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Entrepreneurial skills and workers' wages in small firms

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Abstract This paper contributes to the understanding of how small firms are organized and managed. It tests an entrepreneur-worker matching model in small entrepreneurial firms. The model contemplates the existence of complementarities between workers' and entrepreneur's skills. Using a Portuguese longitudinal matched employer–employee dataset for the period 1995–2003, the empirical analysis provides descriptive results consistent with the matching model: skill stratification—entrepreneurs are more skilled than workers; scale effects—more skilled entrepreneurs run larger firms, though limited by the restriction on firm size; and positive sorting—more skilled entrepreneurs matched with more skilled workers. The estimation of wage regressions shows that the higher the level of education and experience of the entrepreneur, the higher the wage premium for workers. Results suggest that workers' wages reflect the value of the match with entrepreneur's skills. Thus, entrepreneurial skills have an impact not only on job creation, but also on the quality of jobs created.

Keywords Entrepreneurship · Matching · Positive sorting · Small firms · Wages

JEL Classifications L26 · J24 · J31 · M52

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1 Introduction

When creating a new business the entrepreneur chooses which workers to hire. Different entrepreneurs will most likely make different staffing decisions even if they are running similar firms and facing the same market conditions. The more skilled entrepreneur will probably hire more skilled workers. What is the reason for this skill matching? This paper argues that positive sorting between the entrepreneur and the worker is efficient, i.e. the skilled entrepreneur runs a better performing business and workers get a higher pay for their skills.

The production process within a firm consists of tasks performed by skilled labor. Production technologies frequently involve teamwork (Alchian and Demsetz 1972) exhibiting complementarities between different tasks (Kremer 1993). The efficient assignment of skills to tasks implies the assignment of more skilled workers to more demanding tasks

(Sattinger 1993; Kremer and Maskin 1996), namely, those associated with managerial positions (Rosen 1982). In a population of individuals, those who possess greater entrepreneurial knowledge and ability choose to be entrepreneurs (Schumpeter 1934) and their entrepreneurial skills will determine the size of their venture (Lucas 1978). To understand the interplay between entrepreneurial skills and the skills of the workers hired by the entrepreneur, one needs to analyze the matching between the two kinds of skills (Oi 1983).

The present paper tests a simple model matching entrepreneurs' and workers' skills. The matching of skills is multidimensional—one entrepreneur hiring several workers—and the number of hires is the outcome of the matching process, in line with the model for the manager–worker matching (Garicano and Hubbard 2007a). In testing the model, our study focuses on small entrepreneurial firms where the entrepreneur–manager's skills and span of control play a major role (Penrose 1959/1995; Lucas 1978). The entrepreneur has a fixed amount of time to run the firm. Time is divided between production (which depends essentially on human resources) and coordinating workers (supervising and training). When the entrepreneur is more skilled, the opportunity cost (in terms of production) of coordinating workers is higher. To foster business growth, the high-skilled entrepreneur has to increase her locus of control by hiring more workers. Due to production complementarities, entrepreneurial time is more valuable to production if combined with better workers' skills. High-skill workers should need less attention from the entrepreneur/manager and are more autonomous and able to solve more demanding problems. Therefore, the high-skill entrepreneur hires high-skill workers to leverage her skills, leading to positive sorting.[1] If the matching process implies that workers' skills are more valuable to the high-skill entrepreneur, then workers' wages should be higher. Empirically, we should observe a positive relationship between wages and entrepreneurial skills.

We rely on a longitudinal matched employer–employee dataset covering the whole Portuguese private sector for 1995–2003. The dataset includes information on worker and firm characteristics and, in particular, entrepreneur demographics. We select small firms (<50 workers) owned by a sole entrepreneur–manager. We start by describing the skill stratification—entrepreneurs are more skilled than workers—and scale effects—more skilled entrepreneurs run larger firms[2]—found in our data. To inspect the matching process, we present estimates of the match between entrepreneurs and workers along different dimensions of skill. This descriptive evidence points to the existence of sorting.

We also estimate wages on entrepreneur skills along with worker and firm attributes to assess the value of the match, that is, if sorting leads to higher wages. The estimation models consider wages in two ways: wages for the first workers hired at firm creation; and wages across the firm's life span accounting for the workers' unobserved heterogeneity (worker fixed effects). The results are consistent with the model—the estimated relationship between entrepreneurial skills and wages is positive.

We contribute to several strands of the literature. In the field of strategy, we contribute to the understanding of how an entrepreneur–manager expands the firm by hiring high-skill workers, changing the productive opportunity of the firm (Penrose 1959/1995). The study of the matching process also highlights how the entrepreneur acts as a strategic manager responsible for resource allocation and reconfiguration (Teece and Pisano 1994; Teece et al. 1997; Teece 2007; Augier and Teece 2008). The value of the match depends on the entrepreneur's ability to hire the best workers and to combine entrepreneurial skills with workers' skills. To the extent that it is captured by wages, the value of the matching of skills provides an alternative measure of the relationship between entrepreneur's skills and business performance (Bates 1990; Brüderl et al. 1992; Bosma et al. 2004). In labor economics, an important literature stream looks at the relationship between wages and firm size, mostly finding that larger firms pay higher wages to similar workers (Stolzenberg 1978; Mellow 1982). It can be argued that entrepreneurial skills are also part of the explanation for rewarding workers' skills differently. If more skilled entrepreneurs run larger firms, workers in larger firms will be expected to earn higher wages. Finally, the paper contributes to an underdeveloped

[1] As in Becker's (1973) marriage model.

[2] Though these are limited by our restriction on firm size.

field, the study of human resource management in small firms (Cardon and Stevens 2004) and, in particular, the relationship between entrepreneurial skills and the firms' hiring and wage policies.

In the next section, we present the matching model and use it to discuss the extant literature and guide the empirical analysis. The third section describes the dataset and relationship between entrepreneur's and workers' skills within firms. In the fourth section, we present and discuss the results from wage estimations. The fifth section concludes the paper.

2 The matching model

We follow Garicano and Hubbard (2007a) who model the match between two kinds of agents: the manager and the workers. In our setting, the manager of the firm is the entrepreneur. We present the model in order to analyze the matching between the entrepreneur and her workers; we formulate the results that we want to test and discuss the extant literature.

2.1 Production

Assume that agents are endowed with one unit of time and skill level $q \in [0, 1]$. Skill can be interpreted as the capacity to solve more complex problems, or as a lower cost to acquire the knowledge necessary to complete a task. An entrepreneur with skill level q_e hires n workers with skill level q_w with $q_e > q_w$—i.e. the entrepreneur is more skilled than her workers. The entrepreneur and workers form a firm and its production is given by:

$$y = F(q_e, q_w) = v(q_e)g(n(q_w)) \quad (1)$$

where $v(\cdot)$ and $g(\cdot)$ are twice-differentiable, increasing and strictly concave, continuous functions. We do not consider capital in order to keep the model simple. The value of the entrepreneur's production is $v(\cdot)$. The output of the firm is the entrepreneur's skill value $v(\cdot)$, multiplied by the effective time spent in production by the $1 + n$ agents, $g(\cdot)$. The entrepreneur has to devote time to coordinating workers. The cost of coordination occurs since the effective time agents dedicate to production is less than the total available amount of time: $g(n) < 1 + n$.

As in Garicano and Hubbard (2007a), we assume that if workers are more skilled, then the entrepreneur can employ more workers (increase the span of control), that is, $n'(q_w) > 0$ with $n(q_w) > 0$ for all $q_w > 0$. The entrepreneur is time-constrained and must delegate tasks in order for the firm to grow. If workers are more skilled, the entrepreneur spends less time supervising the team, because more skilled workers require less attention (Garicano 2000; Garicano and Rossi-Hansberg 2004), solve more complex problems or difficult tasks (Garicano and Hubbard 2007a), or possess lower learning costs of knowledge acquisition (Garicano and Hubbard 2005, 2007b; Garicano and Rossi-Hansberg 2006).[3] Thus workers' skills facilitate higher leverage of the entrepreneur's skills.

The production function in Eq. (1) is not separable (Alchian and Demsetz 1972), meaning that the cross derivative is not zero ($\partial^2 F/\partial q_e \partial q_w \neq 0$). The function is the outcome of the joint production of one entrepreneur and n workers. The model rests on the assumption that entrepreneur and worker skills are imperfect substitutes. The assumed technology has two main properties: (i) the entrepreneur skills increase the productivity of all workers; and (ii) the entrepreneur skills and worker skills are complementary in production.

The same kind of production function appears in different forms in the literature. Lucas (1978) and Jovanovic (1994), focusing on the size of the firm, define the production function as $y = q_e g(n)$. In Lucas's model, workers' skills are absent and the main characteristic of the function is the multiplicative effect of the entrepreneur skills, as in Eq. (1). The skills of the entrepreneur give rise to a scale effect—higher skilled entrepreneurs manage larger firms. The diminishing returns expressed in the concavity of g limit the size of the firm. The same type of technology appears in Rosen (1982), but in a context of hierarchical job assignment. More skilled workers are assigned to a managerial position and their skill has a scale effect, similar to the effect of the entrepreneur's skill in Lucas's (1978) model. Both models are silent concerning the matching of skills.[4]

Oi (1983) is one of the first to consider the match between the skills of the entrepreneur and skills of the

[3] Or they can perform more tasks per unit of time (Sattinger 1975).

[4] Rosen (1982) suggests his model could be extended to study sorting along the lines proposed by Becker (1973).

workers. Production technology is $y = f(q_e(1 - \lambda n), nq_w)$, where q_e is the entrepreneur's skill and q_w is the worker's skill, as in Eq. (1). Labor is measured in efficiency units, nq_w. The entrepreneur has one unit of time to use in production and in monitoring workers' performance. The time spent monitoring workers is given by λn, where λ is the time needed to monitor each worker. The entrepreneur uses the remaining time $(1 - \lambda n)$ in production. This implies that only a fraction of the entrepreneur's skills contribute to production, given by $q_e(1 - \lambda n)$. The function is not separable and the cross derivative of $f(\cdot)$ is positive, leading to a scale effect, as in Lucas (1978)—more skilled entrepreneurs hire more workers.

The novelty in Oi (1983) is the opportunity cost resulting from the need to monitor workers, which leaves less entrepreneurial time available to production. The higher the entrepreneur's skill q_e, the higher the value of skills applied to production $q_e(1 - \lambda n)$. To run a larger firm, the skilled entrepreneur needs to compensate for the higher opportunity cost of monitoring workers, given by $q_e \lambda n$. The solution is to hire more skilled workers, as their higher contribution to production compensates the higher opportunity cost of the skilled entrepreneur—positive sorting.

A main feature of technology in the above models is the existence of complementarities in production between the entrepreneur and the workers. The role of complementarities in the matching process appears in its purest form in the O-ring theory proposed by Kremer (1993).[5] This author defines the production technology as $y = \prod_{i=1}^{n} q_i$, ignoring who controls the firm or the need to perform different tasks within the firm. This function implies that if one worker fails, then output is zero (the O-ring argument). The author proves the existence of positive sorting—workers with the same skill level will be matched together (self-matching). Perfect complementarity drives the result.

Kremer and Maskin (1996) introduce tasks with different skill sensitivity into the production function. If only two tasks are considered, this yields: $y = q_1^{\alpha} q_2^{\beta}$. The exponents measure the effect of each worker's skill on production, with $\alpha > \beta > 0$. If there are two types of workers, q and q' with $q' > q$, then it is more efficient for the firm to assign worker q' to task 1 and worker q to task 2. Again, skills are complementary, which originates positive sorting, i.e. the matching of the best workers in performing task 1, the more demanding task, with the best workers in performing task 2, the less demanding task (cross-matching). The technology is also similar to Rosen (1982) but without the distinction between hierarchical layers, thus not contemplating a scale effect.

2.2 The value of skills

Assuming that there are no other production factors, the entrepreneur chooses the workers' skills to maximize firm profits,

$$\underset{q_w}{\text{Max}}\, v(q_e) g(n(q_w)) - w(q_w) n(q_w)$$

The first order condition for the entrepreneur optimization problem is given by

$$v(q_e) g'(n(q_w)) = w(q_w) + \frac{w'(q_w)}{n'(q_w)} n(q_w) \tag{2}$$

The left-hand side of Eq. (2) is the marginal value of an increase in workers' skill and the right-hand side is the marginal cost of that increase for one additional worker of skill q_w. The marginal value is the increase in effective production time, g', multiplied by the value of entrepreneur's skill, v. The marginal cost is the additional wage plus a factor that reflects the increase in wage due to the additional skill, w', per additional worker, n', times the number of workers employed, n. To increase the size of the firm and circumvent the time restriction, the entrepreneur employs more skilled workers.

What happens when the entrepreneur's skill-level increases? In a model like Lucas (1978), the first order condition is $q_e g'(n) = w$. When the entrepreneur's skill-level q_e increases, for a given wage, the entrepreneur responds by increasing the number of workers. In the case of the production function in Eq. (1), the entrepreneur increases the number of workers as in Lucas (1978), but hires more skilled workers and pays higher wages.[6] Therefore, we have a scale effect due to

[5] The role of complementarities in production goes beyond the matching issue (see Alchian and Demsetz 1972).

[6] The increase in firm size is smaller than in a case where the workers' skills are absent. There is a trade-off between the quantity (firm size) and quality (skills) of the workers not present in other models except in Oi (1983).

entrepreneurial skill and positive sorting between the entrepreneur and workers. [7]

In the matching model, more skilled workers spend less production time acquiring knowledge, with lower learning costs, and are more valuable to the entrepreneur. This explains the positive relationship between worker's skill and wages. At the margin, the opportunity cost associated with the loss of production due to workers learning is higher for a more skilled entrepreneur, i.e. if a more skilled worker needs less time to learn, then he is more valuable to a better entrepreneur, given that the value of entrepreneur's skills is higher and the production function exhibits skills complementarities. The specialization of the entrepreneur in solving more complex problems—her comparative advantage as manager—is intensified when working with more skilled workers. At the margin, when the entrepreneur is more skilled, the value of more skilled workers is higher, which translates into higher wages. Therefore, we expect to find a positive relationship between wages and the entrepreneur's skills. We propose to test this relationship between the entrepreneurial skills and workers' wages arising from the matching model.

2.3 The entrepreneur

The role of an entrepreneur, who manages the firm (Kaldor 1934; Coase 1937), is present in all the studies mentioned above. However, we do not consider firms where there is an entrepreneurial team controlling the firm's resources (Kamm et al. 1990; Ruef et al. 2003; Ucbasaran et al. 2003). Empirically, it would be difficult to isolate the role of skills of more than one owner with the data available. Given our restriction on size (<50 workers), it is more likely to find small businesses owned by just one entrepreneur than by an entrepreneurial team. We are dealing with simple governance structures (Williamson 1979) managed by a central agent (Alchian and Demsetz 1972).

In addition, along with the size and sole ownership restrictions, we deliberately exclude the hierarchical ladder from the model by including only two layers: the entrepreneur–manager and the workers. Otherwise, we would have to deal with issues related with the internal working of the firm, such as hierarchical control (Williamson 1967), the existence of internal labor markets (Doeringer 1967; Doeringer and Piore 1971), job assignment (Sattinger 1975, 1993; Calvo and Wellisz 1979; Waldman 1984; Gibbons and Waldman 1999), or the matching with the quality and quantity of the remaining firm's resources (Sattinger 1979; Stevenson and Jarillo 1990; Eisenhardt and Martin 2000).

2.4 Previous empirical evidence

Empirical evidence on skill matching between entrepreneurs (or managers) and workers is still scarce. Garicano and Hubbard (2005, 2007a) test their knowledge-based hierarchy model in the context of US law firms. Garicano and Hubbard (2005) find evidence of positive sorting between partners and associates in law firms, measuring lawyers' skills by their experience and education (the quality of the law school). Garicano and Hubbard (2007a) find that partners' skills have a positive effect on the associates' earnings. Smeets and Warzynski (2008) use data from one firm to test the career dynamics and span of control resulting from knowledge-based hierarchy models, as opposed to other theories of hierarchies in organizations, but the authors do not directly test the existence of positive sorting.

The extant literature is mainly focused on the relationship between firm size and wages.[8] Fox (2009) presents empirical evidence on the relationship between wages and firm size in the context of the Garicano and Rossi-Hansberg (2006) hierarchical matching model. This author finds that the firm-size wage gaps increase with job responsibility, i.e. workers assigned to jobs with more responsibilities receive relatively more than comparable workers in smaller firms. A related strand of the literature looks at sorting between worker and firm productivity or, alternatively, at the relationship between worker and firm specific effects estimated from a wage equation. For example, Mendes et al. (2010) estimate firm specific productivity effects from a production function

[7] Literature associated with workers' skill-upgrading also focuses on skill-bias technological change (Goldin and Katz 1998), skill-bias organizational change (Caroli and Van Reenen 2001; Piva et al. 2005), and skill bias of world trade (Epifani and Gancia 2008).

[8] Idson and Oi (1999) review the literature. See also Ferrer and Lluis (2008), Fox (2009), and Gibson and Stillman (2009) for more recent studies.

and find positive sorting between workers' skills and firm productivity. These studies can be read in the light of Becker's (1973) marriage framework, but focus instead on the matching between one worker and one firm in the context of search models.[9]

There may be other reasons for the entrepreneur–worker match which we did not assess in this study. Entrepreneurs in small businesses will tend to employ people they know and trust, as they lack the resources for a comprehensive selection of employees (Aldrich and Langton 1998). Similarly, entrepreneurs may choose their workers among the same family or ethnic group (Aldrich and Langton 1998; Reskin 1999; Ruef et al. 2003).

3 Data

Every private firm in Portugal answers an annual survey—*Quadros de Pessoal* (QP)—conducted by the Ministry of Labor. The survey is mandatory for firms with at least one employee and started in the 1980s. It includes information on workers, business owners and firms. The QP is a longitudinal matched employer–employee dataset where a unique identification number links workers, firms and business owners across time.[10] We use the 1995–2003 period covering over 250,000 firms and two million workers annually. Worker information includes gender, tenure, schooling, job assignment, wages and hours of work. The survey contains the same individual information for the business owners, excluding earnings and hours of work. Firm information includes location, industry, total sales, initial capital and type of ownership.

3.1 The sample

We need to impose some conditions on the sample given our objective of establishing the relationship between the entrepreneur's skills and workers' wages. We select firms based on three conditions in line with the discussion in Sect. 2.3. First, we select small firms, employing <50 workers to be able to identify the role of entrepreneurial skills and exclude larger firms with complex hierarchical structures. Second, we select firms owned by a sole entrepreneur. We do not have enough information on the ownership structure and internal decision-making process to establish a clear link between each member of the entrepreneurial team and their workers. Third, the entrepreneur has to be the top manager of the firm. We need to guarantee that the entrepreneur effectively manages the firm, is responsible for the strategic decision making, and intervenes in the definition of the firm's hiring and compensation policies.

Overall, firms with <50 workers represent 98 % of all firms and 50 % of total employment in the economy. Selecting only firms owned by a single manager–entrepreneur restricts the sample to 60 % of firms with <50 workers.[11] Table 1 presents the firm size distribution for the years covered by the sample (1995–2003). The majority of the firms (65.1 %) employ up to five workers and only 4.3 % employ between 20 and 50 workers. The proportion of workers in each firm size range considered—0–5, 5–10, 10–20, and 20–50 workers—is around 25 %.

3.2 Skill measures

The variables measuring worker skills are education, labor market experience, and tenure. Education measures pre-market training, the individual investment in acquiring skills typically carried out before entering the labor market. Labor market experience and tenure measure skills acquired on the job (Becker 1962, 1964/1975). Table 2 shows the worker descriptive statistics for the sample with almost 1.8 million worker-years for the entire time period (1995–2003). Workers are, on average, 35 years old, and 41 % are female. Three dummy variables measure schooling: 9-year

[9] See the review of the related literature and discussion in Lentz and Mortensen (2010).

[10] The survey is the source of several papers studying workers (e.g. Martins 2009), entrepreneurs (e.g. Amaral et al. 2011), firms (e.g. Geroski et al. 2010); and firms and workers (e.g. Baptista et al. 2012).

[11] In what regards sectorial composition along this time period, it is possible to observe in QP around 33% of workers employed in manufacturing firms, while in construction this proportion is about 11%. Regarding the tertiary sector, the retail businesses represent a share of about 20%, while other services correspond to about 24%. When focusing only on small firms' workers, the structure changes to the following shares: 29% in manufacturing; 15% in construction; 30% in retail; and 18% in other services. Under the restrictions of our sample (including only small firms with a single top manager/business owner), the structure remains virtually the same.

Table 1 Workers and firm size, 1995–2003

Category	Firm size class (number of workers)				
	[1–5]	[6–10]	[11–20]	[21–50]	Total
Workers, *n* (%)	482,299 (27.2)	446,665 (25.2)	426,616 (24.1)	415,678 (23.5)	1,771,258 (100)
Firms, *n* (%)	267,234 (65.1)	85,975 (20.9)	39,558 (9.6)	17,726 (4.3)	410,493 (100)

Table 2 Descriptive statistics—workers, 1995–2003

Variables	
Hourly wage (logarithm)	1.120
	[0.382]
Female (dummy)	0.408
	[0.491]
Age (years)	34.552
	[11.467]
9-Year education (dummy)	0.159
	[0.366]
Secondary education (dummy)	0.140
	[0.347]
College education (dummy)	0.024
	[0.153]
Tenure (years)	4.682
	[6.245]
Experience (years)	20.975
	[12.197]
Observations	1,771,258

Standard deviation (overall) in brackets underneath the mean. Hourly wage is the sum of base wage with regular payments divided by the number of monthly paid hours, deflated using the Consumers Prices Index

education, corresponding to compulsory schooling in Portugal during the period under study; secondary education, corresponding to 12-year school enrolment (high-school); and college education, corresponding to at least a college degree.

Only 2.4 % of workers completed a college education, 14 % completed a secondary education, and 15.9 % completed the 9-year education. More than two thirds are below the 9-year education level. This reflects the relatively low educational attainment of the Portuguese population. The average tenure is nearly 5 years—the sample is composed of small firms where worker turnover is expected to be higher (Idson 1996). Average experience in the labor market is 21 years, measured as age minus years of schooling and tenure (and 6 years). The standard deviations for tenure (6.245) and experience (12.197) are high when compared with the respective means, assuring that there is enough source variation to identify the parameters of interest.

3.3 Skill stratification, scale effects and sorting

Before moving to the estimation of wage equations, we examine whether there is any descriptive evidence in the dataset pointing to the conditions of the matching model, namely, skill stratification—entrepreneurs are more skilled than workers; scale effects—more skilled entrepreneurs manage larger firms; and positive sorting—more skilled entrepreneurs employ more skilled workers.

3.3.1 Skill stratification

The skills of entrepreneurs and workers—education, tenure and experience—are compared in Table 3 for the year 2003. This year was chosen as reference because it is the most recent year and includes a higher number of observations. However, comparing the skills of entrepreneurs and workers for other years in the period of analysis yields similar results. We computed an entrepreneur's "tenure" by counting the years since admission, noting that tenure does not necessarily coincide with firm age, i.e. the entrepreneur is not necessarily the founder, as the owner may have bought or inherited the firm. We define education and experience as in the case of workers. Entrepreneurs are better educated than workers, for example, the proportion of entrepreneurs holding college education is 14.1 and the proportion of workers is 4.7 %. Entrepreneurs also have more years of tenure and experience; entrepreneurs have 6.4 years of tenure and 28.7 years of experience while workers have 4.7 and 21.5 years, respectively. If we measure skills by formal education, tenure and labor market experience, on average, we find that entrepreneurs are more skilled than workers.

Table 3 Skill stratification: workers versus entrepreneurs, 2003

Variables	Workers	Entrepreneurs
9-Year education (dummy)	0.204	0.188
	[0.403]	[0.391]
Secondary education (dummy)	0.160	0.176
	[0.366]	[0.381]
College education (dummy)	0.047	0.141
	[0.213]	[0.348]
Experience (years)	21.544	28.744
	[12.167]	[12.960]
Tenure (years)	4.652	6.434
	[6.118]	[7.337]
Observations	246,072	58,124

Standard deviation (overall) in brackets underneath the mean

3.3.2 *Scale effects*

Table 4 presents the distribution of the entrepreneur's education across firm size classes in the first four columns for the year 2003. The last column presents the distribution of the entrepreneur's education for all firms in the sample. In the first firm size class (between one and five workers), 50.4 % of the firms are owned by entrepreneurs with <9-year education; 19.01 % by entrepreneurs with a 9-year education; 17.29 % by entrepreneurs with secondary education; and 13.29 % by entrepreneurs with college education. In larger firms (between 21 and 50 workers), the proportion of firms owned by less educated entrepreneurs decreases (from 50.4 to 40.8 %) and the proportion of firms owned by better educated entrepreneurs increases (from 13.29 to 18.88 %). When education measures the skills of the entrepreneur, this descriptive cross tabulation points to a scale effect. As we are selecting small firms, the effect is modest.

3.3.3 *Positive sorting*

We expect to find positive sorting through the workers' wages in Sect. 4. However, we can inspect the data directly to probe if more skilled workers are more likely to be employed by more skilled entrepreneurs. We classify and order firms by the level of the entrepreneur's skills, measured by education: (1) firms owned by entrepreneurs having <9 years of education, (2) having completed 9 years of education, (3) having completed secondary education, and (4) holding at least a college degree. With firms ordered in this way, we define an ordered probit model for the four kinds of firms and estimate the probability of a worker from a given skill-level being employed by an entrepreneur from a higher or lower skill-level.[12] Workers' skills are measured by education, work experience and tenure. We also control for worker's gender and the characteristics of the firm, namely, location and industry. Industry controls are included since positive sorting can be due to technology production complementarities requiring a certain skill level from the entrepreneur and the worker. For example, a software firm will probably be founded by a computer scientist (or a similar background) and will need to hire workers with programming skills, obtained most likely through a degree on computer science (or similar).

Garicano and Hubbard (2005) compute the law firm associates' education and experience (normalized) shares across the partners' education and experience and find that the associates are more likely to work with similar partners. We performed the same exercise and found similar results. However, since we are not dealing with a set of organizations as homogeneous as that of law firms, we need to control for industry to try to isolate the sorting due to skills. An ordered estimation model seems the appropriate way of inspecting the data. Homogeneity is ensured by size (small firms, presumably labor intensive) and type of ownership (sole owner who manages the firm).

Table 5 presents the marginal effect of the ordered probit for the probability of employment of young workers in the different kind of firms for the year 2003.[13] We select young workers (under 25) because their skills are captured mainly by education. They are new to the labor market and therefore the acquisition of human capital due to work experience is modest. In this way, we try to reduce the observable dimensions where the matching with entrepreneurs occurs.[14]

[12] We perform the same exercise with the entrepreneur's experience and the results are similar.

[13] The 95% confidence intervals of the estimated threshold parameters do not overlap, suggesting that we can order firms by entrepreneurs' education as should happen with the matching model.

[14] However, the estimation with all workers renders similar results.

Table 4 Firm distribution: entrepreneurs' education level across firm size class, 2003

Entrepreneur education level	Firm size class (number of employees)				Total	Observations
	[1–5]	[6–10]	[11–20]	[21–50]		
<9-Year	50.40 %	49.02	47.00	40.80	49.44	28,737
9-Year	19.01	18.11	19.14	19.27	18.85	10,955
Secondary	17.29	17.27	19.00	21.04	17.59	10,223
College	13.29	15.60	14.85	18.88	14.12	8,209
Total	100.00	100.00	100.00	100.00	100.00	58,124

Dummies defined for the *education* variables

Table 5 Sorting between entrepreneurs and young workers (<25 years old) by education: ordered probit (marginal effects), 2003

Worker education level	Entrepreneur education level			
	Below 9-year	9-Year	Secondary	College
9-Year	−0.161***	0.006***	0.069***	0.085***
	[0.011]	[0.001]	[0.005]	[0.007]
Secondary	−0.282***	−0.014***	0.110***	0.186***
	[0.012]	[0.003]	[0.004]	[0.011]
College	−0.360***	−0.093***	0.081***	0.372***
	[0.012]	[0.010]	[0.006]	[0.026]
Observations	13,238			
Wald χ-squared	4,610.79			
Pseudo R-squared	0.0913			

Dependent variable is the entrepreneur's education (four levels). Estimations also include *female*, *experience*, *tenure*, *industry* (defined for 2-letter ISIC classification) and *region* dummies. Standard errors are in brackets. *** Significant at 1 %

In the first column of Table 5, workers with nine or more years of education have a lower probability of employment in firms owned by entrepreneurs with <9 years of education than workers which have the same level of education as the entrepreneur. Looking by row across the level of workers' education, the marginal effects increase as we move from firms owned by entrepreneurs with <9 years of education to firms owned by those with college education, indicating that more educated workers have a higher probability of employment at firms owned by more educated entrepreneurs. From the second to the fourth column, the marginal effects at the main diagonal correspond to the exact match—entrepreneurs and workers with the same educational level. These marginal effects are always higher than the other marginal effects in the same column. Workers have a higher probability of employment in firms where the entrepreneur has the same education level as themselves. Overall, the evidence derived from the ordered probit points to the existence of positive sorting between entrepreneurs and workers.

4 Workers' wages

The matching model in Sect. 2 predicts the positive sorting between workers and entrepreneurs. The more skilled entrepreneurs own larger firms (scale effect) and employ more skilled workers (sorting). According to Eq. (2), workers' wages should be higher when entrepreneurs are more skilled. By introducing the entrepreneur's skill in a wage equation as an explanatory variable, we expect it to have a positive coefficient, even after controlling for observable workers' skills, e.g. education and labor market experience. In the context of the model, this would

be consistent with production complementarities between entrepreneurs and workers, as in Eq. (1).

4.1 Wage equations and estimation methods

We augment the typical wage equation (Mincer 1974) in order to determine how entrepreneurial skills influence the formation of wages and test the existence of positive sorting. Define the following (log) wage equation for each worker i in year t,

$$W_{it} = \beta_0 + \mathrm{SW}_{it}\beta_1 + \mathrm{SE}_{it}\beta_2 + \mathrm{SI}_{it}\beta_3 + O_{it}\beta_4 + s_i + \varepsilon_{it} \quad (3)$$

where the vectors SW and SE measure the (observable) skills of the worker and the entrepreneur, namely, education, tenure, and work experience; SI includes interactions between worker and entrepreneur skills, as we discuss below; O represents other factors affecting wages, i.e. controls for year, worker's gender, firm's industry and location; s is a worker specific effect; and ε is the error term. We estimate the wage equation with three specifications: specification (1) includes workers' skills (SW) and other controls (O); specification (2) adds entrepreneurial skills (SW); specification (3) introduces the interaction variables (SI).

Positive sorting means that more skilled workers will be matched with more skilled entrepreneurs. In terms of wages, this implies that more skilled entrepreneurs will command higher wages and the expected signs of β_2 are positive. The wage equation includes the interaction variables (SI) to test the existence of a non-linear relationship in the log Eq. (3). Furthermore, if the estimated coefficients are positive, then the high-skill worker benefits proportionally more than the low-skill worker from being employed by a high-skilled entrepreneur. The interaction variables only include education. For most workers and entrepreneurs, education is a pre-market accumulation of human capital, even though there is a potential bias if correlated with the error term (if the workers' specific effects do not fully capture ability heterogeneity). Tenure is specific to the observable employment relationship, and experience measures human capital accumulated in previous employment relationships.

The match between the entrepreneur and the workers implies that the entrepreneur's skills influence wages in two ways in our empirical setting. First, if we compare two firms differing only on the skills of the entrepreneur, the firm managed by the higher skilled entrepreneur will command higher productivity and thus higher wages. The wage increase due to entrepreneurial skills is specific to the match entrepreneur–worker and has a parallel with the effect of specific human capital accumulated with on-the-job experience (Becker 1962, 1964/1975; Topel 1991). The effect on wages comes from entrepreneur's skills contributing directly to production by interacting with workers' skills. The second influence of entrepreneur's skills on wages arises from the imperfect observability of workers' skills. Given the positive correlation between those skills and the skills of the entrepreneur—the positive sorting—the coefficients on entrepreneur's skills also capture the unobservable part of workers' skills.

We estimate the wage equation using two methods. First, we apply ordinary least squares (OLS) restricting the observations to the moment of firm creation. Second, we apply a fixed-effects longitudinal model. We face the usual issue of correlation between the regressors, most notably SW, and the unobserved components of the model. By using these two methods, we expect to reduce the inconsistency accruing from this correlation.

In the first method, workers appear in the estimation in the first year of employment in a new firm. The wages reported in the dataset correspond to October, thus only workers employed in firms created since November of the previous year enter in the regression. We aim to reduce the information asymmetry between the researcher and the entrepreneur concerning the unobserved (to the researcher) components of workers' skills. At the beginning of the employment relationship, the wage is set based on the skills that the entrepreneur can observe at the moment of hiring. As production takes place, the entrepreneur starts to learn about the unobserved workers' skills and wages will reflect this learning process.[15] The restriction reduces the bias arising from the unobserved skills of the worker. We do not claim to eliminate whole bias, but we argue that it is smaller than if we used firms of all ages. The restriction to firm entry has another advantage, that is, we are excluding those business

[15] The model does not account for a learning process about the workers' skills, but this is likely to exist, for example, as in Gibbons and Waldman (1999).

owners who may have acquired or inherited the firm, and thus achieving a definition of entrepreneurship closer to that on the management literature on new venture creation (e.g. Shane and Venkataraman 2000).

The second method applies fixed-effects estimation and controls for worker heterogeneity. The fixed-effects model identifies the coefficient on entrepreneur's education in two ways, namely, when the worker switches to a firm owned by an entrepreneur with a different education level; and when the worker does not switch employers, but the entrepreneur's education level increases. This latter case scenario is highly likely due to the low educational attainment of the Portuguese population, which is also present among entrepreneurs, though to a lesser extent. The reduction in the bias depends on the extent that the specific worker-effects capture the value (to the entrepreneur) of the unobserved workers' skills. The same reasoning applies to the identification of the worker's education.[16]

An important difference between our specifications and others present in the literature is that we introduce the entrepreneur's skills in the wage equation, and are not controlling for firm size (log number of workers). We have already discussed the reasons for using small firms, which limits the role of size. However, in the model, size is a consequence of a scale effect due to the entrepreneur's skills and we benefit from the advantage of having information about those skills. This argument is valid because we are abstracting from other reasons for higher wages associated with larger firms (as discussed in Sect. 2). Moreover, the use of small firms excludes the effect of entrepreneurial skills along dimensions harder to capture. In a mature business, the value of the match, even for new workers, reflects not only the capabilities of the entrepreneur, but also the organization's established routines (Augier and Teece 2006). As the firm ages, wages should change for the entrepreneur's early workers and for the newcomers. The restriction to new firms abstracts from this issue. In the fixed-effects estimation, though only for small firms, the effect of entrepreneurial skills may incorporate intangibles resulting from the combination of workers' skills within the organization, the intangible value of the organizational capital (Prescott and Visscher 1980).

[16] Though beyond the scope of the present paper, it would be possible to further extend our estimation model by considering several additional sources of unobserved heterogeneity, in line with Abowd et al. (1999) and, more recently, Dustmann and Pereira (2007), Abowd et al. (2010; unpublished work entitled, 'How important is endogenous mobility for measuring employer and employee heterogeneity?'), and Buchinsky et al. (2010).

5 Results

Table 6 presents the estimated results for firms' entry year while Table 7 displays the results of the fixed-effects model. Table 8 shows the interaction terms from specification (3) of both models. Estimations of specification (1) in Tables 6 and 7 with the workers' skills (SW) and other factors affecting wages (O) are only used for comparison, so as to verify that there is no abrupt change in the coefficients when estimating the other two specifications. The measures of workers' skills show the expected positive relationship with wages—education (positive), tenure (concave) and experience (concave).

Specification (2) introduces entrepreneur's skills into the wage equation. This specification reveals a positive correlation between wages and the entrepreneur's experience and tenure. The relationship between entrepreneurial experience and wages seems modest with both estimation methods. However, for the first year of firm life (Table 6), wages increase by 8 %, evaluated at the average entrepreneur's experience (28.7 years). Wages change by 1 % for 5 years and 3 % for 10 years of entrepreneurial experience, also at firm entry. For the fixed-effects estimation, the effect is close to zero. The effect of tenure is modest (<0.01 log points), even when evaluated at the average entrepreneurial tenure (6.4 years).

The estimation for the first year of firm life also reveals that the higher the entrepreneur's education level, the larger the wage premium collected by the worker (Table 6, specification 2). The impact on wages at firm entry is 17 % (exp(0.159 log points) − 1) for an entrepreneur with at least college education, 4 % for one with secondary education, and not significant for one with 9-year education. For the fixed-effects estimation (Table 7, specification 2), the 9-year education coefficient is significant, though <1 %. The coefficients for secondary and college education decrease to 2 and 5 %. The decrease of the education coefficients should be expected, given the within variation captured with the fixed-effect.

Table 6 Workers' wages and entrepreneur's skills: new firms (OLS), 1995–2003

Variables	(1) Worker skills	(2) Worker and entrepreneur skills	(3) Interaction of skills
Female	−0.1431***	−0.1451***	−0.1450***
	[0.004]	[0.004]	[0.004]
9-Years education	0.0748***	0.0667***	0.0702***
	[0.004]	[0.004]	[0.006]
Secondary education	0.1861***	0.1612***	0.1583***
	[0.006]	[0.006]	[0.010]
College education	0.6079***	0.5443***	0.4574***
	[0.019]	[0.019]	[0.040]
Experience	0.0156***	0.0151***	0.0151***
	[0.001]	[0.001]	[0.001]
Experience^2 × 10^{-2}	−0.0226***	−0.0220***	−0.0220***
	[0.001]	[0.001]	[0.001]
Entrepreneur skills			
9-Year education		0.0045	0.0131***
		[0.004]	[0.005]
Secondary education		0.0426***	0.0402***
		[0.005]	[0.005]
College education		0.1590***	0.1325***
		[0.008]	[0.010]
Experience		0.0027***	0.0027***
		[0.000]	[0.000]
Experience^2 × 10^{-2}		−0.0046***	−0.0045***
		[0.001]	[0.001]
Intercept	0.6809***	0.6369***	0.6394***
	[0.015]	[0.015]	[0.015]
Interaction of skills	No	No	Yes (see Table 8)
F test	255.43	237.57	202.83
Adjusted R-squared	0.233	0.244	0.246
Observations	47,171	47,171	47,171

Dependent variable is the logarithm of hourly wage at the moment of firm entry. *Tenure* is zero for all workers—regressions only include the first year of firms' life. Dummies defined for the *education* and *female* variables. *Experience* measured in years. All regressions include *year*, *industry* and *region* dummies. Panel A of Table 8 presents the interaction coefficients of specification (3). Standard errors are in brackets

*** Significant at 1 %

Table 7 Workers' wages and entrepreneur's skills: worker fixed-effects regressions, 1995–2003

Variables	(1) Worker skills	(2) Worker and entrepreneur skills	(3) Interaction of skills
9-Year education	0.1472***	0.1443***	0.1439***
	[0.001]	[0.001]	[0.002]
Secondary education	0.3006***	0.2942***	0.2932***
	[0.002]	[0.002]	[0.002]
College education	0.6026***	0.5877***	0.5799***
	[0.004]	[0.004]	[0.006]
Experience	0.0569***	0.0565***	0.0565***
	[0.000]	[0.000]	[0.000]
Experience^2 × 10^{-2}	−0.0264***	−0.0263***	−0.0261***
	[0.000]	[0.000]	[0.000]
Tenure	0.0035***	0.0034***	0.0034***
	[0.000]	[0.000]	[0.000]
Tenure^2 × 10^{-2}	−0.0123***	−0.0129***	−0.0129***
	[0.001]	[0.001]	[0.001]
Entrepreneur skills			
9-Year education		0.0076***	0.0077***
		[0.001]	[0.001]
Secondary education		0.0199***	0.0208***
		[0.001]	[0.001]
College education		0.0452***	0.0384***
		[0.001]	[0.002]
Experience		0.0005***	0.0005***
		[0.000]	[0.000]
Experience^2 × 10^{-2}		−0.0004**	−0.0004**
		[0.000]	[0.000]
Tenure		0.0002*	0.0002
		[0.000]	[0.000]
Tenure^2 × 10^{-2}		−0.0001	−0.0001
		[0.000]	[0.000]
Intercept	0.0082	−0.0025	−0.0017
	[0.008]	[0.008]	[0.008]
Interaction terms	No	No	Yes (see Table 8)
F test	3,717.39	3,247.43	2,769.48
Adjusted R-squared	0.163	0.164	0.164
Observations (number of workers)	1,771,258 (910,130)	1,771,258 (910,130)	1,771,258 (910,130)

Dependent variable is the logarithm of hourly wage. Dummies defined for the *education* variables. *Tenure* and *experience* measured in years. All regressions include *year*, *industry* and *region* dummies. Panel B of Table 8 presents the interaction coefficients of specification (3). Standard errors are in brackets

* Significant at 10 %; ** significant at 5 %; *** significant at 1 %

Furthermore, in the estimation restricted only to the first year of firm life, entrepreneurial skills play the central role but, as the firm ages, the entrepreneur makes adjustment decisions over time, reflecting a process of organizational learning (Cangelosi and Dill 1965; Fiol and Lyles 1985) and acting as a core element of strategic management (Teece et al. 1997; Eisenhardt and Martin 2000).

Table 8 presents separately the coefficients of the interaction variables introduced in specification (3) of Table 6 (Panel A) and Table 7 (Panel B). Three

Table 8 Interaction of entrepreneur's and worker's education, 1995–2003

Variables	Entrepreneur education		
	9-Years education	Secondary education	College education
Panel A: New firms (from model (3) in Table 6)			
Worker education * Entrepreneur education			
9-Years education	−0.0224**	0.0014	−0.0886
	[0.009]	[0.015]	[0.067]
Secondary education	0.0169	−0.0024	0.0994*
	[0.011]	[0.012]	[0.056]
College education	0.0127	0.0504***	0.1680***
	[0.017]	[0.019]	[0.048]
Panel B: Worker-fixed effects (from model (3) in Table 7)			
Worker education * Entrepreneur education			
9-Year education	−0.0014	0.0012	0.0134*
	[0.002]	[0.003]	[0.008]
Secondary education	−0.0004	−0.0037	0.0145**
	[0.003]	[0.003]	[0.007]
College education	0.0117***	0.0167***	0.0121**
	[0.003]	[0.003]	[0.006]

Dependent variable is the logarithm of hourly wage. Dummies defined for the *education* variables. See notes in Tables 6 and 7. Standard errors are in brackets

* Significant at 10 %; ** significant at 5 %; *** significant at 1 %

different types of variables account for specific interaction effects between entrepreneur's and worker's levels of education. Generally, the coefficients are significant only when the entrepreneur or the worker hold a college degree. The evidence is mixed, but seems to indicate that workers with a college education benefit more from the education of the entrepreneur.

The estimation results are consistent with the predictions of the matching model. We show that there is a positive relationship between entrepreneurial skills, mainly determined by education, and workers' wages. The interaction coefficients—between the entrepreneur's and workers' education level—indicate that more educated workers benefit more from the entrepreneur's education, though mainly at the college education level. The results rest on the assumption that our two estimation methods reduce the bias coming from the possible endogeneity of the regressors. Restricting to firms with <50 workers allows us to argue that the scale effect comes essentially from the entrepreneurial skills. We set the size restriction so as to be able to abstract from other issues associated with the management and internal organization of larger firms. Replacement of the usual measures of firm size with entrepreneurial skills in the wage equation provides a direct way to understand the value of the entrepreneur–manager to workers in small firms. Moreover, these results arise while controlling for industry and firm location, precluding an explanation based solely on technology and local labor market conditions.

6 Conclusion

This study contributes to the understanding of how small firms are organized and managed. We test an entrepreneur–worker matching model in small firms where individual skills play a central role. We provide evidence on the matching process between the workers and the individual who owns and manages the firm. The model assumes the existence of complementarities between the workers' and entrepreneur's skills. We use a longitudinal matched employer–employee dataset with information on workers, firms and entrepreneurs. The sample was restricted to firms with <50 employees and with a sole entrepreneur–manager. Skills are measured by education, labor market experience, and tenure.

In the firms studied, the descriptive analysis shows that entrepreneurs are more skilled than workers—skill stratification—and more skilled entrepreneurs manage larger firms—scale effects. Estimates of the matching probabilities also indicate the existence of positive sorting between workers and entrepreneurs. The empirical analysis provides results consistent with the matching model, i.e. the estimation of wage regressions shows that the higher the level of education and experience of the entrepreneur, the higher the wage premium for workers. We argue that our estimation methods are a viable estimation strategy to identify the parameters of the wage equation. While the restriction to sole ownership is justified by the need to identify the entrepreneur's locus of control, the restriction to small firms is at the cornerstone of our analysis. Expanding the analysis to larger firms would not allow for a comparable level of confidence in the identification of the parameters associated with

entrepreneurial skills. A grey area remains as skills are only partly observable by the researcher. Devising an estimation model to allow for greater precision in measuring and identifying skills is one of the possible extensions to our work.

The high mortality of small businesses is a concern for policy-makers, as entrepreneurship is considered a route out of disadvantageous economic conditions. Our results stress that workers' wages reflect the value of the match with entrepreneur's skills. Thus, entrepreneurial skills have an impact not only on job creation, but also on the quality of jobs created. When promoting entrepreneurship, policy-makers should not only look at the potential value of the business idea, but also at the skills of the entrepreneur.

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