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ORGANIZATION OF PRODUCTION AND THE DISTRIBUTION OF LABOR INCOME IN SPAIN*

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This paper examines evidences of market labor income inequality in Spain, as if they were the outcome of the market equilibrium from occupational choices of individuals with different general skills. We find that the parameters of the distribution of skills, production technology, and internal organization of firms that match the observed organization of production (number of persons occupied as employees, entrepreneurs-managers and solo self-employed, distribution of firm sizes) in Spain, also explain reasonably well the distribution of market labor income, within groups and for all occupied individuals together. The proposed model can be of use in evaluating the potential consequences for labor income inequality of changes in the organization of production.

Key words: income inequality, occupational choices, scale economies of skills, organizational size diseconomies.

JEL classification: D31, J24, L25.

The topic of income and wealth inequality has been on the agenda of economists and other social scientists for a long time[1]. Comprehensive studies of income and wealth inequality around the world, especially Thomas Piketty's (2014) book, *Capital in the XXI Century*, but also Milanovic (2005), together with the highly influential academic work of Atkinson (2015), have made inequality a dominant topic in the social, political, and economic debate. The generalized high –and rising– income inequality documented in publications like the recently released World Inequality Report 2018 [Alvaredo *et al*. (2017)], elaborated

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(1) See Atkinson (1997) for an excellent review of early economic research in income distribution and inequality.

under the intellectual influence of Piketty's work, will feed the interest in income inequality in the years to come. This paper presents a conceptual framework for the study of income inequality based on occupational choice models [Lucas (1978)]. Although the paper uses Spanish data to calibrate the parameters of the model and to compare and contrast some of the theoretical results, the exposition intends to offer new and generalizable insights into the determinants of market income inequality that are not contemplated in the dominant macroeconomic views.

Studies on income distribution vary depending on the nature of the income being measured (market income or disposable income, labor income or income from labor and capital), on who are the income earners (individuals or households), and on the inequality measures being used (the GINI coefficient or income of the top 1%). This paper focuses on the determinants of the distribution of income of individuals who contribute with their skills, time, and effort to the production of goods and services sold in consumer markets. Thus, "income" in this paper accrues to individuals, not to households, it includes only labor income, and the earned income is the result of supply and demand conditions.

From a social welfare perspective, the disposable income of households can be considered more important than individual market income in the analysis of income inequality. After all, disposable income is directly related to consumption that will ultimately determine individual wellbeing, and the consumption takes place primarily in households[2]. However, we believe that a better understanding of the sources of income inequality immediately related to market conditions (income before taxes and subsidies) is important for several reasons. First, in many households the market income will be the most important determinant of the disposable income. Second, with some hypotheses on the ownership of capital used in production together with labor, the analysis presented here could be extended to include all market income, i.e. labor income and income earned from the ownership of productive capital. Third, there will be, necessarily, political and economic limits to the redistribution of income through taxes and subsidies so that, at some point, policy efforts must shift the attention towards how to influence the distribution of income in its origination, and not so much on income redistribution policy. Taxes and subsidies create distortions in the allocation of resources and can affect the incentives to work and invest and, eventually reduce the wealth created. A better understanding of the importance of market forces, combined with organizational and technological decisions about production by firms, as determinants of market income inequality, will open new avenues for the thinking and policy actions concerning the distribution of income and wealth.

Another feature of economic research on income inequality is that the macroeconomic approach dominates in both, theoretical and empirical research [Jones

(2) There exist several comprehensive studies on income distribution in Spain. For example Prados de la Escosura (2008), Arranz and Garcia-Serrano (2014), Ayala Cañón (2016) and Goerlich- Gispert (2016), adopting mainly a long-term comparative perspective and use household disposable income data. The work of Goerlich-Gispert (2016) provides detailed evidence with Spanish data of the gap between income inequality calculated with market labor income data, and income inequality calculated with household disposable income, including imputed income from consumption of subsidized public goods such as education and health. Arellano and Bover (2013) present evidence on income inequality from the survey on financial conditions of Spanish households.

(2015)]. Piketty's (2014) three laws of Capitalism as the drivers of income and wealth inequality, is a good example of the dominant intellectual framework. In reality, however, most of the income is generated and distributed at the microeconomic level. The salaries of employees, the profits of business owners, the incomes of solo self-employed, and the rents of capitalists, all come from production and sales activities that take place in firms and other organizations. How many firms comprise total production? How do producing firms differ in size? How competitive are the product and input markets? What are the incentives to self-employment? Who are the owners of the businesses… will have a lot to say in the distribution of income, particularly in the distribution of market income, yet they are generally ignored in the dominant analyses of income inequality [Davis (2017)].

This paper adapts existing (micro) economic theories of occupational choices to model the distribution of market labor income in a frictionless economy. So far, the application of the occupational choice model to study income inequality has been limited to explaining the compensation of top managers [for example Rosen (1982), on why managers' compensation is positively correlated with the size of the firm, and Rosen (1981), on the earnings of "superstars"], under a partial equilibrium approach. This paper extends Rosen's model to account for the occupational group of the solo self-employed, solves for the distribution of income of all occupied individuals, as well as within each occupational group, and adopts a general equilibrium approach.

Individuals with different levels of general skill choose to work as employees, as solo self-employed, or as entrepreneurs-managers until the market equilibrium is reached where no individual wants to change occupation. The relative size of occupational groups, together with the size distribution of production units under the direction of entrepreneurs managers in the market equilibrium, jointly determine the organization of production *and* the distribution of income in the economy from market forces. Then, our first important insight is that the factors that explain the organization of production, as defined here, are the same factors that explain inequality in the economy-wide distribution of labor income. Next, we calibrate the parameters of the model with data on sizes of the occupational groups in Spain, and use the calibrated parameters to evaluate inequality in the distribution of labor income that comes out of the same market equilibrium. Finally, we compare the income-inequality values calculated from the model with published data on actual values of income inequality in Spain. The comparison provides a first assessment of the usefulness of occupational choice models in explaining observed market labor income inequality.

Consistent with the dominant macroeconomic approach, the high and rising income inequality around the world has been explained with arguments such as these: the evolution towards less redistributive income and wealth taxation policies; the globalization of production and trade; labor market reforms that weaken the bargaining power of workers; the expansion of private capital and contraction in the public sector [Alvaredo *et al*. (2017)]. These and other more idiosyncratic reasons, for example the steep rise in unemployment with the onset of the financial and economic crisis, are generally accepted as explanation of the high and rising income inequality in Spain (see references in note 2).

In the model proposed here, labor income inequality is determined by pure market forces in interaction with the distribution of skills in the population, the characteristics of the production technology and the internal organization of firms. Only one market friction is considered, the introduction of a minimum wage. The minimum wage is used mainly to differentiate between voluntary and involuntary solo self-employment and not to address policy issues. We are aware that institutions and government interventions in the economy affect the output, along with income distribution outcomes, and this is one reasons why, at this point, the research should not be viewed as an attempt to explain income inequality in Spain, but simply as evidence that market forces may have much to say in explaining market income inequality.

The rest of the paper is organized as follows. In section 1, we present a review of the related literature and highlight the distinct features of our approach. Section 2 presents the basic model on organization of production and the characterization of the market equilibrium from occupational choices. Section 3 explains the calibration of the parameters of the model, with data on sizes of occupational groups in Spain and solves for labor income inequality measures that result from the occupational choice equilibrium. In Section 4, we compare the predicted values of inequality indicators from the model, with published evidence on income inequality in Spain. The Conclusion summarizes the important features of the micro foundations of income inequality proposed in this paper, and outlines extensions for future research.

1. Literature review

Occupational choice models [Lucas (1978)]explain the organization of production in the economy as the outcome of competition among entrepreneurs with different skills, for the control of direct employees and capital services deployed in the production of goods and services sold in the market. In Lucas' (1978) pioneer paper, individuals differ in entrepreneurial skill levels and entrepreneurs contribute to production with the quality of their strategic decisions (increasing with their respective skills). Lucas' main interest is to explain the distribution of firm sizes, i.e., why do sizes and growth rates of firms differ the way they do. The conventional explanation of the size of the firm, based on production cost minimization and convergence to the efficient production scale, cannot explain the persistent heterogeneity of firm sizes and productivity within the same industry and market. The alternative explanation of the actual organization of production as the equilibrium allocation of productive resources among entrepreneurs-managers of different skills competing for the control of these resources, responds directly to the issue of heterogeneity in firm sizes.

One limitation of the Lucas model was that it ignored the internal organization of firms and by doing so ignored some of the functions of entrepreneurs-managers other than simply making strategic decisions on what to produce and how. Rosen (1982) points out that a firm tends to be organized in multiple layers (hierarchies) for control and supervision purposes. The function of the entrepreneur-manager is to make strategic decisions, as in Lucas, but also to assure that employees correctly execute the decisions of management. The entrepreneurial-strategy formulation function has scale economies of skills assigned to top management positions, while the supervision function has decreasing returns to the size of the supervised group (organizational size diseconomies). The decreasing returns to scale in the production function that Lucas assumes ad hoc, in Rosen's formulation emerges as a direct consequence of decreasing returns in the supervision function of the entrepreneur [Calvo and Wellisz (1979)]. Rosen's main interests is to explain why higher-skilled managers earn higher salaries and manage larger firms, i.e. to explain the widely-observed positive correlation between managerial compensation and the size of firms [Gabaix and Landier (2008); Kaplan and Rauh (2013)].

The application of occupational choice models to studying inequality in the distribution of income for all occupied individuals requires extending the original models in several ways. The first extension consists in the distinction between individual skills used in operational jobs and skills used in entrepreneurial and managerial jobs. Lucas (1978) assumes that individuals only differ in their entrepreneurial skills and, therefore, all those working as employees in operational jobs earn the same salary. Consequently, in the Lucas model, the only differences in labor income will occur within the group of entrepreneurs-managers. In our model, individuals differ in the amount of general skill that is applied to production in operational jobs, or in entrepreneurial functions. Then, individuals with different skills earn a different income within both occupational groups, the employees occupying operational jobs and the entrepreneurs-managers. The second extension is to allow for the third occupational choice of solo self-employed, i.e. self-employed individuals who do not hire employees and who use their own general skill in both, entrepreneurial and operational tasks. With the solo self-employed, the model gains realism in the explanation of both the organization of production and the distribution of income. Finally, we add capital as a third resource input used in production, together with the operative labor input of the employees and the managerial labor input provided by the entrepreneurs-managers.

Even though the model introduces certain generalizations, tractability concerns still impose some restrictive assumptions. There is no uncertainty regarding the payoffs, and the agents have symmetric information; thus, in contrast to Khilstrom and Laffont (1979), the risk preferences of individuals and the transaction costs play no role in the analysis. Second, the distribution of general skills in the population (which will be the result of differences in innate abilities, past education, and work experience) is given in our analysis. Banerjee and Newman (1993) model the occupational choices made by those who borrow against collateral to invest in entrepreneurship (imperfect financial markets), but leave aside the issue of income inequality. Wu (2017) extends Lucas's (1978) occupational choice model to situations of moral hazard in contracting between owners and managers in organizations, but in that analysis individuals only differ in entrepreneurial skill levels, and what matters is the difference between the compensation of managers and that of employees.

Galor and Zeira (1993) study income inequality in a model in which individual skills are acquired by investing in human capital, and financial markets are imperfect, so borrowers must pledge collateral to obtain finance; for this reason, only those with sufficient endowed or inherited wealth can acquire the funds needed to pay for the investment in human capital. The model is useful in explaining the link between the distribution of wealth and the distribution of income, but does not solve the occupational choice equilibrium.

Garicano (2000) models the equilibrium in occupational choice models, modifying the function of entrepreneurs-managers from the supervision and control function assumed by Rosen (1982), to the function of helping direct employees in solving complex production problems. The internal organization of firms responds to a knowledge hierarchy, not to a hierarchy of power and control. One important prediction of the knowledge hierarchy approach is that higher-skilled managers will prefer to hire higher-skilled employees, and that differences in salaries of employees will be more than proportional to differences in their skills. This prediction contrasts with that of Rosen's model where entrepreneurs-managers see the operational skills of all employees as perfect substitutes so skills used in operational jobs occupied by employees will all have the same unit price. Garicano and Rossi-Hansberg (2006, 2015) apply the knowledge hierarchy view of the internal organization of firms to explain some regularity observed in wage compression and income polarization in recent years, especially in the US. In particular, they claim that the knowledge hierarchy explains better than does the control hierarchy why the ratio of percentiles 90 and 50 of hourly wages, P90/P50, in the US increases over time, while the ratio P50/P10 remains stable.

Our model is an extension of Rosen (1982) and, for this reason it views the internal organization of firms as a control hierarchy with one or multiple layers. Our model also differs from the knowledge hierarchy models in the introduction of capital as a production input, and the distinction between voluntary and involuntary solo self-employment by introducing a minimum wage. Finally, our empirical reference is the Spanish economy, not the US economy.

Another related literature investigates income inequality within occupational groups of salaried employees [Katz and Artur (1999); Arranz and García-Serrano (2014); Casado and Simón (2015); Bonhomme and Hospido (2017)] and the self-employed [Parker (1999); Goerlich Gisbert (2016)], and within the group of top income earners [Alvaredo and Saez (2009); Alvaredo (2013); Jones (2015); Aoki and Nirei (2013); Aguinis *et al*. (2018)]. In this paper, we provide some foundations on why income inequality differs within each occupational group, and on why the distribution of income at the top can be, at first glance, modeled as a Pareto distribution, as is generally done. The evidence of income inequality in Spain, published in some of the references listed above, will be compared with the predictions on income inequality from the theoretical model, as a preliminary test of our hypothesis that occupational choice theory provides a good explanation of the determinants behind labor income inequality.

2. Organization of production and market equilibrium

2.1. Production function

The total working population in the economy is normalized to one. Individuals differ in the quantity of general skill q that each is endowed with[3]. The cumulative distribution of skills in the working population is given by the function $G(q)$ de-

(3) The "general" skills to which we refer throughout the paper can be assimilated with the cognitive skills that the large scale and cross-country projects sponsored by the OECD (IALS, ALL, PIAAC) and the World Bank (STEP) have attempted to obtain comparable measures of skills since the mid-nineties. The cognitive skills in turn include literacy, numerical and problem solving skills. Non-cognitive skills that can also be assimilated with the notion of general skills include perseverance, self-control, communication skills, etc. [Broecke (2016)].

fined in the range of values of q, $[q_m, q_M]$. Each individual in the working population chooses one of the three possible occupations, entrepreneur-manager, solo self-employed and employee. The choice will be based on the criteria of income maximization (the disutility of work is assumed to be the same in the three occupations). We now explain how the income earned in each occupation is determined.

The production problem of an *entrepreneur-manager* who hires employees involves two steps. In the first the entrepreneur converts the general skills of employees into homogeneous units of skills that will be the units of direct labor used in production. Next, the homogeneous units of labor input are combined with capital services and with the quality of the strategic decisions of the entrepreneur and, with a given production technology, all inputs are converted into a level of output of a production unit commanded by an entrepreneur of given quality.

The homogenization of the operational skills input works as follows (Rosen, 1982). Entrepreneurs convert operational skills supplied by the employees they hire into homogeneous units of labor input, by allocating part of their skill-weighted working time to supervising the activities of the employees. An employee identified by sub-index i with general skills q_i, together with an entrepreneur of general skills q who assigns t_i units of working time to supervise the employee "produce" l_i units of homogeneous labor input according to the function, $l_i = f(qt_i; q_i)$, where $f(\ )$ is a linear homogeneous, increasing and concave function with inputs qt_i and q_i. Adding up the homogenized labor inputs from all employees under the direction of an entrepreneur of skill q, we obtain $L(q) = \sum_i f(qt_i; q_i)$.

The entrepreneur decides the allocation of total working time $T = 1$, among the supervised employees so that $L(q)$ is maximized. This happens with values of t_i that satisfy the condition $t_i/q_i = T/Q$ for all i, where $Q = \sum_i q_i$. In the optimal solution, the entrepreneur allocates supervision time among employees proportionally to the general skills of the respective employee (entrepreneurs assign more supervision to more-skilled employees than to less-skilled ones so that the marginal productivity of supervision time is homogenized among all employees). In the optimal solution, the units of homogeneous labor input from employees working under the supervision of an entrepreneur with skills q is given by (using the linear homogeneous property):

$$L(q;Q) = \sum_i q_i f\left(qt_i/q_i;1\right) = Q\phi\left(qT/Q\right) \qquad [1]$$

The function $\phi(x) = f(x; 1)$ satisfies the conditions $\phi'(x) > 0$ and $\phi''(x) < 0$, given that $f'(x)$ and $f''(x) < 0$.

In the second step, the homogenous units of operational skills from all employees are combined with capital input services K to produce output that will be sold in the market according to the production function, $Y = qF(L(q; Q); K)$. The first term q on the right- hand side is the contribution to total output from the quality of the decisions of the entrepreneur-manager about what to produce and how (strategic decisions), proportional to his/her level of general skills. The production function satisfies the conventional conditions of being an increasing and concave function in input quantities.

Given the output selling price p normalized to 1, and the market prices of capital services, c, and of the unit of operational skill, w, the entrepreneur of skill q solves for the profit-maximizing input quantities and resulting optimal profit:

$$\Pi^*(q;w) = \underset{Q,K}{Max}\,\Pi(q) = q\,F\big(L(q;Q);K\big) - cK - wQ$$

The optimal demand of operational skills and capital services by the entrepreneur of skill q, $Q^*(q, w, c)$, $K^*(q, w, c)$, will be decreasing with the unit price of skill, w, and with the cost of capital, c, and increasing on his/her own skill, q.

When an individual with general skills q works as *solo self-employed* the quantity of skill q will be the only labor input, combined with capital services used in production. The solo self-employed would choose the level of capital input that maximizes net income:

$$R^*(q) = \underset{K}{Max}\,h(q)\,F(q;K) - cK$$

Where, in general, $h(q) \leq q$, the effect of the quality of entrepreneurial decisions on output produced, is expected to be less than or equal to the effect in the case of hiring employees, since with employees, the entrepreneur has more possibilities for specialization.

An individual of skill q working as an *employee* will earn the salary $S = w\,q$.

2.2. Minimum salary

Let S_{min} denote the legally established minimum salary that an entrepreneur-manager must pay to an employee. For a market price per unit of skill w^*, only individuals with skills above the value of q_0 given by

$$q_0 = \max\left(\frac{S_{\min}}{w^*}, q_m\right),$$

will be hired as employees. Those individuals with skills lower than the minimum threshold will either be unemployed or work as solo self-employed. Since this choice is the consequence of the impossibility of finding a job as employees, the low-skilled solo self-employed individuals will be called *involuntary* solo self-employed.

2.3. Market equilibrium

The market equilibrium, if it exists, will satisfy these conditions:

i) each individual chooses the occupation that gives the maximum possible income, $Max\,\{w^*q, R^*(q), \Pi^*(q)\}$, and therefore no one wants to change occupation; and

ii) the price per unit of operational skill, w^*, is such that the supply of operational skills from those who want to work as employees is equal to the aggregate demand for these skills by employers.

In the Appendix, we present in detail the market equilibrium solution for the following explicit Cobb-Douglas type functional forms:

$$
\begin{gathered}
f\left(qt_i;q_i\right)=\left(qt_i\right)^{\beta} q_i^{1-\beta} \\
L\left(q;Q\right)=q^{\beta}Q^{1-\beta} \\
Y=\theta\, q\left(q^{\beta}Q^{1-\beta}\right)^{1-\mu} K^{\mu}=\theta\, q^{\alpha}Q^{\rho}K^{\mu}
\end{gathered}
\tag{2}
$$

where $0 < \beta < 1$, $\alpha = 1 + \beta\,(1 - \mu)$, $0 < \rho = (1 - \beta)\,(1 - \mu) < 1$ and $0 < \mu < 1$.

The parameter θ captures the total factor productivity (TFP) component of the production technology, the parameter ρ is the elasticity of output to the quantity of operating skills supplied by employees, and μ is the elasticity of output to the quantity of capital services. The production technology exhibits decreasing returns to scale of operational labor skill and capital, $\rho+\mu < 1$, as long as $\beta > 0$. The decreasing returns increase with β, that is, with the intensity of the skill-weighted time of the entrepreneur in the supervision of the employees in each job position. The internal organization of firms will determine the value of β; for example, in more decentralized organizations, the supervision will be less intense and the value of the parameter is expected to be lower. In this context, β is considered in this paper a measure of organizational size diseconomies.

The production function of a solo self-employed with general skill q is given by:

$$
Y=\theta\, k\, q\, q^{1-\mu}K^{\mu}=\theta\, k\, q^{2-\mu}K^{\mu} \tag{3}
$$

with $k \leq 1$.

Finally, the general skills, q, are distributed among the population according to a lognormal distribution (the log of q will be normally distributed with mean λ and standard deviation σ).

The market equilibrium, where all individuals choose their optimal occupation and demand for skills for operational jobs is equal to supply, is characterized by the following equations (in the unknowns w^*, q_1, and q_2):

$$
w^* q_1=\left(1-\mu\right)\left(k\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{1-\mu}} q_1^{\frac{(2-\mu)}{(1-\mu)}} \tag{4}
$$

$$
\left(k\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{1-\mu}} q_2^{\frac{(2-\mu)}{(1-\mu)}}=\beta\left(\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{\beta(1-\mu)}}\left(\frac{\left(1-\mu\right)\left(1-\beta\right)}{w^*}\right)^{\frac{(1-\beta)}{\beta}} q_2^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}} \tag{5}
$$

$$
\int_{q_2}^{\infty} Q\left(q;w^*\right)dG\left(q\right)=\int_{q_0}^{q_1} q\, dG\left(q\right) \tag{6}
$$

Where $Q(q, w)$ is the operational labor demand of the entrepreneur with skills q (equation [A3] in the Appendix), and $G(q)$ is the distribution function of skills, assumed lognormal in the computation of the equilibrium solution (see the Appendix for details). Equation [4] gives the level of skills q_1 for which it is indifferent working as employee or as solo self-employed; equation [5] gives the level of skills q_2 for which it is indifferent working as a solo self-employed or as an entrepreneur-manager who hires employees. Finally, equation [6] is the equality between demand and supply of operational skills.

In equilibrium, individuals with skills in the interval $q_0 \leq q \leq q_1$ work as employees; those with skills in the interval $q_1 \leq q \leq q_2$ work as solo self-employed, and those with skills $q \geq q_2$ will be the employers.

3. Predictions of the distribution of market labor income

3.1. Calibration of the parameters of the model

The list of parameters for the calibration includes: the general TFP, θ; the user cost of capital, c; the relative labor intensity of the production technology, μ; the organizational size diseconomies, β; the relative production efficiency of the solo self-employed, k; the minimum salary $S_{\min}$; and the parameters λ and σ of the log-normal distribution of skills.

The value of the general TFP parameter in the production function is normalized to one, $\theta = 1$. The cost of capital c includes the financial opportunity cost plus the depreciation rate. A reasonable estimate of the real financial cost of capital, weighted for debt and equity, is 4%. From National accounts, the ratio of depreciation over total operating assets in Spanish non-financial corporations, NFC, is around 8%. Then our central estimate of the user cost of capital is $c = 12\%$. Also from National accounts, the ratio of total operating assets over value added, K/Y, in Spanish NFC is approximately 0.50. From the profit maximizing conditions $K/Y = \mu/c$; solving for the value of μ from $0.5 = \mu/0.12$, we set the elasticity of output to capital $\mu = 0.25$.

For the calibration of the value of the parameter β we use information on the distribution of firm sizes in Spain, compared with that in the US. The sum of elasticity of output to operational skills and capital inputs, $(1 - \beta)(1 - \mu) + \mu = \tau$, gives the level of scale economies in the production function. Estimates of τ for the USA are in the range of 0.8 to 0.9 [Guner *et al*. (2006)]. For a value of $\mu = 0.25$ this would imply a value of β between 0.2 and 0.3. The average size of firms in Spain is one third of the average size in the USA [Medrano *et al*. (2018)] and therefore β for Spanish firms will reasonably be higher than 0.3. Then we set $\beta = 0.4$ as our estimate of the organizational size diseconomies parameter for Spain.

The lognormal distribution of general skills in the population has two parameters, λ and σ. The parameter λ determines the location of the distribution in the horizontal axis and therefore the mean of the skills variable, while σ determines the dispersion of skills around the mean. The value of the mean of skills will depend on the generally arbitrary scale used to measure the level of skills (for example the PIACC project measures cognitive skills in a scale from 0 to 500). Moreover, the coefficient of variation of the lognormal distribution does not depend on the value of the parameter λ. For these reasons we set arbitrarily the value of $\lambda = 2$, while the value of σ will be calibrated with the empirical data.

We have left three parameters, σ, $S_{\min}$ and k. Their values will be calibrated from the market equilibrium conditions of the occupational choice model and data on the sizes of occupational groups in Spain, as reported by the Economically Active Population Survey (EAPS) of the Spanish official statistical office, INE. According to the survey data, the individuals occupied in the private sector of the Spanish economy are distributed as follows: 80% employees, 12% solo self-employed and 8% entrepreneurs-managers [Salas-Fumás *et al*. (2014)][4]. The official statistics do not distinguish between the involuntary and the voluntary solo self-employed. That is, we do not have official information on the numbers of highly skilled solo self-employed who voluntarily choose this occupation, and of the solo self-employed who concentrate in the lower tail of the distribution of skills because, in the model with minimum wage, they do not have sufficient skills to be hired as employees. The empirical evidence confirms that the two groups exist [IVIE (2008) for Spain; and Boegenhold and Fachinger (2007) for Germany]. The solution adopted in this paper to separate the solo self-employed into voluntary and involuntary is to use the data reported by the GEM Spain (2014) on necessity and opportunity entrepreneurs. The GEM Study reports that one-third of the respondents who state having started a business do so because of necessity. Taking this result into account, we assume that one-third of all the solo self-employed are involuntary self-employed, 4% of all occupied individuals, and two-thirds, the other 8%, are voluntary solo self-employed.

The calibrated parameters must be consistent with the market equilibrium where 80% of the individuals choose working as employees, 8% as entrepreneurs-managers, 4% as involuntary solo self-employed, and 8% as voluntary solo self-employed (observed proportions of individuals in each occupation group in Spain). Since all these proportions add to one, one of them is redundant. This means that we have three equations for the calibration of three parameters (σ, $S_{\min}$ and k).

In the Appendix, we show the market equilibrium equations [A6]-[A8] and the restrictions from the values of relative sizes of occupational groups from which we obtain the calibrated values of the parameters k, $S_{\min}$ and σ. Solving these equations numerically, we obtain the calibrated values of the three parameters $\sigma = 0.39$, $k = 0.67$ and $S_{\min} = 50$ (around 52% of the average salary of employees).

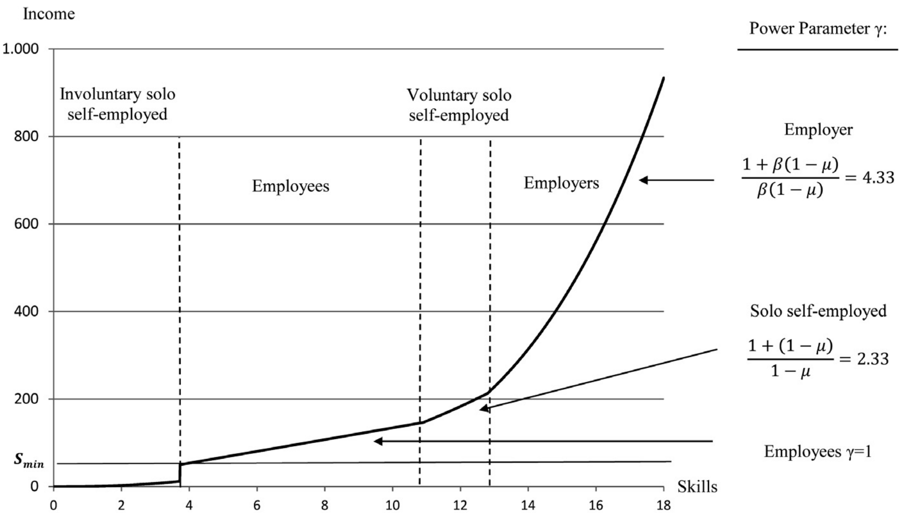
3.2. Market income distributions: graphical analysis

Figure 1 shows the labor income of individuals, salaries of employees, income of solo self-employed and profit of employers as a function of the respective level of general skills, in the equilibrium with the values of the parameter calibrated for the Spanish economy, including the minimum salary, $S_{\min}$. These income functions of skills, together with the distribution of skills in the population, will determine the inequality in the distribution of the labor market income.

The minimum salary implies a minimum skill required to work as an employee, q_0, equal to 3.72. The calibrated skill level that makes individuals indifferent between work as solo self-employed and work as an employee is $q_1 = 10.89$, and the level that makes them indifferent between working as solo self-employed and starting to hire employees is $q_2 = 12.79$.

(4) An entrepreneur who hires and manage employees can be the owner of the business or a professional manager with delegated strategy formulation and organizational functions. The occupational statistics distinguish between employees and self-employed; the latter are further divided into self-employed without employees and self-employed with employees (employers). The top professional managers are included among salaried employees. According to the model, top managers and employers perform the same managerial functions and therefore should belong to the same occupational group.

Figure 1: LABOR MARKET INCOMES IN EQUILIBRIUM AS A FUNCTION OF GENERAL SKILLS



Source: Own elaboration with the calibrated values of the parameters of the model.

The salary of employees is proportional to their skills with a factor equal to the equilibrium price per unit of skill, $w^* = 13.42$ in this calculation. The compensation of solo self-employed and entrepreneurs-managers as functions of skills are given by $R^*(q) = M_1 q^{\frac{(2-\mu)}{(1-\mu)}}$ and $\Pi^*(q;w) = M_2 q^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}}$, with values of M_1 and M_2 being a function of the parameters of the model according to equations [A4] and [A5] in the Appendix. Therefore, the compensations of self-employed and entrepreneurs-managers are power functions of skills, with power parameters increasing with the intensity of capital in the production technology, μ, and decreasing with the degree of organizational size diseconomies, β. For the calibrated values of the parameters with Spanish data, the revenue and profit functions are $R^*(q) = 0.56q^{7/3}$ and $\Pi^*(q; w) = 0.00339q^{13/3}$, respectively.

For the solo self-employed and the entrepreneurs-managers the compensation per unit of skill is an increasing, and in this case convex, function of the level of skills, $\frac{R^*(q)}{q} = 0.56q^{4/3}$ and $\frac{\Pi^*(q;w)}{q} = 0.00339q^{10/3}$. The return per unit of skill is then constant for the skills assigned to operational jobs by salaried employees, and increasing with the level of skills if assigned to entrepreneurial and managerial jobs. The price per unit of operational skills of employees is independent of the level of skills of the employee, since in the Rosen model, the optimal allocation of working time of entrepreneurs-managers among employees of different skills makes the operational skills of all employees perfect substitutes (the match of employees and managers is irrelevant). This is one of the important differences between the control hierarchy [Rosen (1982)] and the knowledge hierarchy [Garicano (2000)] internal organization of firms; in the latter, the unit price of skills in operational jobs increases with the level of skill, as it is optimal that more skilled employees work with more skilled managers[5].

The difference in the return per unit of skill between solo self-employed and entrepreneurs-managers occurs because the solo self-employed use their respective general skill in operational tasks and in making entrepreneurial decisions, while the entrepreneur-managers use their respective skills to make entrepreneurial decisions and to supervise the operational employees.

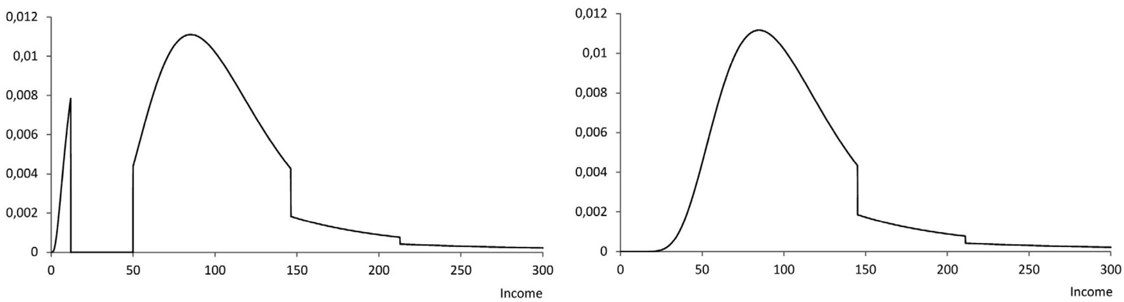
The distribution of market labor income in the population is the result of combining the income as a function of skills of Figure 1 (upper envelope), and the log-normal distribution of skills in the population Figure 2. The resulting labor income distribution is a power transformation of the distribution of skills, but the power parameter driving the transformation is equal to 1 in the interval of skills $[q_0, q_1]$, 2.33 in the interval $[0, q_2] \cup (q_1, q_2)$ and 4.33 in $[q_2, +\infty]$. If there is a legally established minimum salary, the lower tail of the distribution includes the income of the involuntary solo self-employed. Notice that no individual earns income values in the interval between $R(q_0)$ and $S_{\min}$ (the gap between the income of the more skilled involuntary solo self-employed and the legally established minimum salary).

Figure 3 shows the Lorenz curves of the distribution of skills, dashed curved line, and of the distribution of labor income, continuous line. The distribution of income would coincide with the distribution of skills if every individual earned a level of income proportional to his/her skill. The comparison of the two Lorenz curves illustrates the increase in labor income inequality resulting from the organization of production according to the assumptions of the occupational choice model, beyond that resulting from a distribution of income based only on differences in skills. The area between the diagonal line (zero inequality) and the corresponding Lorenz curve in Figure 3 is equal to one half of the corresponding GINI coefficient of income inequality.

The model says nothing on the distribution of ownership of productive capital, and therefore does not explain how the capital income, the cost of capital times the optimal capital stock in the equilibrium, will be distributed among individuals. The empirical evidence indicates that the labor income and the wealth of individuals are positively correlated and that the distribution of wealth is more concentrated than the distribution of income [Piketty (2014); OECD (2015)]. If high-labor-income individuals concentrate a relatively higher proportion of capital ownership then the distribution of total market income, from labor and capital, will result in greater inequality than inequality in labor income only.

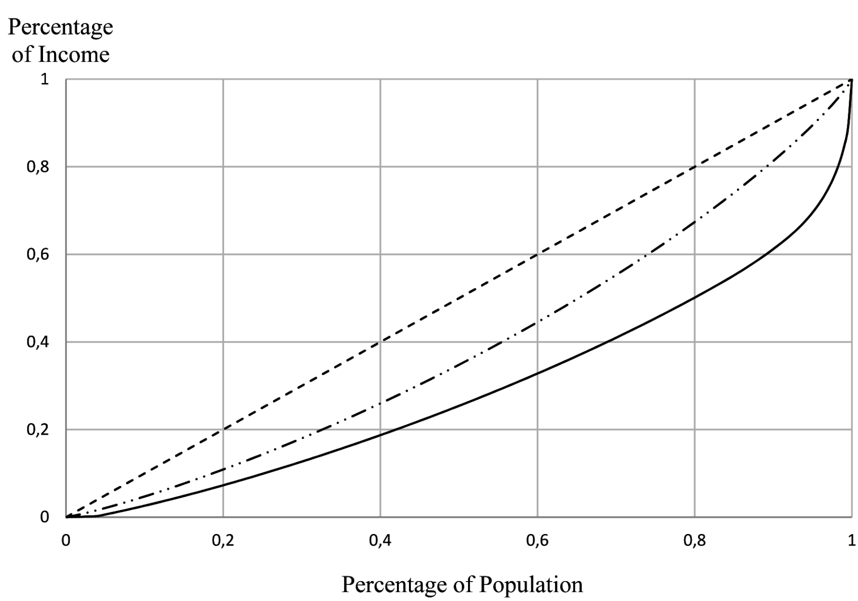
(5) In favor of the result that all operational skills have the same market price is the evidence reported by Mueller *et al.*, (2017) with data on differences in pay within multilayer hierarchical firms in the UK. The paper reports that larger firms exhibit higher internal pay inequality than smaller firms, but hierarchical levels where managerial skills are important drive entirely this result. The pay ratios of lower hierarchical levels, operational tasks, are invariant with respect to firm size.

Figure 2: LABOR INCOME DISTRIBUTION IN EQUILIBRIUM:
WITH A MINIMUM SALARY (LEFT) AND WITH NO MINIMUM SALARY (RIGHT)



Source: Own elaboration with the calibrated values of the parameters of the model.

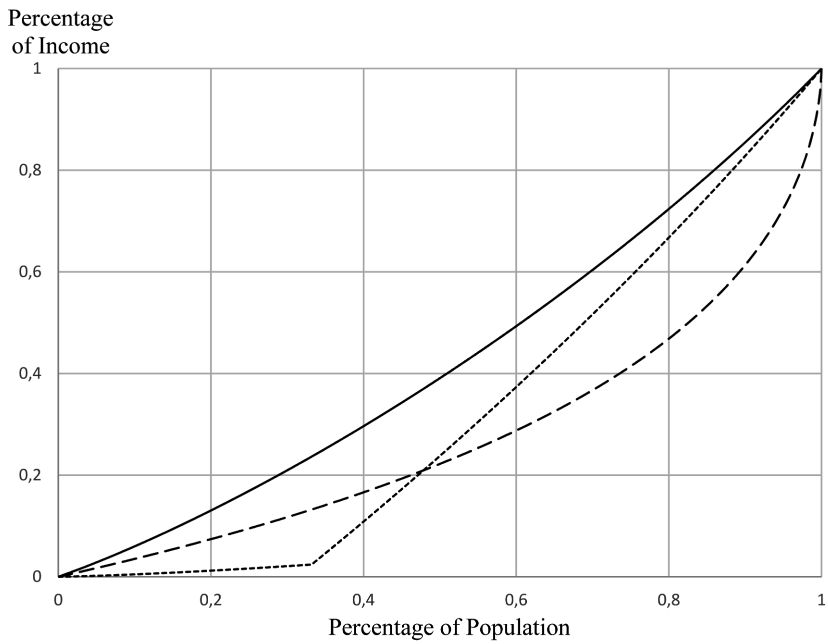
Figure 3: LORENZ CURVES OF MARKET LABOUR INCOME DISTRIBUTION
(CONTINUOUS LINE) AND SKILLS' DISTRIBUTION (DOT-DASHED LINE)



Source: Own elaboration with the calibrated values of the parameters of the model.

Together with the inequality in the distribution of market labor income in Figure 3, we present the Lorenz curves of the distribution of income within each of the three occupational groups: employees, solo self-employed, and entrepreneurs-managers, Figure 4.

Figure 4: Lorenz curves of market labor income distribution for the occupational groups of employees (continuous line), solo self-employed (dotted line) and entrepreneurs-managers (dashed line)



Source: Own elaboration with the calibrated values of the parameters of the model.

3.3. Market income distribution: simulated values

More detailed values of some important measures of income distribution from the market equilibrium, calculated with the calibrated values of the parameters, are presented in Table 1. The table has two columns: the first with values of output and inequality calculated from the market equilibrium in an economy with a minimum wage, and the second with values of variables in an economy without a minimum salary. The table shows: the functional distribution of income (the share of salaries of operational employees, share of income of the solo self-employed, share of income of employers and managers and share of capital income), the GINI coefficient of inequality in the distribution of skills, the GINI coefficient of the income distribution in equilibrium, the ratios of selected income percentiles (P90/P10 for example), and the shares of income for individuals at the top of the distribution (the top 1% for example).

Table 1: INCOME DISTRIBUTION AND INCOME INEQUALITY FROM THE PARAMETERIZED MODEL

	Min. salary $S_m = 50$	No min. salary
Total output (productivity)	188.23	190.05
Functional income distribution		
Salaries	40.42%	40.56%
Income SSE	7.63%	7.39%
Profits	26.95%	27.04%
Capital rents	25.00%	25.00%
GINI skills	21.77%	21.77%
Inequality labor only		
GINI All	41.64	40.57
GINI Employees	14.91	16.39
GINI Solo Self-employed	34.95	6.21
GINI Entrepreneurs-Managers	44.50	44.62
P90/P10	3.16	3.18
P90/P50	1.92	1.93
P50/P10	1.65	1.65
P99/P90	5.33	5.37
Share top 1%	15.43%	15.39%
Share top 5%	30.42%	30.35%
Share top 10%	38.78%	38.67%
Share low 10%	2.61%	3.53%

Source: Own elaboration with the calibrated values of the parameters of the model.

Introducing a minimum salary reduces the total output produced by approximately 1% (short-term efficiency loss). Moreover, it increases the overall inequality in the labor income distribution, the GINI index, from 40.57 to 41.64. This occurs mainly because the minimum salary excludes some individuals with low skills (4% of all occupied individuals in the private sector of the Spanish economy) from being employed as salaried employees and forces them to become (involuntarily) solo self-employed and earn an income lower than what they would earn as employees. Consequently, the GINI coefficient of the distribution of income within the group of the solo self-employed increases from 6.21 with no minimum salary, to 34.95 with a minimum salary. The minimum salary increases the equilibrium price per unit of skills used in operational activities by 0.45%. Therefore, individuals continuing to work as employees after the introduction of a minimum salary increase their salary income by the same proportion as the increase in the price per unit of skill. Entrepreneurs-managers, in contrast, earn lower profits with the minimum wage than without it, because the minimum wage raises the price of operational skills in the equilibrium.

According to Table 1, the functional distribution of income in the equilibrium that matches the observed sizes of occupational groups in Spain as follows: 40-41% of the gross value added corresponds to the salaries of operational employees; 7-8% is the income of the solo self-employed; 27% is the income/profits of entrepreneurs-managers; and 25% compensates for the capital services used in production. Taking into account the sizes of occupational groups (80% employees, 12% solo self-employed and 8% entrepreneurs-managers) the functional distribution of income implies that the average income per entrepreneur-manager is 6-7 times the average salary of operational employees. The top 5% (1%) of entrepreneurs-managers earn, on average, 1.78 (4.4) times the average income of the occupational group. An entrepreneur-manager in the top 1% of the labor income distribution earns on average around 30 times the average income of operational employees.

The GINI coefficient of the distribution of labor income in the population is 41.64, almost twice the GINI coefficient of the distribution of skills with parameters $\lambda = 2$ and $\sigma = 0.4$, equal to 21.77. In fact, the ratio of the two GINI coefficients can be interpreted as the amplifying effect on market labor income inequality, over the inequality in the distribution of skills, of the way production is organized in the economy (sizes of occupational groups, distribution of firm sizes). The GINI coefficients of the income distribution within each occupational group are the following: employees in operational jobs, 14.91, entrepreneurs-managers, 44.50, and solo self-employed (voluntary and involuntary together), 34.95. Since there is only one market equilibrium price per unit of operational skill, the GINI coefficient in the group of employees is equal to the GINI of the distribution of skills for only those individuals working as employees in operational jobs.

The results from the occupational choice model indicate that the distribution of income within the group of entrepreneurs-managers contributes the most to overall market labor income inequality. This is confirmed by the high income ratio P99/P90 = 5.3, i.e., the individual in the 99th percentile of the distribution of income earns an income more than 5 times the income of an individual in the percentile 90, compared with P90/P50 = 1.9, i.e. the income of the person in the 90th percentile of the distribution is less than twice the income of the individual in the 50th percentile. Notice, however, that the individual in the 99th percentile (P99) is an entrepreneur-manager, the one in P90 is a voluntary solo self-employed, and the one in P50 is a salaried employee. Since those compared belong to different occupational groups, and therefore each earns a different kind of income (profits, income from solo self-employment, and salaries).

4. Predictions of the model and evidence on income inequality in Spain

In this section, we compare observed data on income inequality in Spain with the values of selected measures of income inequality calculated from the market equilibrium conditions of the model, and the calibrated values of the parameters. The calibration of the parameters of the model is purposely made using observed data on the relative sizes of occupational groups in Spain since the main objective of the paper is not to explain income inequality in Spain but rather to respond to the question of whether the observed income inequality is compatible with the income inequality that results from a model explaining the sizes of occupational groups. We understand that the results from this comparison will provide a conclusion on the relationship between occupational choices, as modelled here, and market income inequality that is more robust than those obtained when observed income inequality is used in the calibration of the parameters of the model.

Whether the observed data on income inequality in Spain are compatible or not with the predictions from occupational choice models must be assessed taking into account that the theoretical model has not been calibrated to explain the observed data and, more importantly, with the difficulty of finding observed measures of income inequality that match the theoretical measures. For example, official statistics on the functional distribution of income distinguish between labor and non-labor income in the value- added of corporations, but the non-labor income is not further divided into cost of capital and economic profits that, in our model, represent the compensation of the entrepreneur-manager. Second professional managers, at high and at intermediate levels, are generally included in the group of salaried employees for the purpose of calculating wage statistics, for example in the Continuous Sample of Working Life and the Structure of Earning Survey, while, according to the model, they should be included in the group of entrepreneurs with employees (managers and entrepreneurs indistinctly perform the same tasks of directing the allocation of resources within firms). Finally, the official statistics report output, capital cost, and labor income of the solo self-employed as part of the activity in the household sector of the economy.

To illustrate the importance of these limitations in matching actual and predicted income data, consider the measurement of inequality with the ratios of income percentiles[6] PX1/PX2. If the individuals in the percentiles X1 and X2 are employees in operational jobs then the model predicts that the ratio PX1/PX2 will just be equal to the ratio of the percentiles of the respective skills qX1/qX2, since the price per unit of skill will cancel out. Wage inequality within the group of employees who occupy operational jobs is determined entirely by the distribution of skills within the population of this occupational group. However, if the individual in the percentile X1 is a person performing a managerial function and the individual in percentile X2 is an operational employee, then the ratio of incomes will be $\frac{PX2}{PX1} = \frac{\Pi^*(q_{X2};w)}{w^* q_{X1}}$ which will vary with the distribution of skills but also with all the other parameters of the model; this will complicate the explanation of differences in income inequality.

(6) We will denote the X1% income percentile by PX1 and the X1% skill percentile by qX1. For instance, P90 and q90 denote the 90th percentiles of the distributions of income and skills, respectively.

Finally, in our analysis, income is referred to an occupied individual while most of the empirical work on income inequality at the society-wide level is done with household income, adjusted or non-adjusted for differences in the size of the household. The household income is sometimes defined as pre-tax market income, from labor and from owned assets, financial and/or productive, and others such as disposable income, i.e. income adjusted for subsidies and paid taxes. Therefore, the comparison of the economy- wide measures of income inequality calculated from the theoretical model with those often reported with actual data will be complicated by the different unit of analysis, and by the nature of the income considered: all the market income or only the labor income, pre-tax income or after-tax disposable income.

4.1. Wage inequality

Table 2 shows, in the upper part, the wage inequality of selected countries, including Spain, calculated by the ratios of the percentiles P90, P50 and P10 of the wage distribution as reported by Eurostat (Structure of Earnings Survey). In the lower part we show the ratios of the percentiles of income from the market equilibrium calculated within the occupational group of operational employees, and calculated for all the population.

Table 2: Ratios of percentiles of the distribution of wage-income

	Observed data		
Countries	P90/P10*	P90/P50	P50/P10
Denmark	2.4	1.6	1.5
France	2.7	1.8	1.5
Germany	3.8	2.0	1.9
Italy	3.2	2.1	1.5
Portugal	4.4	2.8	1.5
Spain	3.3	2.1	1.6
Sweden	2.1	1.6	1.3
UK	3.8	2.2	1.7
Mean countries	3.21	2.02	1.56
SD countries	0.78	0.39	0.18
	Income Ratios predicted from the model†		
	P90/P10*	P90/P50	P50/P10
Employees only	2.1	1.4	1.5
All population	3.2	1.92	1.65

*P90, P50 and P10 are the 90th, 50th and 10th percentiles of the distributions of wages income, respectively.

† Ratios predicted from the model for the parameter values calibrated in section 3.

Source: Observed data, Eurostat: Structure of Earnings Survey. Income Ratios predicted from the model. Both 2014.

First, notice that P50/P10 wage ratios are more homogeneous across countries, with standard deviation of 0.18, than the P90/P50 ratios, with a standard deviation 0.39. This would be consistent with individuals in P50 and P10 occupying operational jobs in all countries, while individuals in the percentile P90 occupying managerial jobs in some countries and operational in others. The occupational choice model predicts that higher inequality in the distribution of skills will result in higher inequality in the distribution of income; for this reason, the lower P50/P10 wage ratios of Sweden and Denmark, and the higher of Germany and UK would be consistent with lower dispersion of skills in the former countries than in the latter.

The P50/P10 wage ratio for Spain, 1.6, is in line with the ratio of the other countries and in line with the ratios calculated from equilibrium solutions of the model: 1.5 if the ratio is calculated from the distribution of income of employees in operational jobs only, and 1.65 if the ratio is calculated from the distribution of income of all occupied individuals (remember that the employees are 80% of all the occupied). The predicted P50/P10 ratio compares well with the respective value of the ratio, 1.52, in the conditional wage distribution reported in Table A1 of Arranz and García Serrano (2014); with the range of ratios, 1.58 to 1.72 of Bonhomme for the time period 1997-2010, and with the ratios between 1.52 and 1.64 reported by Casado and Simón (2015) for the period 2002-2010, all calculated with survey data.

As said above, the values of the ratio P90/P50 in Table 2 are more heterogeneous across countries than those of the ratio P50/P10. Moreover, these ratios are higher than the value of 1.4 calculated from the model's distribution of wages within the occupational group of employees, and in line with the 1.92 value of the P90/P10 ratio calculated from the distribution of income for the whole population. Once again, in the context of the occupational choice model, the heterogeneity across countries and the difference between observed and predicted values of the ratio P90/P10 must be attributed to differential dispersion of skills, which determines the distance between the skill percentiles q90 and q50, as well as to the heterogeneity in the jobs occupied by individuals in P90 of the wage distribution. In our particular case, the individual in the P90 of the distribution of income for the whole population is a voluntary solo self-employed. The observed wage of the P90 for the different countries can well be the compensation of an employee performing managerial functions[7].

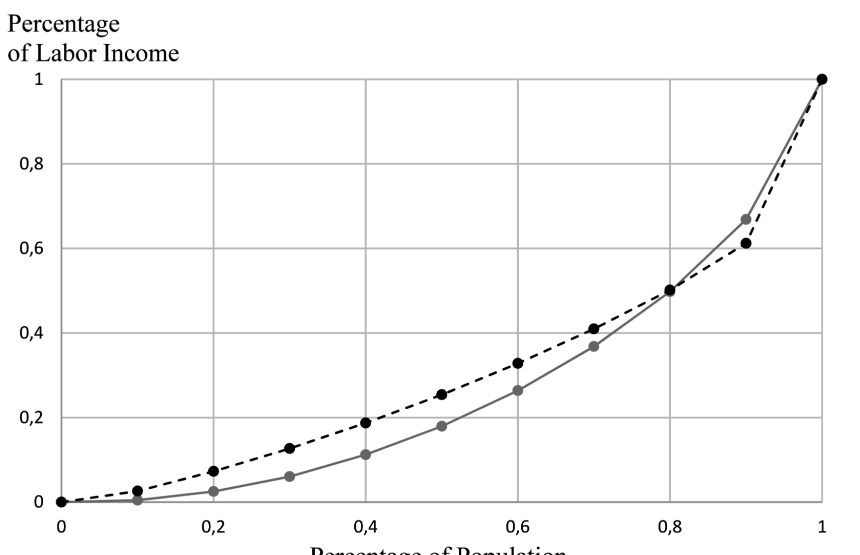
4.2. Income inequality for all occupied and within occupational groups

The GINI coefficient from the income distribution of the whole occupied population in Table 1 is 41.64. The OECD (2015) publishes a value of the GINI coefficient of 41 from the distribution of market labor income in Spain in 2013. Goerlich Gisbert (2016, Figure 3.9), with data from the Survey on Living Conditions, estimates a GINI coefficient from the distribution of gross monthly income of all occupied individuals in Spain (salaried employees and self-employed) between 36 and 38 in the period 2004-2013. The GINI coefficient published by Eurostat for Spain, before social transfers (excluding pensions), has a value of 40.

(7) If the comparison between observed and predicted wage inequality is restricted to percentiles P20 to P80 of the wage distribution as reported in Table A1 of Arranz and García-Serrano (2014), in the top or in intermediate hierarchical levels, the observed and predicted wage and income ratios are more similar than when P90 is included. Arranz and García-Serrano report that around 20% of the individuals in the database, presumably the highest paid, perform managerial functions.

Figure 5 shows the cumulative concentration of income for deciles 1 to 10 from the distribution of taxable labor income in Spain, and the cumulative concentration calculated from the distribution of labor income predicted by the model. The distribution with the income predicted by the model concentrates relatively more income at the top than the distribution with observed taxable labor income. There can be many reasons explaining this result given the caveats advanced earlier about the difficulties of making homogeneous comparisons. One of these is that the taxable labor income does not include the fraction of economic profit that the entrepreneurs-managers retain in the business, while the labor income recognized by the model will include all economic profits, distributed or not, as part of the labor income of entrepreneurs-managers. The distinction between part-time and full-time work, important in reality but not considered here, could also matter in explaining the differences between the two curves.

Figure 5: Lorenz curves of taxable labor income from Spanish tax files* (dashed line) and cumulative labor income predicted from the model (continuous line)



(*) Lorenz curve from Taxable Labor Income elaborated by Professor Fernando Rodrigo.

Source: Taxable Labor Income, Instituto de Estudios Fiscales – Panel de Declarantes del IRPF, 1999-2011. Prediction, Own elaboration with the calibrated values of the parameters of the model.

The third comparison focuses on income concentrated at the top of the distribution. Table 3 shows the percentages of income of the top 1% and 10% of the distribution, and the percentage of the bottom 50% for selected countries, including Spain, as reported by the World Top Income Data Base, and the proportions of labor income in the same brackets as predicted by the model. According to Table 3, the concentration of income (household market income before taxes, collected from tax files) at the top is substantially higher in the US than in Spain and France. In terms of the model, this evidence would be consistent with a higher dispersion of skills and/or a lower value of β in the US than in Spain or France.

Table 3: INCOME CONCENTRATION IN THE BOTTOM AND IN THE TOP OF THE DISTRIBUTION

Percentiles of income	Observed data for selected countries			Predicted by the model
	Spain	France	US	
0-50	n. a.	0.22	0.14	0.19
90-100	0.34	0.34	0.45	0.39
99-100	0.10	0.11	0.20	0.15

Source: Observed data from the World Income Inequality Data Base.

Predicted: own elaboration with the calibrated values of the parameters of the model.

The model predicts concentration of income in the top for Spain higher than the reported by the World Inequality Data Base, especially the income concentrated in the top 1%: 0.15 versus 0.10, although the observed value of the share of income concentrated in the upper 1% of the distribution reached a maximum of 0.125 in 2007. It could be that the model overestimates the labor income concentrated at the top of the distribution for Spain, or it could be that the data from the tax files used to calculate the distribution of pre-tax market income in Spain underestimates the income at the top (mainly economic profits that compensate the entrepreneurs-managers for their work).

Goerlich Gisbert (2016, Figure 3.9) reports separate GINI coefficients calculated from the distribution of labor income of full-time employees only, from the distribution of all occupied employees, and from the distribution of income of the self-employed individuals, with and without employees. The reported values of the GINI coefficients show that inequality is higher in the group of self-employed individuals, and lower in the group of full time employees. This order from higher to lower observed values of the GINI coefficient is consistent with the order of values of the GINI coefficient for each occupational group reported in Table 1. However, the GINI coefficient estimated for the group of employees in Table 1, 14.91, is lower than the GINI coefficient of 27 reported by Goerlich Gispert for permanent full time employees. Once again, the difference could be because Goerlich Gispert includes the managers in the group of employees while the model excludes them.

Other evidence from Goerlich Gispert (2016, Figure 3.9) is that, in the years of the crisis, the GINI coefficient from the employee income distribution decreases, while the GINI coefficient from the income distribution of all the occupied, in the same time period, increases. To compare this empirical evidence with the results from the model, we perform comparative statics on changes in the GINI coefficient of the income distribution of all occupied, and in the GINI index of the employees' income distribution, to changes in the value of the parameter θ (business cycle). The estimated elasticity of the GINI coefficients to an increase of 1% in the set value of $\theta = 1$, keeping the rest of parameters at their calibrated values, are: $-0.19 < 0$ for the GINI of the income distribution of the whole occupied, and +0.55 for the GINI of the distribution of income within the group of operational employees. Therefore, the model predicts that the GINI coefficient of the income of individuals in the group of employees with operational jobs will be pro-cyclical, while the GINI coefficient of the distribution of income of all occupied will be countercyclical. The evidence supports these predictions.

5. Conclusion

This paper models the distribution of market labor income as the equilibrium from occupational choices, work as employees, as solo self-employed, and as entrepreneurs-managers, of individuals with different general skills, under the criteria of income maximization. Next, the parameters of the model are calibrated with data on the sizes of occupational groups in Spain. Finally, the predicted values of different measures of income inequality from the model are compared with actual values of the same measures observed in studies of income inequality in Spain. Overall, the predicted and observed values of income inequality match rather well, especially when taken into account that information on income inequality has not been used in the calibration of the values of the parameters, meaning that occupational choice models may provide a good starting point to study the determinants of income inequality from pure market forces.

In occupational choice models, income of occupied people varies with their productivity and, in turn, productivity varies with skills. However, the productivity of skills in operational jobs differs from the productivity in management jobs, and also from the productivity of solo self-employed individuals. Technological and organizational factors determine the individual compensation in each occupation/function so, in the market equilibrium, the distribution of income differs within each occupational group. Consequently, the distribution of labor income for the whole population of occupied individuals will be determined by the distribution of labor income within each occupational group, and by the relative size of each group. Particularly important is the implication for income inequality at the top of the distribution of how differences in skills affect the productivity of entrepreneurs-managers in the context of the model. More skilled entrepreneurs-managers are more productive than less skilled ones in the two functions they perform, making strategic decisions and supervising the proper execution of these decisions. Nevertheless, the former function shows scale economies of skills (better quality of decisions increase the productivity of all resources under the direction of the entrepreneur-manager), while supervision and control show scale diseconomies. The supervision function is performed in an individual basis with a fixed supervision time that will have to be divided among many employees as the size of the organization increases. At some point, management-supervision of employees will be implemented with multilayer hierarchies, not contemplated in this paper.

The balance between the two forces –scale economies of quality in decisions and diseconomies of scale in hierarchical supervision and control–, determines the number of entrepreneurs-managers and the resources directed by each of them, the productivity of skills, and finally the compensation received (profits). Overall, under standard production functions, managers' compensation, in the form of economic profits, increases more than proportionally with skills, which explains the disproportional differences in compensation of top managers relative to the compensation of their employees[8]. These differences are expanded or contracted across the incomes of all occupied individuals, depending on the diseconomies of size from the supervision function of entrepreneurs, the value of parameter β, but in all cases income inequality in the equilibrium becomes greater than the inequality resulting from differences in skills only.

It is also remarkable that the occupational choice model solves simultaneously for the organization of production and for the distribution of labor income. In our simple model, the organization of production includes the number of production units with and without employees, and differences in firm sizes. The sizes of firms, in volumes of inputs and total output, are given by equations [A3] and [A4] in the Appendix. Sizes of firms and respective economic profits (the compensation of entrepreneurs-managers) both increase with the skills of their respective entrepreneur-manager; occupational choice models then provide an (efficiency) explanation of the positive correlation between sizes of firms and managers' compensations (a result already advanced in Rosen's original paper).

How robust are the results to the assumptions of the model? The answer is not definitive since, to the best of our knowledge, very few studies have yet applied occupational choice models to study income inequality. One pending issue in this respect is the claim by Garicano and Rossi-Hansberg (2015) that the knowledge hierarchy better explains some regularity in the evolution of income distribution over time than does the control hierarchy implicit in Rosen's model. The main regularity is the observed evidence with US data that the ratio of wages P90/P50 increases over time, while the ratio P50/P10 remains rather constant. The knowledge hierarchy explains this evidence with the argument that skills-intensive technological progress raises the price per unit of skill for highly skilled individuals while leaving it unchanged or lower for less skilled individuals. In the control hierarchy, there is only one price per unit of skill and if it changes over time, it will change equally for all individuals, the highly skilled and the low skilled.

However, the argument of Garicano and Rossi-Hansberg ignores the possibility that what changes over time is the distribution of skills in the population. For example, it could be that the distribution shifts over time in the way that the proportion of individuals in the upper tail decreases (it can be expected that globalization increases proportionately more the labor force with average skills than the labor force with high skills) so the skills level of the P90 individual increases relative to that of the P50 individual. Then the ratio P90/P50 would increase even if the price per unit of skill did not change[9].

(8) Cagetti and Di Nardi (2006) report from US data that 81% (54%) of those who belong to the top 1% (10%) of the wealth distribution declare that they are either self-employed or business owners. Therefore, much of what is observed in the distribution of income at the top will have to do with the distribution of income among entrepreneurs-managers.

(9) With Spanish data on the distribution of wages, Carrasco *et al*. (2015) find that changes in demand and supply of skills, and changes in return on skills contribute differentially to wage inequality in Spain

There are several assumptions around the simple model presented here that should be revised in future extensions. Some have to do with the external environment of firms: imperfect financial markets that constraint the occupational choices, especially of non-wealthy entrepreneurs [Khilstrom and Laffont (1979); Evans and Jovanovic (1989); Hurst and Lusardi (2004); Cagetti and De Nardi (2006)] are more realistic than the perfect capital markets assumed here. The non-direct labor costs of employees [Autor *et al*. (2006)], non-competitive wage setting, and labor-markets regulations (others than the minimum wage considered here) are also realistic situations. The family environment, educational experience, culture, technology, and globalization will all shape the general skills of individuals, how skills are distributed in the population, and how the distribution changes over time. Moving from static to dynamic occupational models, with individuals learning about their skills over time and/or investing in acquiring additional skills, is also a challenge.

Other extensions should focus on gaining realism, incorporating into the model a more complete list of management and organization decisions; for example, how to address agency problems in the competitive assignment of entrepreneurs-managers to management positions [Edmans *et al*. (2009); Bandiera *et al*. (2015); Wu (2017)]. Another hypothesis that should be contrasted with more detail is the homogeneity in tasks performed in what we refer as operational jobs. This is a consequence, in part, of assuming that one unit of general skills transforms equally into one unit of operational skill or one unit of entrepreneurial skill. This assumption could be modified to explore the possibility that the return from one unit of general skill will differ if applied to perform operational tasks than if applied to entrepreneurial ones.

The paper has emphasized that in occupational choice models the organization of production and income inequality are jointly determined. Decisions on defining the boundaries of firms (vertical integration, outsourcing), human resource management practices (compensation, career), and organization structures (definition of jobs, hierarchical levels) are part of the organization of production not explicitly addressed in this paper. Management research has traditionally analyzed how these decisions affect operating performance (business profitability). Recently, this research begins to show interest in the distributional consequences of how firms are managed and organized [Cobb (2016, 2017); Davis and Cobb (2010); Aguinis *et al*. (2018)]. A reasonable extension of this paper would be to perform comparative static analysis on the effects of changes in all the parameters of the model on the organization of production and on income inequality, and compare the results with observed evidence on the determinants of income inequality from the management literature. For example, examining the relationship between the importance of large firms in the economy and inequality in the distribution of income and productivity.

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during the period 1995-2010, so wages are compressed in the period 1995-2006 and disperse in the years following. Arranz and García-Serrano (2014) and Bonhomme and Hospido (2017) also with wage data, conclude that in the period 2005-2010 most of the observed variation in wage inequality in Spain was due to changes in the distribution of worker and job attributes and the contribution of changes in returns were relatively modest. Therefore, the Spanish distribution of wages, so far, does not move in the direction of wage polarization with higher price per unit of skill for high values of skills and lower for low values of skills, that Garicano and Rossi-Hansberg (2015) say occurs in the US.

Appendix: Equilibrium solution with Cobb-Douglas production function and lognormal distribution of skills

1. Production function and distribution of skills

In the calculation of the market equilibrium solution, we assume that the production function at the job level is that of a Cobb-Douglas already introduced in the main text. For the entrepreneur-manager:

$$f\left(qt_i;q_i\right)=\left(qt_i\right)^{\beta} q_i^{1-\beta}, \qquad L\left(q;Q\right)=q^{\beta}Q^{1-\beta}$$
$$Y=\theta\, q\left(q^{\beta}Q^{1-\beta}\right)^{1-\mu} K^{\mu}=\theta\, q^{\alpha}Q^{\rho}K^{\mu} \tag{A1}$$

where $0<\beta<1$, $\alpha=1+\beta\,(1-\mu)$, and $\rho=(1-\beta)\,(1-\mu)$.

The output of a solo self-employed with general skill q is given by:

$$Y=\theta\, k\, q\left(q^{\beta}q^{1-\beta}\right)^{1-\mu} K^{\mu}=\theta\, k\, q^{2-\mu}K^{\mu} \tag{A2}$$

The salary of employees is $S= w\, q$.

The general skills, q, are distributed among the population according to a lognormal distribution (the log of q will be distributed with mean λ and standard deviation σ), with density probability function and distribution function given by:

$$g(q)=\frac{1}{\sigma q\sqrt{2\pi}}\mathrm{e}^{-\frac{\left(-\lambda+\ln(q)\right)^2}{2\sigma^2}}, \quad \left(q>0\right)$$
$$G(q)=\frac{1}{2}\left(1-\mathrm{Erf}\left[\frac{\lambda-\ln\left(q\right)}{\sigma\sqrt{2}}\right]\right), \quad \left(q>0\right)$$

Erf is the error function, which does not have an analytical expression but can be calculated numerically at any level of precision:

$$\mathrm{Erf}\left[z\right]=\frac{2}{\sqrt{\pi}}\int_0^z e^{-t^2}\,dt$$

The first and second moments of the distribution, median and quantile ζ, are given by

$$E\left[q\right]=\mathrm{e}^{\lambda+\frac{\sigma^2}{2}}$$
$$\mathrm{var}\left[q\right]=\mathrm{e}^{2\lambda+\sigma^2}\left(\mathrm{e}^{\sigma^2}-1\right)$$
$$Median\left[q\right]=\mathrm{e}^{\lambda}$$
$$Quantile\left(\zeta\right)=\mathrm{e}^{\lambda-\sqrt{2}\sigma\, InverseErfc\left[2\zeta\right]} \qquad 0<\zeta<1$$

The Pareto distribution has been used to model the distribution of entrepreneurial skills in the population [Lucas (1978)] and to model the upper tail of the income distribution [Jones (2015)]. In this paper, individuals differ in a general skill that is transformed either into operational skills or into entrepreneurial skills, depending on the job. It is reasonable to expect that the distribution of general skills in the population will be more bell-shaped than the distribution of entrepreneurial skills. Moreover, data collected by the OECD's Survey of Adult Skills (PIAAC) show that cognitive skills, which can be assimilated with the general skills in our model, have a bell-shaped distribution, which suggesting that the lognormal distribution is more appropriate than the Pareto distribution.

Capital services are purchased in the market at a cost of capital c (this is a market-clearing price that equates the supply and demand from consumption, the saving decisions in the internal economy, and possible output and input foreign capital flows). The price per unit of skill w will be determined as the market equilibrium from the occupational decisions of individuals with different skills, which in turn determine the demand and supply of operational skills.

For given input prices and final output sold at a price of one, the profit-maximizing problem of an entrepreneur-manager of skills q is given by:

$$\underset{Q,K}{Max}\,\Pi(q) = Y - cK - wQ = \theta q^{\alpha} Q^{\rho} K^{\mu} - cK - wQ$$

The profit-maximizing input and output quantities and the corresponding profits are:

$$Q^*(q,w) = \left(\frac{\rho}{w}\right)\left(\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{\beta(1-\mu)}}\left(\frac{(1-\mu)(1-\beta)}{w}\right)^{\frac{(1-\beta)}{\beta}} q^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}}$$

$$K^*(q,c) = \left(\frac{\mu}{c}\right)Y^*, \qquad Y^* = \left(\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{\beta(1-\mu)}}\left(\frac{(1-\mu)(1-\beta)}{w}\right)^{\frac{(1-\beta)}{\beta}} q^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}} \qquad \text{[A3]}$$

$$\Pi^*(q;w) = \beta(1-\mu)\left(\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{\beta(1-\mu)}}\left(\frac{(1-\mu)(1-\beta)}{w}\right)^{\frac{(1-\beta)}{\beta}} q^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}} \qquad \text{[A4]}$$

For the solo self-employed, the decision is only on the capital input services:

$$\underset{K}{Max}\,R(q) = Y - cK = \theta q^{2-\mu} K^{\mu} - cK$$

with the solution:

$$K^* = \left(k\theta\frac{\mu}{c}\right)^{\frac{1}{1-\mu}} q^{\frac{(2-\mu)}{(1-\mu)}}$$

$$y^* = \left(k\theta \left(\frac{\mu}{c} \right)^{\mu} \right)^{\frac{1}{1-\mu}} q^{\frac{(2-\mu)}{(1-\mu)}}$$

$$R^*(q) = (1-\mu) Y^* = (1-\mu) \left(k\theta \left(\frac{\mu}{c} \right)^{\mu} \right)^{\frac{1}{1-\mu}} q^{\frac{(2-\mu)}{(1-\mu)}} \quad \text{[A5]}$$

The functions $\Pi^*(q)$ and $R^*(q)$ are both increasing and convex functions of the general skills of the entrepreneur, q. The profit function of employers decreases with the price of skills, w, and both profit functions decrease with the cost of capital services, c.

2. Market equilibrium

Since $k \leq 1$ by assumption, and comparing [A4] and [A5], the income of employers is more convex in q than the income of the solo self-employed. The two functions are also more convex in q than the compensation of employees, $w\,q$. In the equilibrium with solo self-employed individuals, there will be two values of skills, q_1 and q_2, so $R^*(q)$ will intersect $w\,q$ from below at q_1 and $\Pi^*(q; w)$ will intersect $R^*(q)$ from below at q_2. In this equilibrium individuals with skills lower than q_1 will choose to work as employees; individuals with skills above q_2 will work as employers-managers; and those with skills between q_1 and q_2 will be voluntary solo self-employed.

The market equilibrium where no individual will want to change occupation and demand of skills for operational jobs is equal to supply, is characterized by the following equations:

$$w^* q_1 = R^*(q_1) = (1-\mu) \left(k\theta \left(\frac{\mu}{c} \right)^{\mu} \right)^{\frac{1}{1-\mu}} q_1^{\frac{(2-\mu)}{(1-\mu)}} \quad \text{[A6]}$$

$$R^*(q_2) = \Pi^*(q_2) \Leftrightarrow$$

$$\left(k\theta \left(\frac{\mu}{c} \right)^{\mu} \right)^{\frac{1}{1-\mu}} q_2^{\frac{(2-\mu)}{(1-\mu)}} = \beta \left(\theta \left(\frac{\mu}{c} \right)^{\mu} \right)^{\frac{1}{\beta(1-\mu)}} \left(\frac{(1-\mu)(1-\beta)}{w^*} \right)^{\frac{(1-\beta)}{\beta}} q_2^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}} \quad \text{[A7]}$$

$$\int_{q_2}^{\infty} Q(q; w^*)\, dG(q) = \int_{q_0}^{q_1} q\, dG(q) \quad \text{[A8]}$$

where

$$\int_{q_2}^{\infty} Q(q; w^*)\, dG(q) =$$

$$= \frac{1}{2} \left(\frac{k^{\frac{1}{1-\mu}}}{\beta} \right)^{\frac{1}{1-\beta}} q_2^{\frac{-1}{\beta(1-\mu)}} e^{\frac{\lambda(\beta(1-\mu)+1)}{\beta(1-\mu)} + \frac{\sigma^2(\beta(1-\mu)+1)^2}{2\beta^2(1-\mu)^2}} \left(1 + Erf\left[\frac{\lambda + \sigma^2\left(1 + \beta^{-1}(1-\mu)^{-1}\right) - \log[q_2]}{\sigma\sqrt{2}} \right] \right)$$

and

$$\int_{q_0}^{q_1} q\,dG(q) = \frac{1}{2}e^{\lambda+\frac{\sigma^2}{2}}\left(Erf\left[\frac{\lambda+\sigma^2-\log\left[\frac{S_{min}}{w^*}\right]}{\sigma\sqrt{2}}\right] - Erf\left[\frac{\lambda+\sigma^2-\log\left[q_1\right]}{\sigma\sqrt{2}}\right]\right)$$

Equation [A6] determines the skill level of indifference between working as an employee and working as solo self-employed, and [A7] the skill level of indifference between being solo self-employed and being an employer. Equation [A8] is the condition for the demand of operational skills by employers equal to the supply by employees. The lower bound of skills, q_0, is again determined by the existence or otherwise, of a binding minimum wage, $q_0 = \max\left(\frac{S_{\min}}{w^*}, q_m\right)$, as before.

Solving for w^* as a function of q_1 in [A6] and substituting in [A7] and in [A8], the system is reduced to two equations and two unknowns. The system has a unique solution, with or without solo self-employed individuals, although the equilibrium must be calculated numerically. From the values of w^*, q_1 and q_2, the total output produced in the economy is:

$$YT^* = \int_{q_2}^{\infty} Y_1^*\left(q; w^*\right)dG(q) + \int_{q_1}^{q_2} Y_2^*\left(q\right)dG(q)$$

where $Y_1^*\left(q;w^*\right) = \left(\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{\beta(1-\mu)}}\left(\frac{(1-\mu)(1-\beta)}{w^*}\right)^{\frac{(1-\beta)}{\beta}} q^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}}$ is the output produced by the employer of skills q and $Y_2^*\left(q\right) = \left(k\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{1-\mu}} q^{\frac{(2-\mu)}{(1-\mu)}}$ is the output produced by the self-employed of skills q.

The sizes of the respective occupational groups are given by $G(q_1) - G(q_0)$ (employees), $1 - G(q_2)$ (employers) and $G(q_2) - G(q_1)$ (solo self-employed), where $G(q)$ is the cumulative distribution function of general skills, q.

3. Calibration

From the main text, parameters whose values will be calibrated from information on relative sizes of occupational groups in Spain are k, $S_{\min}$ and σ. The other parameters are set at values $c = 0.12$; $\beta = 0.4$; $\theta = 1$; $\lambda = 2$; $\mu = 0.25$. We substitute these values in equations [A6] to [A8] and add the additional equations on the sizes of occupational groups:

$$G(q_1) - G(q_0) = 0.80 \text{ (employees)}$$
$$1 - G(q_2) = 0.08 \text{ (employers)}$$
$$G(q_2) - G(q_1) = 0.08 \text{ (voluntary solo self-employed)}$$

where $G(q)$ is the cumulative log normal distribution given above.

Using numerical methods in the calculation we get: $k = 0{,}67$; $S_{\min} = 50$; $\sigma = 0.39$; $q_0 = 3.72$, $q_1 = 10.89$, $q_2 = 12.79$. The equilibrium price per unit of skill is $w^* = 13.42$.

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RESUMEN

Este trabajo examina la evidencia sobre desigualdad de ingresos laborales en España, a partir del equilibrio de mercado en una economía en la que individuos con diferentes habilidades toman decisiones ocupacionales óptimas. Los resultados muestran que los valores de los parámetros (de la distribución de habilidades, la tecnología de producción y la organización interna de las empresas) calibrados a partir de datos sobre la organización de la producción observados en España (número de personas ocupadas como empleados, empresarios-gerentes y autónomos, distribución de tamaños de empresa), también explican razonablemente bien la distribución de los ingresos laborales, dentro de los distintos grupos ocupacionales y para toda la población ocupada en su conjunto. El modelo propuesto puede ser útil para evaluar las posibles consecuencias para la desigualdad de cambios en la organización de la producción.

Palabras clave: desigualdad de ingresos, elecciones ocupacionales, economías de escala en habilidades, des-economías organizacionales de tamaño.

Clasificación JEL: D31, J24, L25.