentioned above. The sample includes data from 859 manufacturing plants which are representative of the sampling plan in terms of employment, production and exportation.

In each surveyed country, up to ten employees were randomly sampled in each firm following the idea advocated by Mairesse and Greenan (1999). All the employees of small firms have been interviewed, while the sampling rate decreases with the size of the firms. The number of workers interviewed in Senegal and Morocco are respectively equal to 1645 and 8561.

3.2. Descriptive statistics of the workers

To estimate the structural parameters of the on-the-job learning model, we need several observations of workers in each firm. Recall that we assume that the more capable worker in a given firm takes up the teaching role. We make the following selections to the initial samples (similar for each country).

First, we restrict the samples to firms having information on at least four workers. Second, as our modelling framework is in discrete time, we decide to exclude all the workers

[7] Further details of the surveys and their methodology can be found in World Bank (2005) for Senegal and in World Bank (2002) for Morocco.

having less than one year of tenure in the current firm. In so doing, it may be that we underestimate the rate of knowledge diffusion within the firm, if we assume that the learning-by-watching process is very efficient once entering the firm (and there is less to learn from colleagues a couple of months later). However, we also argue that the level of earnings is unlikely to increase just after being hired and before reaching one year of tenure, even if there is a rise in the worker's productivity due to learning from others. Finally, we drop from the sample all the observations with missing values or outliers.

The final samples are described in Table 1. This leaves us with samples comprising 7622 workers and 822 firms in Morocco, and 1284 workers and 180 firms in Senegal. Owing to the large size of its sample, the FACS Moroccan data are expected to be much more informative. More than 75% of workers are employed in firms with 10 completed individual questionnaires. The same proportion is equal to 31.9% in Senegal. Meanwhile, the proportion of workers belonging to firms with information on less than 7 respondents is much higher in Senegal than in Morocco (respectively 30.3% vs. 4.6%)[8].

Insert Table 1 here

The questionnaires of the two surveys allow us to construct identical human capital indicators for the workers in Morocco and Senegal. We compute for each respondent the number of years of completed schooling, the number of years of experience off the current firm and the number of years of tenure in the incumbent firm. All these variables provide good controls for the potential advantage on the labour markets. We further construct a dummy variable which is equal to one when the worker has received formal on-the-job training in the past. Owing to data constraints, this training is off the current job in the case of Morocco and in the current firm for Senegal. Finally, we add two demographic variables, i.e. a dummy for gender and a dummy for whether the individual is married or not[9].

In Table 2, we present some descriptive statistics related to the different covariates introduced into the earnings equations. On average, Moroccan workers are less educated than Senegalese employees (8.7 years of education against 10.3 years). This is surprising because Sub-Saharan African countries are often believed to be less endowed in human capital as compared to North African ones. An explanation is that an overwhelming proportion of poorly educated individuals actually work in the informal sector of Senegal (see DIAL, 2007).

[8] The distribution of firms by number of employees is characterized by a U-shaped profile in Senegal.

[9] This variable is approximated in the case of Morocco where the marital status was not collected from the workers. Instead, we use the fact of having declared children. In Morocco like in many African countries, it is reasonable to assume that all individuals who have declared children are (or have been) married because of the social norms in force.

The formal private sector in Senegal, highly selective, might be in fact reserved to the most educated workers. This is probably less true for Morocco where uneducated workers are also found in significant proportion in garment firms for instance.

Insert Table 2 here

Also, we find a much higher proportion of women in Morocco compared to Senegal (40% against 16%). At the same time, the specific gender composition of the Moroccan subsample is not so influential when explaining the lower education observed in that country. Indeed, while the mean number of years of schooling is equal to 8.8 among men, it is only slightly lower among women, equal to 8.5 years.

In terms of work experience, the workers of the two samples have the same amount of potential experience off the current firm, which stands at 12.7 years. Tenure in the current firm is on average higher for the Senegalese workers (8.9 versus 7.4 years). Finally, we note that 35% of the Senegalese workers received formal job training in the incumbent firm.

As returns to on-the-job learning are expected to depend on both workers' and firms' characteristics, we now investigate the differences in the composition of the firms.

3.3. Firm heterogeneity

For the sake of comparability, it matters to know whether there are any differences in the characteristics of the firms. In Table 3, we summarize the descriptive statistics of the final samples of selected firms for each country.

Insert Table 3 here

For Morocco, 40.9% of the 822 firms are small and medium-sized plants with less than 50 permanent employees. Firms with more than 150 permanent employees represent 23% of the firm sample. Most of these firms are found in the textile and garment sectors (60.3%). More than half of these firms are exporting companies, therefore submitted to strong market competition, especially in the garment sector. However, less than 5% of the sample of firms can be described as 'multinationals', i.e. with more than 75% foreign capital. Note that 62% of the firms have positive profits (hereafter 'profitable' firms).

The Senegalese sample represents well the actual distribution of jobs and firms in the manufacturing sector of Senegal (World Bank, 2005). The firm size is quite similar to that of the Moroccan sample, with 52% of the 180 plants being small and medium-sized companies. Large-sized firms are also found in relatively fair proportion (21%). Firms in agro-industry are predominant (34%), the second most important sector being the industry of paper, closely followed by the textile and leather firms (10%). There are slightly more foreign owned

companies in the Senegalese sample (15%), while profitable firms are also well represented (84%).

4. Econometric specification

We turn to a structural econometric analysis to recover the values of the different parameters of interest. We first consider equation (4) and then show how to add the impact of self-learning into the estimation strategy. By taking the logarithm of h_t, we get:

$$\ln h_t = \ln h_0 + \ln\left[1 + \left(1 - \frac{1}{(1+n)^t}\right)\left(\frac{H}{h_0} - 1\right)\right] \tag{7}$$

In a setting with only learning-by-watching, we get a human capital earnings function which depends on the human capital of both the worker's initial stock and the most qualified worker. It is also non-linear in both the rate of knowledge diffusion and tenure, so that the appropriate econometric approach is to rely on non-linear least squares (NLSQ).

Suppose that the initial earning (when entering the firm) is not observed. We can then approximate the level h_0 using a Mincerian earnings function. We introduce into the earnings function both years of education and years of experience outside the firm in a quadratic way. Several studies have indeed shown that returns to education are convex in African countries[10]. We denote by s, e and t respectively years of education, years of experience off the firm and tenure. We express h_0 as:

$$h_0 = \exp\left(\alpha_0 + \alpha_1 s + \alpha_2 s^2 + \alpha_3 e + \alpha_4 e^2\right) \tag{8}$$

since $t = 0$ by definition when entering the firm. Assume now that we can perfectly observe the most qualified worker to whom each individual is exposed. Following the same approach, we can rely on a Mincerian earnings function to approximate the level H. With S, E and T respectively being years of education, years of experience outside the firm and tenure for the most qualified worker and using quadratic profiles for these three covariates, it follows:

$$H = \exp\left(\alpha_0 + \alpha_1 S + \alpha_2 S^2 + \alpha_3 E + \alpha_4 E^2 + \alpha_5 T + \alpha_6 T^2\right) \tag{9}$$

[10] The assumption of convex returns to human capital seems important. Taking into account a linear form for the returns to education when the 'true' profile is convex is likely to lead to an overestimated value of the rate of knowledge diffusion, since workers will benefit less from the rewards of their own personal characteristics when estimating the model.

A difficulty with the data is that we have no information on the most productive worker who may be imitated by each individual. Such observation would require a description of "student-teacher" interactions within the establishments.

To overcome this shortcoming, we follow the method of Destré and Nordman (2002) and Destré et alii (2008). There are then two important assumptions. First, as we have matched employer-employee data and observe a random sample of employees from the same firm, we consider the whole set of employees for each firm and suppose that the most qualified worker within the firm is the one with the highest characteristics recorded in the survey[11]. Second, as we are not sure that an individual is really subject to the influence of the most qualified worker (as measured with the data), we account for a distance indicator between the maximum position and the individual situation.

Formally, this means that for an exogenous covariate denoted by $\overline{X}$ for the most productive worker and by x for the selected individual, we suppose that the characteristic of the teacher is such that:

$$X = \delta_x \overline{X} + (1-\delta_x)x \tag{10}$$

with δ_x a parameter to be estimated ($0 \leq \delta_x \leq 1$). It measures the relative distance between the individual and the most capable worker within the firm. δ_x takes the value 0 if the individual has no possibility of learning from others and the value 1 if his/her most qualified teacher corresponds effectively to the worker having the biggest $\overline{X}$ of the firm's sub-sample[12]. This implies that there are three parameters of relative distance to estimate, i.e. δ_s, δ_e and δ_t. After some calculations, we finally deduce the following non-linear form for the earnings equation under learning-by-watching:

[11] In that sense, this means that we tend to underestimate the rate of learning-by-watching. Indeed, there may be even more productive workers within the firms, who have not been interviewed during the survey process.

[12] Implicitly, the distance method makes the assumption that any firm includes several knowledge pyramids and that workers can only acquire the knowledge of their work group. Alternatively, Chennouf et alii (1997) made use of firm average human capital variables corrected by a variation index of either education or tenure inside the firm. Nordman (2000) and Destré and Nordman (2002), who applied both methods on the same dataset, show that the alternative techniques provide a negligible difference in the estimation of the parameters of interest. However, the distance indicator seems to be more accurate because the relative knowledge between the 'teacher' and the new entrant is then not diluted among mean variables. Ideally, of course, one would like to consider externalities within each occupation, which seems far beyond the possibilities of most available matched employer-employee data on Africa.

$$\ln h_t = \ln\left[1+\left(1-\frac{1}{(1+n)^t}\right)\exp\begin{pmatrix}\alpha_1\delta_s(\bar{S}-s)+\alpha_2\delta_s^2(\bar{S}-s)^2+2\alpha_2\delta_s(\bar{S}-s)s+\\ \alpha_3\delta_e(\bar{E}-e)+\alpha_4\delta_e^2(\bar{E}-e)^2+2\alpha_4\delta_e(\bar{E}-e)e+\\ \alpha_5\delta_t\bar{T}+\alpha_6\delta_t^2\bar{T}^2\end{pmatrix}\right] \quad (11)$$
$$+\alpha_0+\alpha_1 s+\alpha_2 s^2+\alpha_3 e+\alpha_4 e^2+\beta Z+\varepsilon$$

where Z is a set of control variables, β is the corresponding vector of estimates, and ε is a random perturbation. We estimate equation (11) using non-linear least squares (NLSQ) to get the coefficients of both the parameters and the explanatory variables. Let us briefly discuss identification issues. Clearly, the parameters α_0, α_1, α_2, α_3, α_4, δ_s and δ_e are identified according to the data. However, since we have only two estimates for $\alpha_5\delta_t$ and $\alpha_6\delta_t^2$, this implies that we cannot recover the individual values of the three coefficients α_5, α_6 and δ_t.

A very similar strategy is used to estimate the model with both self-learning and learning-by-watching. There is now an additional parameter to estimate (g). From (6), we can express $\ln h_t$ as a function of $\ln h_0$, $\ln(1+g)^t$ and a third term, more complex, which depends on the ratio H_0/h_0, n and g. The term H_0 is defined as in (9). Then, using (8) and (10), we obtain a non-linear form very similar to (11), except that the log earnings equation is now a function of an additional term $\ln(1+g)^t$ and that both n and g affect the exponential expression corresponding to H_0/h_0. If g is small, the extended model of on-the-job learning can be expressed as:

$$\ln h_t = gt+\ln\left[1+\left(1-\left(\frac{1+g(1+n)}{(1+g)(1+n)}\right)^t\right)\exp\begin{pmatrix}\alpha_1\delta_s(\bar{S}-s)+\alpha_2\delta_s^2(\bar{S}-s)^2+2\alpha_2\delta_s(\bar{S}-s)s+\\ \alpha_3\delta_e(\bar{E}-e)+\alpha_4\delta_e^2(\bar{E}-e)^2+2\alpha_4\delta_e(\bar{E}-e)e+\\ \alpha_5\delta_t\bar{T}+\alpha_6\delta_t^2\bar{T}^2\end{pmatrix}\right] \quad (12)$$
$$+\alpha_0+\alpha_1 s+\alpha_2 s^2+\alpha_3 e+\alpha_4 e^2+\beta Z+\varepsilon$$

If *n* equals zero, meaning that there is no possibility of learning by watching others inside the firm, (12) reduces to a simple linear-in-tenure Mincerian earnings function with the parameter *g* reflecting a 'gross' effect of tenure on wages (including informal learning effects on wages but admittedly also other aspects of this relationship). One may then interpret specification (12) as a generalisation of the Mincerian model, including a sum of a linear-in-tenure earnings function and a correction factor considering what firms have to offer to their employees in terms of learning[13].

[13] The Mincerian model actually offers an accurate description of gross earnings for new entrants, *i.e.* for *t*=0, and in two other specific circumstances: i) if firms offer no extra knowledge to their employees; and ii) if the rate

Owing to the importance of the work environment in which workers are placed, which is more or less favourable to learning-by-watching other colleagues, it seems important to control for firm heterogeneity. However, accounting for firm heterogeneity is complex when estimating (11) since the extended earnings equations are intrinsically highly non linear. Thus, we cannot control for firm heterogeneity using firm fixed effects. In this paper, we rely on a factor analysis following Muller and Nordman (2004) and Jellal et alii (2008). We summarize the main statistical information on the firms' characteristics using first a multivariate analysis and then introduce the computed principal components (factors) into the earnings functions deriving from this analysis.

Using factors may be seen as a further step with respect to studies that have added mean firm variables into earnings functions, individual characteristics being controlled for. With respect to firm fixed effects, the factors are expected to pick up the impact of more qualitative characteristics of the firms. Specifically, we use a principal component analysis (PCA) to summarize the information about the surveyed enterprises. This method is based on the calculation of the inertia axes for a cloud of points that represents the data in table format. As long as the computed factors account for most of the firm heterogeneity, this approach allows us to obtain consistent estimates close to those of the fixed effect estimator.

In the case of Morocco, the first ten inertia axes, defined as the estimated factors which are linear components of all the firm's characteristics, concentrate a large proportion of the total variance of the original variables (63%). This reflects therefore a fair amount of the relevant information about the firm's characteristics. For Senegal, firm heterogeneity seems to be greater according to very basic descriptive statistics. We thus choose to rely on twelve factors which concentrate 55% of the total variance of the firm variables. In both cases, the selected factors reflect a wide range of firm characteristics that can mainly be summarised by the sector affiliation, size, performances, and workforce composition[14].

of knowledge diffusion within firms approaches zero. Both assumptions are clearly unrealistic, but the Mincerian earnings function stands as a first-order approximation insofar as each firm can only make a small contribution to an individual's stock of human capital.

[14] To save space, the detailed results of the two factor analyses (including the complete list, definitions and descriptive statistics of the firms' characteristics) are not shown but available from the authors upon request.

5. Econometric results

5.1. Basic earnings regressions

We begin by estimating earnings equations with a set of individual demographic and labour characteristics as control variables. We wonder then whether controlling for firm heterogeneity has an impact or not on our findings. Under the assumption that both $n = 0$ and $g = 0$, we estimate the earnings functions using simple OLS regressions. The dependent variable is defined as the log of the hourly earnings, which is computed as the ratio of monthly earnings (including additional salaries and premiums) divided by the number of worked hours per month. The corresponding results are in Table 3.

Insert Table 3 here

In panel A, we describe the estimates obtained without control for firm heterogeneity. Models (1A) and (2A), respectively for Morocco and Senegal, include as regressors education and off-the-firm work experience along with their squared values, and three dummy variables for being female, married and the receipt of formal job training[15]. For both countries, the results exhibit a convex profile in years of education. This finding contradicts much of the comparative studies on the rates of return to education across countries which often use a linear in education specification of the earnings function (see Trostel et alii, 2002). However, constant or decreasing rates are more and more challenged in both developed and developing countries and non-linearities (mostly convexity) in the returns to education have been recently put forward by some studies on Africa (Bigsten et alii, 2000, Schultz, 2004, Söderbom et alii, 2006, Kuepie et alii, 2009).

Concerning the other covariates, we find that the gender dummy is only significant in Morocco. In that country, Nordman and Wolff (2009) have evidenced the presence of a glass ceiling effect using quantile regressions. The fact that there is no gender difference in Senegal is somewhat surprising, but this result may be due to the low number of female workers in the sample. Being married has a positive effect in the two countries, and the receipt of formal training (treated as exogenous) only really matters in Morocco. Finally, we note that the values of the R^2 in the regressions are reasonably high (around 0.4), but there are less significant explanatory variables in Senegal.

In columns (1B) and (2B), we add in the list of covariates the years of tenure in the firm and rely on a cubic form. Several comments are in order. First, this additional covariate

[15] The different regressions in Table 3 also include dummy variables related to occupations (not reported).

does not really affect the previous estimates, except the marital status whose effect is now much lower. Second, the squared and cubic tenure terms are only significant in Morocco, while they turn to be insignificant in Senegal. Third, we evidence a U-shaped profile for the returns to years of tenure in the current firm without control for firm heterogeneity in Morocco, while the shape is continuously decreasing in Senegal. This result is of interest as it stands in contrast with the standard Mincerian earnings function, which relies on a quadratic profile for years in tenure (the marginal returns to tenure are thus linearly decreasing).

Fourth, we find lower returns to years of tenure in Morocco than in Senegal. The returns to tenure remain rather flat in the former country, equal to 2% after either 5, 10 or 20 years of tenure. These returns amount to 4%, 3% and 2% in Senegal respectively after 5, 10 and 20 years of tenure[16]. Fifth, we find that it matters to control for the firm heterogeneity. In the two countries, we evidence that the returns to tenure are lower when being calculated with either firm fixed effects or firm factors models. Both in Morocco and in Senegal, the shape of the returns curve is not really affected by the use of either fixed effects or firm factors. In what follows, we rely on the firm factor strategy when turning to the structural estimation.

5.2. Estimation of the learning-by-watching model

We now turn to the estimation of the structural model of learning-by-watching. For each country, the model is estimated twice using NLSQ, once with individual covariates only and once with inclusion of firm factors in order to pick up the impact of firm unobserved heterogeneity. The corresponding estimates are in Table 4.

A first remark is that introducing the possibility of learning-by-watching colleagues does not really affect the coefficients obtained through Mincerian equations for education, experience off the firm, gender or marital status. For instance, being a woman reduces the hourly earnings in Morocco by 7.8% with the Mincerian specification (without firm controls), and by 7.3% with the possibility of informal on-the-job training. We still find a convex profile for years of schooling in both countries, at least when firm heterogeneity is controlled for[17]. Conversely, years of experience off the firm always exhibit a concave profile.

[16] It is interesting to compare our results with those found in Anglophone African countries with similar data sets. For instance, Bigsten et alii (2000) obtain lower rates of return to tenure, though it is difficult to compare their estimates with ours with accuracy as their specifications differ somewhat from ours in that they use a quadratic term in tenure only. From their sample statistics and estimates, however, we can evaluate their rates at 1.8% for Ghana at the sample mean (after 4 years of tenure), 0.2% for Kenya (after 7 years), 3.4% for Zambia (after 6 years) and 0.9% for Zimbabwe (after 9 years).

[17] Without firm factors, the squared term for education is not significant in Senegal.

Let us focus on the values of the structural parameters of the model. When firm heterogeneity is not controlled for, we find a significant value for n in Morocco and Senegal (at the 1% level). This suggests that the learning-by-watching mechanism described in the theoretical section is probably operative in the selected countries. These results are in accordance with the previous findings reported in Chennouf et alii (1997) for Algeria and Canada, Nordman (2000) for Morocco and Mauritius, Destré and Nordman (2002) for Morocco, Tunisia and France and Destré (2003) for France. The rates of knowledge diffusion within firm amount to 6.3% and 7.6% respectively in Morocco and Senegal. Our rate of knowledge diffusion for Morocco is lower than the estimated values found in Nordman (2000) and Destré and Nordman (2002), around 15%[18].

In Figure 1, we show how the diffusion of the firm specific knowledge is sensitive to the parameter n. Specifically, we calculate the number of years of tenure which is requested to assimilate a given proportion of the knowledge of the firm. Denoting by ϑ the share of the firm knowledge, the number of years t to assimilate ϑ is $t = -\ln(1-\vartheta)/\ln(1+n)$. Hence, a worker will get faster a given proportion of the firm knowledge when n is important. For the sake of illustration, suppose that we seek the number of years in tenure to assimilate half of the firm knowledge. We find that t is equal to 11.3 years in Morocco and 9.5 years in Senegal. The requested years in tenure are respectively 26.3 and 18.9 when $\vartheta = 0.8$.

It is of interest to have a look at δ_s and δ_e. These parameters measure the relative distance which separates the average worker from the most qualified teacher inside the firm, respectively in terms of years of education and in terms of experience off the firm. We find that the educational distance is much lower in Morocco than in Senegal (respectively 0.069 and 0.430). This explains in part the slightly lower value found for n in Morocco. As the average worker is rather close to his/her most qualified teacher, the potential of learning-by-watching is less important. At the same time, the relative distance in terms of experience off the firm is not significant in Morocco, while it is in Senegal.

So far, we have neglected the influential role of firm characteristics so that we may overestimate the rate of job-specific knowledge diffusion. This would be the case if there are some differences in wage policies among firms related to sectors of activity or to the size of the firm for instance. In models (1B) and (2B) of Table 4, we add in the country-specific

[18] The sample used for Morocco in Nordman (2000) and Destré and Nordman (2002) is a non-representative sample of workers in only two manufacturing sectors. Interestingly, results reported in Destré (2003) for a representative sample of French workers in the private sector, with *n* standing at about 5%, are closer to our estimates for Morocco and Senegal.

regressions a set of firm factors obtained by the PCAs. The main conclusion is that controlling for firm characteristics does significantly reduce the value of the rate of knowledge diffusion. The magnitude of this coefficient is now twice lower both in Morocco and Senegal. It amounts to 3.6% for the former country and to 3.5% for the latter, but the parameter is only significant in Morocco (at the 10 percent level).

Insert Table 4 here

Finally, we calculate the marginal returns to tenure in the learning-by-watching model. Of course, if workers have the opportunity to learn a lot from colleagues, they are expected to improve quickly their earnings and then the returns to tenure should exhibit a more convex profile. Doing as if the time variable t is continuous, we first express equation (11) as $\ln h_t = \ln\left[1+\left(1-(1+n)^{-t}\right)A\right]+B$, A being the exponential term in (11) and B a constant (these two terms are independent of t). The derivative $\partial \ln h_t / \partial t$ is:

$$\frac{\partial \ln h_t}{\partial t} = \frac{A\ln(1+n)(1+n)^{-t}}{1+\left(1-(1+n)^{-t}A\right)} \tag{13}$$

which is clearly not linear in t as with Mincerian earnings functions. We describe in Figure 2 the profiles of returns to tenure. For each country, we compare the results from earnings regression with a cubic profile in tenure to those of learning-by-watching models, both without and with firm factors.

Insert Figure 2 here

Both in Morocco and Senegal, we find that the benefits from learning-by-watching others are essentially reaped by workers during the first ten years of their career. The returns to tenure with the learning-by-watching model are strongly decreasing till about the 15th years of tenure. Owing to the opportunities of imitating others, the returns are more important just after being hired with this model compared with the Mincerian specification. In Morocco, the returns curves of the Mincerian and learning-by-watching model cross at around 20 years in tenure[19]. Finally, in Senegal, the returns to tenure are more convex with the Mincerian specification, so that there are fewer differences with the learning-by-watching model. The possibility of imitating other colleagues conveys again an economic benefit in the first years of the career (at least with no firm factors).

[19] We also note that in Morocco the returns to tenure are slightly lower with the learning-by-watching model with firm factors. As the rate of knowledge diffusion is lower in that case, there are fewer opportunities for workers to learn quickly from others (and then less economic benefits).

5.3. Learning from others or learning by oneself?

In the previous estimations, we have done as if workers were unable to acquire any job knowledge by themselves. We now relax this constraint and estimate the extended model of on-the-job learning given by (12), with both learning from both others and oneself. The model is again estimated using non-linear least squares, respectively without and with firm factors.

For the sake of comparison, we begin by considering a simple model of human capital formation with no possibility of learning-by-watching ($n = 0$). The dynamics of human capital is $h_{t+1} = (1+g)h_t$, so that $h_t = (1+g)^t h_0$. Taking the logarithm of this expression and assuming that $h_0 = \exp(\alpha_0 + \alpha_1 s + \alpha_2 s^2 + \alpha_3 e + \alpha_4 e^2)$ as in (8), we estimate the following regression[20]:

$$\ln h_t = t\ln(1+g) + \alpha_0 + \alpha_1 s + \alpha_2 s^2 + \alpha_3 e + \alpha_4 e^2 + \beta Z + \varepsilon \qquad (14)$$

It is straightforward to estimate this model with learning-by-oneself only. Our estimates are in Table 5. We find very similar values for the parameter g in both countries. It is equal to 1.3% per year in Morocco and to 1.1% in Senegal. Results lead to somewhat different findings once accounting for the possibility of imitation within the firm.

Insert Table 5 here

In the case of Senegal, we find a more important value for g with the extended learning model (columns 2B and 2C). Indeed, this parameter takes a value of 2.1% without firm factors and 1.8% with firm factors. At the same time, we fail to evidence a significant value for the rate of knowledge diffusion. In models (2B) and (2C), the parameter n is still positive and is equal to 0.041 once controlling for firm heterogeneity. A similar result was found with the pure learning-by-watching specification, with an insignificant parameter of 0.035. A last remark, suggesting that there is still something to learn from colleagues (despite the insignificant rate of job-specific knowledge diffusion), is that the relative distance separating the average worker from the most qualified worker remains highly significant. In the meantime, the distance is quite low, around 0.16 in presence of firm factors.

In Morocco, introducing the possibility of learning-by-imitation leads to higher returns to learning-by-oneself, just like in the Senegalese case. The parameter g is equal to 3.2% without firm factors and to 5% with firm factors. At the same time, while n is insignificant in model (1B), it appears significant at the 1 percent level and equal to 4% in model (1C) which

[20] Clearly, equation (14) is a restrictive case of (11). It is obtained when the rate of knowledge diffusion is equal to zero, meaning that the characteristics of the most qualified worker are in fact those of the considered worker (there is nothing to learn from others).

controls for firm heterogeneity. Among Moroccan firms, there is thus a real potential benefit of learning from colleagues and this learning-by-watching process also conveys higher benefits to self-learning. Finally, the rate of diffusion of 4% in the learning-by-oneself and others model (1C) of Table 5 is very close to the value of 3.5% found in the pure learning-by-watching model (1B) of Table 4.

It is worth comparing our results with those of Destré and Nordman (2002). For Morocco, these authors have found that the learning-by-oneself process was the only component of informal training influencing earnings. Conversely, they exhibit both a high rate of knowledge diffusion and a significant impact of learning-by-oneself (1.9%) for Tunisian workers. The argument advocated to explain this difference is that the distance with the most educated ($\bar{S} - s$) in the Tunisian firms is on average higher than in the Moroccan ones, while the number of years of schooling is equivalent in both countries. These statistics may justify the possibilities that learning by imitation is much more important among Tunisian employees.

In our case, however, this does not seem to be a relevant explanation for the divergence of learning effects in the Moroccan and Senegalese cases. While $\bar{S} - s$ amounts on average to 5.5 years for the Moroccan workers, it is 6.7 years for the Senegalese. Besides, the average education is slightly higher for the Senegalese. Similarly, the distance to the most experienced worker is respectively 13.9 versus 14.3 years, again higher for the Senegalese where the benefits of the imitation process are found to be null. Hence, the fact that there are no benefits from learning-by-watching in the Senegalese case should be explained by other factors, beyond the workers' human capital endowments.

A first explanation could lie in strong rigidity in the fixation of wages. Another explanation may refer to the work organisational features within firms, the environment of employees contributing to intensification of the learning-by-watching process. For instance, more compartmentalized firms may leave fewer places to the emergence of peer effects. Unfortunately, we lack relevant information on the firms to know whether Senegalese firms are more partitioned[21]. Finally, the important presence of temporary workers in firms, or firms with high labour turnover, could also explain why the diffusion of knowledge is not efficient. While the ratio of the number of full time temporary workers to the total number of full time permanent employees amounts to 27% in the Moroccan firms, it is much higher in the

[21] However, indicators of the supervision rates in firms are informative. Note that while the proportion of firms with a share of managers higher than 10 percent of the total employees amounts to 11% for Morocco, it is much higher for Senegal with 39%.

Senegalese firms (67%). The underlying higher turnover may well explain the divergence of knowledge diffusion efficiency between these two countries.

A last comment is whether we can interpret estimates of the structural model as pure measures of learning capacities or knowledge externalities. Given the first-term of the right-hand-side of (12), the estimated parameters of the learning model do not only pick up the tenure effects on earnings since we are able to disentangle the role of g and n when estimating the model. Nevertheless, that observed tenure effects on wages reflect pure learning is challenged by alternative interpretations of this relationship.

A first possibility is that there is a positive correlation between recorded tenure and time invariant worker productivity, because high-ability workers get paid well and tend to keep their jobs. Second, job transitions may affect the relationship between tenure and wages if young workers are likely to have higher exit rates, as a result of searching for better paid jobs. The quality of the match, which determines earnings, should be better amongst middle-aged workers than for young workers. So, the latter will have short spells of tenure partly because they are young and partly because they switch jobs a lot. It is clear that recorded tenure may be positively correlated with wage for other reasons than pure learning effects. However, since we only have at our disposal a cross-section of workers, we cannot investigate the potential bias introduced by unobserved worker heterogeneity.

6. Concluding comments

Using matched worker-firm data from Morocco and Senegal, we have developed and estimated in this paper a model of on-the-job learning which accounts for two forms of informal learning within firms, i.e. learning-by-watching and learning-by-oneself. With a pure learning-by-watching model without controls for firm heterogeneity, we note little difference in the estimated rates of knowledge diffusion for Morocco and Senegal (between 6% and 8%). Controlling for firm characteristics significantly reduces the values of the rate of knowledge diffusion. Both in Morocco and Senegal, the benefits of learning-by-oneself are revealed, but the potential benefit of learning from colleagues disappears in the latter country. Moroccan estimates still exhibit significant economic returns to both learning-by-watching and self-learning.

From our results, it turns out that the overall return to human capital explaining the remuneration of a given worker involves personal skill characteristics, including individual abilities to learn, but also firms' knowledge characteristics. It is then important to consider

these two sources of returns from human capital simultaneously because education policies and policies promoting vocational training may affect both worker's human capital and firm's human capital environment. In particular, assessing policies without accounting for educational and knowledge externalities within firms may largely under-estimate the benefits of such policies.

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Table 1. Composition of the sample

Number of employees per firm	**Morocco**				**Senegal**			
	Workers		Firms		Workers		Firms	
	N	%	N	%	N	%	N	%
4	40	0.5	10	1.2	128	10.0	32	17.8
5	130	1.7	26	3.2	105	8.2	21	11.7
6	180	2.4	30	3.6	156	12.1	26	14.4
7	224	2.9	32	3.9	105	8.2	15	8.3
8	320	4.2	40	4.9	200	15.6	25	13.9
9	1008	13.2	112	13.6	180	14.0	20	11.1
10	5720	75.0	572	69.6	410	31.9	41	22.8
All	7622	100.0	822	100.0	1284	100.0	180	100.0

Sources: ICA Senegal, FACS Morocco.

Table 2. Descriptive statistics of the workers

Variables	**Morocco**	**Senegal**
Log of hourly earnings	4.050	6.590
	(0.616)	(0.885)
Years of education	8.679	10.322
	(5.428)	(5.661)
Years of experience off the firm	12.766	12.747
	(9.300)	(9.280)
Years of tenure in the firm	7.435	8.981
	(6.305)	(7.870)
Female	0.398	0.160
	(0.490)	(0.367)
Married	0.518	0.673
	(0.500)	(0.469)
Formal training	0.041	0.355
	(0.199)	(0.479)
Number of observations	7622	1284

Sources: ICA Senegal, FACS Morocco; authors' calculations.
Standard deviations are in parentheses.

Table 3. Estimates of the log of hourly earnings

A. Without controls of firm heterogeneity

Variables	Morocco		Senegal	
	(1A)	(1B)	(2A)	(2B)
Constant	3.443***	3.177***	5.594***	5.087***
	(34.55)	(32.37)	(52.73)	(44.16)
Years of education	-0.018***	-0.006*	0.011	0.027**
	(4.85)	(1.80)	(0.92)	(2.39)
Years of education ² (/10)	0.026***	0.026***	0.014***	0.017***
	(11.43)	(11.61)	(2.72)	(3.33)
Years of experience off the firm	0.005**	0.016***	0.007	0.025***
	(2.51)	(8.27)	(1.15)	(4.08)
Years of experience off the firm ² (/10)	-0.002***	-0.003***	-0.002	-0.004**
	(3.86)	(6.38)	(1.27)	(2.51)
Female	-0.105***	-0.078***	-0.074	-0.016
	(9.00)	(6.84)	(1.21)	(0.28)
Married	0.171***	0.062***	0.407***	0.169***
	(14.12)	(4.79)	(9.45)	(3.65)
Receipt of formal training	0.260***	0.263***	0.086*	0.058
	(9.50)	(9.89)	(1.86)	(1.30)
Years of tenure in the firm		0.034***		0.050***
		(7.35)		(3.16)
Years of tenure in the firm ² (/10)		-0.012***		-0.009
		(3.47)		(0.83)
Years of tenure in the firm ^{3} (/100)		0.003***		0.001
		(3.53)		(0.44)
Observations	7622	7622	1284	1284
R-squared	0.43	0.46	0.42	0.48

B. With controls of firm heterogeneity

Variables	Morocco		Senegal	
	(1C)	(1D)	(2C)	(2D)
Constant	3.242***	3.292***	5.421***	5.153***
	(41.21)	(35.63)	(54.05)	(46.13)
Years of education	-0.002	-0.001	0.011	0.020*
	(0.71)	(0.26)	(1.12)	(1.89)
Years of education ² (/10)	0.018***	0.018***	0.013***	0.017***
	(8.93)	(8.64)	(3.06)	(3.39)
Years of experience off the firm	0.013***	0.013***	0.013**	0.024***
	(8.62)	(7.45)	(2.54)	(4.16)
Years of experience off the firm ² (/10)	-0.002***	-0.002***	-0.001	-0.004***
	(5.74)	(5.38)	(0.94)	(2.59)
Female	-0.066***	-0.065***	-0.032	0.035
	(6.79)	(5.89)	(0.65)	(0.61)
Married	0.048***	0.059***	0.081**	0.171***
	(4.64)	(4.85)	(2.11)	(3.82)
Receipt of formal training	0.024	0.134***	0.089**	0.043
	(0.86)	(5.27)	(2.30)	(1.00)
Years of tenure in the firm	0.036***	0.029***	0.034**	0.048***
	(8.47)	(6.58)	(2.31)	(3.10)
Years of tenure in the firm ² (/10)	-0.014***	-0.011***	-0.003	-0.014
	(4.58)	(3.32)	(0.35)	(1.31)
Years of tenure in the firm ^{3} (/100)	0.002***	0.002***	-0.000	0.002
	(3.86)	(3.36)	(0.23)	(0.91)
Observations	7622	7622	1284	1284
R-squared	0.51	0.52	0.46	0.52

Sources: ICA Senegal, FACS Morocco; authors' calculations.
Regressions (A) and (B) are OLS, (C) are fixed effects models, and (D) are OLS estimates with firm factors. Absolute value of t statistics are in parentheses, significance levels being respectively equal to 1% (***), 5% (**) and 10% (*). All regressions also include a set of dummies for occupation.

Table 4. Structural estimates of the learning-by-watching model

Variables	Morocco		Senegal	
	(1A)	(1B)	(2A)	(2B)
Constant	3.260***	3.365***	4.854***	5.216***
	(33.42)	(36.47)	(39.36)	(45.94)
Years of education	-0.021***	-0.008*	0.065***	0.004
	(4.95)	(1.95)	(7.52)	(0.32)
Years of education ² (/10)	0.033***	0.021***	0.002	0.025***
	(13.13)	(8.96)	(1.07)	(4.14)
Years of experience off the firm	0.015***	0.011***	0.029***	0.030***
	(7.24)	(5.88)	(4.40)	(4.87)
Years of experience off the firm ² (/10)	-0.003***	-0.002***	-0.004***	-0.005***
	(5.67)	(4.29)	(2.89)	(3.30)
Female	-0.073***	-0.064***	0.009	0.056
	(6.38)	(5.82)	(0.15)	(1.00)
Married	0.074***	0.074***	0.191***	0.183***
	(5.74)	(6.14)	(4.28)	(4.22)
Receipt of formal training	0.243***	0.129***	0.049	0.044
	(9.13)	(5.06)	(1.13)	(1.05)
δ_s	0.069***	0.061***	0.430***	0.142***
	(5.83)	(2.69)	(3.74)	(3.07)
δ_e	0.026	0.001	0.150***	0.120**
	(1.19)	(0.02)	(2.75)	(2.05)
$\alpha_5\delta_t$	0.014***	0.019**	0.023**	0.025
	(3.53)	(2.42)	(2.25)	(1.41)
$\alpha_6\delta_t^2$	0.000	-0.000	-0.000	-0.000
	(0.51)	(0.79)	(0.20)	(0.70)
n	0.063***	0.036*	0.076***	0.035
	(3.50)	(1.90)	(2.61)	(1.45)
Observations	7622	7622	1284	1284
R-squared	0.46	0.52	0.50	0.53

Sources: ICA Senegal, FACS Morocco; authors' calculations.
Regressions (A) and (B) are estimated using non-linear least squares, models (B) including firm factors. Absolute value of t statistics are in parentheses, significance levels being respectively equal to 1% (***), 5% (**) and 10% (*). All regressions also include a set of dummies for occupation.

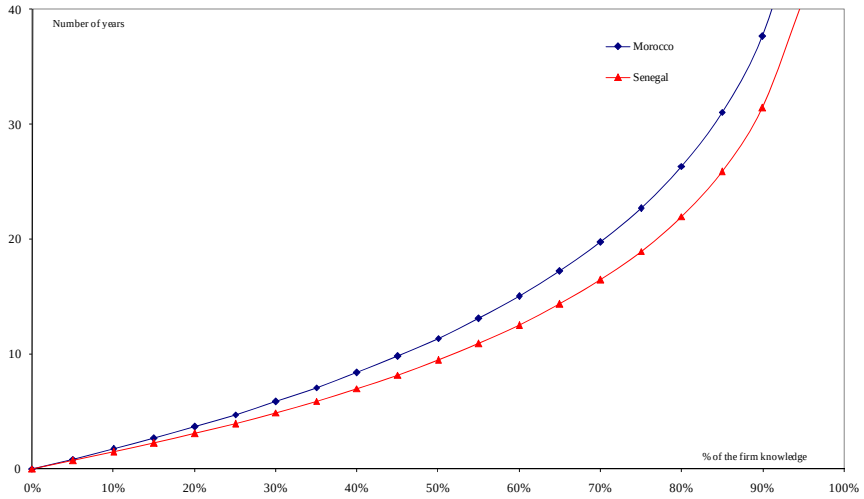
Table 5. Structural estimates of the learning by oneself and others model

Variables	Morocco			Senegal		
	(1A)	(1B)	(1C)	(2A)	(2B)	(2C)
Constant	2.324***	3.187***	3.298***	4.200***	5.028***	5.190***
	(25.26)	(32.54)	(35.81)	(45.48)	(46.52)	(51.32)
Years of education	-0.001	-0.008**	-0.004	0.033***	0.028*	0.017
	(0.19)	(2.12)	(1.08)	(3.03)	(1.94)	(1.22)
Years of education ² (/10)	0.018***	0.027***	0.020***	0.015***	0.021***	0.024***
	(8.51)	(11.69)	(9.04)	(3.09)	(3.32)	(3.93)
Years of experience off the firm	0.013***	0.015***	0.014***	0.028***	0.037***	0.032***
	(7.13)	(7.79)	(7.47)	(4.68)	(5.67)	(5.19)
Years of experience off the firm ² (/10)	-0.002***	-0.003***	-0.003***	-0.004***	-0.006***	-0.005***
	(5.07)	(6.23)	(5.59)	(2.82)	(3.82)	(3.31)
Female	-0.064***	-0.077***	-0.064***	0.185***	0.168***	0.197***
	(5.82)	(6.77)	(5.81)	(3.63)	(3.24)	(3.93)
Married	0.063***	0.061***	0.061***	0.187***	0.171***	0.170***
	(5.24)	(4.73)	(4.99)	(4.16)	(3.72)	(3.82)
Receipt of formal training	0.136***	0.265***	0.134***	0.119***	0.127***	0.115***
	(5.32)	(9.94)	(5.26)	(2.81)	(2.96)	(2.74)
δ_s		0.376***	0.228**		0.070***	0.161**
		(4.32)	(1.98)		(3.26)	(2.40)
δ_e		0.761***	0.247		0.084***	0.107
		(3.31)	(1.50)		(2.91)	(1.55)
$\alpha_5\delta_t$		0.050	-0.239***		-0.001	-0.018
		(0.23)	(2.88)		(0.09)	(0.66)
$\alpha_6\delta_t^2$		-0.015	0.005***		0.000	0.000
		(1.12)	(2.86)		(1.46)	(0.79)
n		0.012	0.040***		0.242	0.041
		(1.11)	(2.78)		(1.37)	(1.28)
g	0.013***	0.032***	0.050***	0.011***	0.021***	0.018**
	(19.42)	(3.08)	(3.60)	(8.88)	(3.65)	(1.96)
Observations	7622	7622	7622	1284	1284	1284
R-squared	0.52	0.46	0.52	0.50	0.48	0.52

Sources: ICA Senegal, FACS Morocco; authors' calculations.

All regressions are estimated using non-linear least squares, models (A) and (C) including firm factors. Absolute value of t statistics are in parentheses, significance levels being respectively equal to 1% (***), 5% (**) and 10% (*). All regressions also include a set of dummies for occupation.

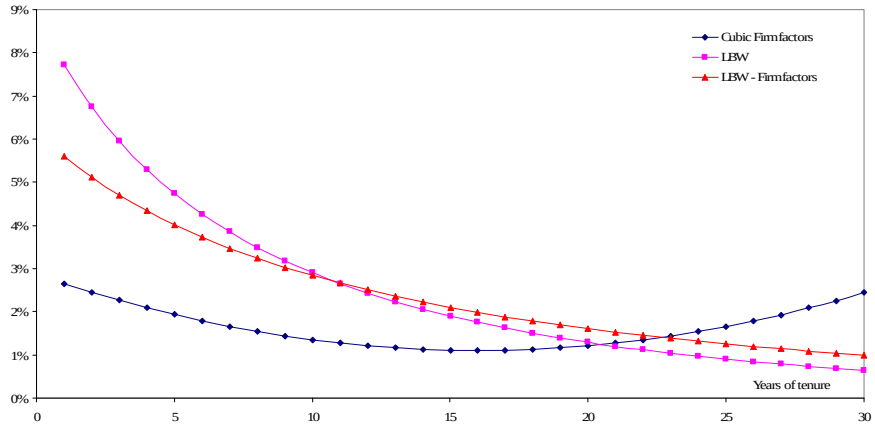
Figure 1. Time needed to accumulate the firm knowledge



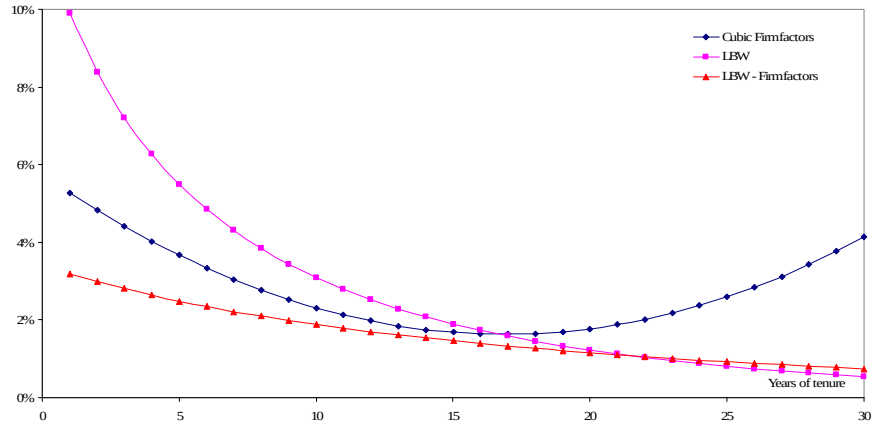
Sources: ICA Senegal, FACS Morocco; authors' calculations.

Figure 2. Rates of return of tenure – learning-by-watching models

A. Morocco



B. Senegal



Sources: ICA Senegal, FACS Morocco; authors' calculations.