Banco de México

Documentos de Investigación

Banco de México

Working Papers

N° 2016-09

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June 2016

Documento de Investigación
2016-09

Working Paper
2016-09

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Abstract: A quantitative framework of firm dynamics is developed where the size of the informal sector is determined by financial constraints and the burden of taxation. Improving access to credit for formal sector firms increases aggregate TFP and output while reducing the size of the informal sector. Introducing size-dependent taxes reduces the gains from financial development as they incentivize firms to produce at a relatively limited scale. The aggregate effects of eliminating formal sector registration costs are positive but modest relative to previous theoretical models and the gains generated by financial development, and consistent with empirical evidence based on micro-level data.
Keywords: informal sector, misallocation, aggregate productivity, financial constraints, size-dependent taxes
JEL Classification: E26, L11, O11, O17, O40

Resumen: Se desarrolla un marco teórico cuantitativo con dinámica de firmas donde el tamaño del sector informal está determinado por restricciones financieras y la carga fiscal. Mejorar el acceso al crédito para firmas del sector formal incrementa la productividad y el producto agregado mientras que reduce el tamaño del sector informal. Introducir impuestos que dependen de la escala de la firma disminuye las ganancias del desarrollo financiero dado que incentivan a las firmas a producir a una escala relativamente limitada. El efecto agregado de la eliminación de los costos de registro en el sector formal es positivo pero modesto comparado a los resultados de modelos teóricos previos y de las ganancias generadas por el desarrollo financiero, lo cual es consistente con la evidencia empírica basada en datos microeconómicos.
Palabras Clave: sector informal, asignación de recursos, productividad agregada, restricciones financieras, impuestos dependientes de la escala

*I am grateful to Cristina Arellano, Tim J. Kehoe, Fabrizio Perri and Kei-Mu Yi for their guidance. I benefitted from thoughtful feedback from Jose Asturias, Costas Azariadis, Maria Elisa Belfiori, Javier Cano-Urbina, Pablo Cotler Avalos, Enrique Covarrubias, Alan Finkelstein Shapiro, Sandhya Garg (discussant), Ravi Kanbur, Julio Leal, Santiago Levy, David Perez-Reyna, Terry Roe, Andrea Szabo (discussant), Naoki Takayama and participants of various conferences and seminars.

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1 Introduction

In many developing countries the informal economy accounts for over 30% of non-agricultural employment and well above 30% of GDP.[1] The informal sector has long been associated with financial underdevelopment and the excessive burden of taxes and regulation. The informal sector has also been attributed significant losses in terms of aggregate productivity, capital accumulation and output. I construct a framework to quantify the losses associated with the existence of a large informal sector and then exploit this framework to evaluate policies intended to ameliorate these losses.

I build a model of entrepreneurship and stochastic firm dynamics based upon the frameworks of occupational choice and industry equilibrium of Lucas (1978) and Hopenhayn (1992). Individuals differ in their ability to operate a decreasing returns to scale technology. More able entrepreneurs set up firms and decide whether to belong to the formal or informal sector (an early example of self-selection in a static environment is Rauch, 1991). The trade-off is the following: firms in the informal sector avoid taxation and the costs of registration but face a sector-specific cost of production that represents the costs of not having access to enforcement of commercial contracts, inferior access to public services and infrastructure, etc. (De Soto, 1989; Perry et al., 2007). This sector-specific cost limits the optimal scale of firms in the informal sector. Although limited, formal sector firms have access to credit while informal sector entrepreneurs have no access to external finance.[2]

Financial constraints restrict the amount of capital used by entrepreneurs and have a leading role in the model. In equilibrium the size of the informal sector depends on the burden of taxes and access to credit in the formal sector. Intuitively, lower access to credit in the formal sector reduces the demand for labor and the equilibrium wage level. As a result, individuals with lower entrepreneurial ability set up firms in the informal sector. The entrepreneur has the option to start his business in the informal sector and later

[1] Statistics of informal sector employment are discussed in Section 2. Schneider and Enste (2000) describe nine widely applied methodologies for estimating the size of the *shadow economy*, highlighting their respective advantages and weaknesses. Data based on labor force and micro-business surveys are generally preferred. The *shadow economy* includes all market-based legal production of goods and services that are concealed from public authorities to avoid taxation, social security contributions and compliance with regulation in general, while pure household production, voluntary nonprofit (social) services and criminal activities are excluded.

[2] The difficulties for informal sector firms to collateralize their assets were already stressed in the work of De Soto (1989). In the same manner, Straub (2005), Catão et al. (2009) and Perry et al. (2007) emphasize the requirements of financial institutions such as credible documentation of physical location and pledgeable assets of the firms, their financial statements, etc. which, because of their nature, are not available for informal sector firms. I evaluate the consequences of introducing informal sector credit in the model.

transition to the formal sector depending on entrepreneurial ability, financial assets and a firm productivity shock. I show that these results are consistent with firm-level data for different countries.

The model is calibrated to match certain key statistics of developing economies where the size of the informal sector is significant (I consider the cases of Mexico, Turkey and Egypt). Then I evaluate the impact of different policies: the elimination of the costs of registration and initial minimum capital requirements in the formal sector and the improvement of access to credit in the formal sector.

Increasing access to credit for formal sector firms (by improving their ability to collateralize assets) increases wages, aggregate TFP and output per worker while reducing the size of the informal sector. However, I show that the gains from financial development are reduced in a version of the model with size-dependent taxes, as these incentivize firms to produce at a relatively limited scale. This result highlights the importance of reducing other obstacles to firm growth in order to reap the full potential benefits of financial development.

The impact of eliminating formal sector registration costs and initial minimum capital requirements is positive but modest relative to the gains generated by financial development. In the model, entrepreneurs can initiate their firms in the informal sector and accumulate enough wealth to register and comply with initial minimum capital requirements. However, given their low productivity, most informal sector entrepreneurs will not find this to be optimal. This result is consistent with country level empirical case studies that analyze this type of reforms (see the summary of this literature by Bruhn and McKenzie, 2013), but contrasts with previous theoretical models (this is further discussed below).

The rest of the article is organized as follows. In Section 2 I review the related literature, S.3 documents the key empirical facts that guide the construction and calibration of the quantitative framework: I compare the size distribution of firms, define the informal sector and provide estimates of its size for the countries under study. Then I exploit firm level data to document empirical regularities of informal sector firms compared to those in the formal sector. The model is presented in S.4. A brief characterization of the equilibrium and the sources of misallocation in the model are discussed in S.5. The parameters and the calibration procedure are discussed in S.6. In S.7 I conduct and discuss the policy simulations and present the main results. I conclude with final comments in Section 8.

2 Relation to the literature

This article builds upon several recent strands of the macro-development literature. A brief overview follows.

The *misallocation* literature underscores the macroeconomic implications of distortions to the allocation of resources across firms, typically focusing on total factor productivity (TFP) and output losses, capital accumulation and the size and productivity distribution of firms. Hsieh and Klenow (2009) find that the dispersion in the marginal products of labor and capital across plants can explain a large part of the differences in TFP between China and India compared to the U.S. Busso, Fazio and Levy (2012) perform a similar exercise for Mexico analyzing informal and formal sector firms. Restuccia and Rogerson (2008) analyze the potential quantitative effects of idiosyncratic tax schemes, suggesting the importance of evaluating specific distortions. Accordingly, Guner, Ventura and Xu (2008) and Garcia-Santana and Pijoan-Mas (2014) study policies that impose restrictions on the size of firms. Barseghyan and DiCecio (2011) asses the role of entry costs, while Bah and Fang (2014) stress the interaction between entry costs and financial frictions (both abstract from existence of the informal sector). Financial frictions have been extensively studied, Buera, Kaboski and Shin (2011) analyze endogenous collateral constraints and Greenwood, Sanchez and Wang (2013) focus on costly state verification, among many others.[3] Midrigan and Xu (2013) challenge the view that financial constraints can generate quantitatively significant aggregate productivity losses through the dispersion in the marginal product of capital, although the impact on TFP through firm selection can be significant.

There is a sizable literature that analyzes the determinants of the size of the informal sector. Many results are now standard:[4] the size of the informal sector decreases as credit availability improves in the formal sector (Straub, 2005; Antunes and Cavalcanti, 2007; Quintin, 2008; Catão et al., 2009; D'Erasmo and Moscoso-Boedo, 2012); the size of the informal sector increases with labor-market restrictions, heavier regulation of entry and

[3]The growth of smaller firms is particularly constrained by the underdevelopment of the financial system. This mechanism has been found to be empirically more robust than other obstacles to firm-growth such as inefficient regulation and taxation, inadequate enforcement of property rights, political instability, insufficient provision of infrastructure, etc. (Beck and Demirgüç-Kunt, 2006).

[4]Schneider and Enste (2000), Tybout (2000) and Perry et al. (2007) offer extensive sets of references related to the informal sector. The literature also analyzes other issues of the informal sector related to inequality, labor market segmentation, human capital accumulation, the consequences of trade reform, optimal audit policies and rent-seeking bureaucracies. These topics are outside the scope of this article. De Soto (1989), a classic reference in the literature, already emphasized the impact of an overburdening regulatory system, weak property rights enforcements and lack of access to external finance in the informal sector.

the tax burden of the formal sector and decreases with enforcement of legal obligations (Djankov et al., 2002; Antunes and Cavalcanti, 2007; Perry et al., 2007; Prado, 2011; Leal-Ordoñez, 2014).[5] Busso, Neumeyer and Spector (2012) emphasize human capital considerations as a driving force behind the large informal sectors in the developing world. Alonso-Ortiz and Leal (2014) and Levy (2008) discuss the impact of social programs and transfers in Mexico. At the firm level, compliance with regulation is associated with better access to external finance and informal sector firms are found to be less capital intensive, less productive, smaller and younger (Levenson and Maloney, 1998; Perry et al., 2007; La Porta and Shleifer, 2008; Pratap and Quintin, 2008; World Bank, 2010; de Paula and Scheinkman, 2011; Busso, Fazio and Levy, 2012).

Several articles have studied the significance of financial constraints in models that incorporate firm dynamics and the informal sector. Quintin (2008) finds that lax tax enforcement alone does not suffice to generate a large informal sector and contractual imperfections are necessary. Antunes and Cavalcanti (2007) find that for a developing country with low financial development, the size of the informal sector is equally accounted for by low financial contract enforcement and high regulation costs.[6] My framework is most closely related to D'Erasmo and Moscoso-Boedo (2012). They develop a model of firm dynamics with imperfect debt enforcement and entry costs. They find that these frictions can explain a drop in total factor productivity of up to 25%, with entry costs accounting for 3/4 of model-generated TFP differences across countries. Their model, however, does not allow for occupational choice or firm transitions from the informal to the formal sector, and therefore provides a partial understanding of the impact of different obstacles to firm registration and their aggregate effects as discussed below. Furthermore, in my framework the existence of the informal sector is associated with lower wages as an entrepreneur that opts to produce with an informal sector technology will employ a reduced number of workers.[7] Finally, we complement previous research by taking into considera-

[5] In contrast, Elgin (2015) develops a dynamic political economy model with two political parties alternating in office. If incumbent parties are more likely to stay in power they can set a higher tax rate to invest more in productive public capital, with a smaller informal sector.

[6] There are several important differences with their frameworks and the one presented here. In Antunes and Cavalcanti (2007) agents live for one period (with an empirical counterpart of 35 years, and thus not allowing for transitions between sectors) while in Quintin (2008) each period corresponds to 8 years. My model allows us to consider a richer set of data to be contrasted with the model, particularly in terms of exit rates and age characteristics of firms, in line with the more recent literature on misallocation and firm dynamics. More importantly, neither model incorporates firm idiosyncratic productivity shocks, which are essential to quantitatively evaluate the impact of financial constraints on aggregate productivity (Buera et al., 2011; D'Erasmo and Moscoso-Boedo, 2012; Midrigan and Xu, 2013; Moll, 2014; Bah and Fang, 2014). Consequently, while their focus is on output per capita, my framework furthers their analysis by making a number of modifications that allow me to evaluate the impact of different frictions on TFP.

[7] In D'Erasmo and Moscoso Boedo (2012) there is free entry of firms: in the model with an informal sector there is a shift in the demand for labor that keeps the equilibrium wage higher relative to a model

tion the role of size dependent distortions (Hsieh and Klenow, 2012), to understand how they interact with the elimination of formal sector registration costs and minimum capital requirements as well as financial development.

Empirical country-case studies that exploit micro-level data have found a moderate impact resulting from reforms that reduce the cost of entering the formal sector. Kaplan et al. (2011) estimate the effect of the simplification of firm registration procedures on business start-ups in Mexico. They suggest that attention in business deregulation may have been overemphasized given the limited increase in new start-ups and conclude that the limited benefits of being formal may explain the low impact of the implemented reforms. In Brazil, Rocha et al. (2014) find that reducing entry costs to the formal sector had modest effects on the formalization of existing informal sector entrepreneurs and none on the creation of new formal businesses. Bruhn and McKenzie (2013) provide a summary of the literature studying the effects of this type of reforms. They find in general a modest increase in the number of formal firms. The suggested explanation is that informal sector firms have low productivity and would find little benefit in formalizing and therefore remain informal despite the reforms. My model provides a formal quantitative structure that illustrates the mechanisms that account for this result.

3 Empirical motivation

In this section I document the key empirical facts that guide the construction and calibration of the quantitative framework. First, I compare the distribution of employment and firms by firm size category for the U.S., with three developing economies: Mexico, Turkey and Egypt. In the developing economies a relatively large share of the non-agricultural private labor force belongs to small firms (less than 10 workers). Next, I define informal sector employment and provide measures of its size in these countries. Then, using micro-level databases for the three developing economies, I document how the formal/informal status and the capital-labor ratios of the firms are related to education and experience of the manager, size and age of the firm and revenue per worker, while controlling for additional variables that are standard in the literature.[8]

with no informal sector (see their discussion in pg. 300).

[8]Examples in this literature are: Levenson and Maloney (1998) for Mexico, de Paula and Scheinkman (2011) for Brazil, World Bank (2010) for Turkey (same dataset for this country) and La Porta and Shleifer (2008) using cross-country firm level data.

3.1 Distribution of employment and firms

In the U.S. firms with less than 10 workers, represent 74.5% of the total number of firms and account for 12% of employment.[9] For Mexico, Turkey and Egypt the share of firms with less than 10 workers is approximately 95% and these firms account for over 67% of employment.

Table 1. Dist. of Employment and Firms by Firm Size.

	dist. employment			dist. of firms		
size of firm:	<10	10-49	≥50	<10	10-49	≥50
U.S.	11.8	19.1	69.1	74.5	20.5	5.0
Mexico	72.2	11.5	16.3	95.6	3.5	0.9
Turkey	67.0	16.0	17.0	95.0	3.2	1.8
Egypt	77.3	10.3	12.4	95.7	4.0	0.3

Data sources: INEGI (Mexico), Helfand et al. (2007), CAPMAS (Egypt), World Bank (2010).

Recent work by Poschke (2014) documents the increase of average firm employment with income per capita (entrepreneurship and the importance of small firms fall with income per capita). Unsurprisingly, the preponderance of smaller firms in developing countries has been associated to the informal sector (Tybout, 2000) and self-employment (Gollin, 2000).

3.2 The informal sector

In this section the concept of informal sector is defined and estimates of its size are provided for the countries of interest. As emphasized in the literature, informality encompasses different phenomena. In developed economies, informality is generally associated with tax evasion and undeclared labor in registered firms. In emerging economies it is typically associated with small unregistered firms that avoid all or most forms of taxation. We can make an important distinction here, following ILO (2012):

> Employment in the informal sector is an enterprize-based concept and covers persons working in units that have *informal* characteristics in relation to, e.g., the legal status, registration, size, the registration of the employees,

[9] See the appendix for a description of the sources for Table 1.

their bookkeeping practices, etc. Informal employment is a job-based concept and encompasses those persons whose main jobs lack basic social or legal protections or employment benefits and may be found in the formal sector, informal sector or households.

Informal employment can include workers in larger firms with relatively better access to finance that comply with most of their legal obligations.[10]

In Egypt, the share of informal wage workers in the private non-agricultural sector is 81.5% (Abdelhamid and El Mahdi, 2003). Wahba (2009) finds that informal employment represented 76% of total private, non-agricultural waged employment in 2006 (80.5% in 1998).[11] Of total micro and small enterprizes, 82% are informal (El Mahdi, 2002; Ministry of Foreign Trade, 2003). Since small and micro enterprizes contribute to 77% of the jobs in the non-agricultural private sector,[12] we can infer that informal sector employment represents well over 50% of total non-agricultural private employment.

In Turkey, the informal sector accounts for approximately 25-39% of employment depending on the different estimation criteria applied (Bulutay and Tasti, 2004). For Mexico, Leal-Ordoñez (2014) exploits data from the Economic Census and the micro-enterprize and household surveys to reach an estimate of 45% of employment in the informal sector. Estimates of the size of the informal sector for the U.S. are not available.[13]

3.3 Firm level data and evidence

The ERF firm level data was collected by teams supervised by Dr. Alia El Mahdi

[10] See International Labour Office (2012) for a sample of countries where data for both informal employment and informal sector employment is available. For comparison, in India the figures are 83% and 67% respectively in non-agricultural activities. The informal sector is large in most developing economies such as, for example, Pakistan (73%), Philippines (72%), Colombia (52%), Peru (49%). An extension of the quantitative framework takes into account the possibility of informal employment in registered firms.

[11] Data from the Egypt Labour Market Surveys, carried out by the Economic Research Forum in cooperation with CAPMAS. A more conservative estimate for informal sector employment can be computed considering only informal (no contract, no social security): self-employed, employers, unpaid family workers, casual workers. This results in approximately 40% of the labor force in 1998.

[12] Before a recent reform, in Egypt the process to obtain a business license required 372 days and 127 administrative steps passed before 50 public entities. Dissolution and settlement procedures consisted of 25 bureaucratic steps during 244 days and a cost equivalent to over 20 monthly salaries of a worker. A bankruptcy process consisted of 53 bureaucratic steps, 653 days and the equivalent of well over 50 monthly salaries of a worker (Abdelhamid and El Mahdi, 2003).

[13] Neither the BLS nor the ILO have data on informal employment for the U.S., where it is generally associated to work by illegal migrants (OECD, 2004). Illegal foreign workers represent 3.5% of the workforce (OECD, 2004). However, illegal immigrant work is a different concept from informal sector employment. The share of the labor force without pension contributions was 7.8% in 2003 (World Development Indicators).

(Egypt) and Dr. Semsa Ozar (Turkey), as part of the project: Promoting Competitiveness in Micro and Small Enterprizes in the MENA Region (Middle East and Northern Africa). The database includes, for each country, information on approximately 5,000 micro and small enterprizes (less than 50 workers) in urban areas and covers all sectors except agriculture.[14]

The informal sector encompasses different industries. Among the main activities at the four digit level (ISIC, 3rd Revision) in Turkey we observe: maintenance and repair of motor vehicles (5020, 14.9% of observations), other retail in specialized stores (5239, 8.6%), restaurants, bars and canteens (5520, 7.7%), retail sale of textiles, clothing, footwear and leather goods (5232, 6.7%), retail sale in non-specialized stores with food, beverages or tobacco predominating (5211, 5.3%). Two manufacturing activities enter the top ten sectors at the four digit level: manufacturing of wearing apparel, except fur apparel (1810, 2.6%) and manufacture of furniture (3610, 2.6%). In Egypt, retail sale of food, beverage and tobacco (5220, 26.9%) represents a larger share of total observations and the top manufacturing industry is that of other fabricated metal products (2899, 3.7%) at the seventh position, otherwise the group of top ten activities is unchanged.

The status of a business, formal/informal, is defined according to compliance with legal requirements: a formal firm has a license, business registration and registration with tax authorities and social security subscription.[15] With this baseline definition the share of informal firms is 36% and 24% for Egypt and Turkey, respectively in this database. Different (more lax) definitions of informality were used as a robustness check on the regressions below, with very similar results. The different definitions of informal status are highly correlated as firms decide simultaneously on compliance with respect to different obligations (see for example Catão et al., 2009; Perry et al. Ch. 5, 2007).

For Mexico, the micro-enterprize database ENAMIN is collected by the national statistics institute INEGI (see Leal-Ordoñez, 2014). The formal sector status is determined according to registration with the Ministry of Finance: for the year 2002, 56 percent

[14] A detailed description of the dataset and methodology for Turkey is found in Ozar (2006). In the case of Turkey, the survey was designed so that the weighted results capture the actual distribution of micro-small enterprizes across sectors of activity, size, location and gender. The sampling was national in coverage and chosen by stratified, multi-stage systematic sampling method by TurkStat. On the basis of pre-test surveys and assessment of field experience, questions judged to be inaccurate were modified or excluded. Several questions were identified to ensure the consistency among the responses of the interviewees and participation in the survey was voluntary.

[15] For the ERF Egypt database, in particular, registration certificates were verified during the survey, the results are similar across countries. In all cases ERF surveys were voluntary, strictly confidential and conducted by non-government organizations.

of the firms in the sample were informal according to this definition. The main activities at the 3 digit level (CAE classification system) are: retail trade (621, 23.9%), repair services (721, 12.4%), construction (600, 9.6%), passenger transportation (641, 8.7%), food services (630, 6.9%) and domestic services (726, 3.7%).

Table 2. Probit Estimates of Informality.

	Turkey	Egypt	Mexico
workers	-0.047***	-0.211***	-0.310***
working experience	-0.013***	-0.002	-0.003
years of educ. manager	-0.021**	-0.031***	-0.738***
age of firm	-0.027***	-0.086***	-0.035***
age of firm squared	0.001***	0.001***	0.001***
years current management	-0.007**	-0.001	−−
revenue/workers (log)	-0.158***	-0.197***	-0.421***
skilled workers/total	-0.275***	0.128	-0.507***
number of relatives at work	0.084***	0.039	−−
born rural	0.222***	0.272***	−−
industry controls	3 dig.	3 dig.	3 dig.
geographic controls	−	#8 gov.	#33 ent.
pseudo R2	0.12	0.22	0.28
n. observations	3,703	4,687	2,009

Statistical significance: *** 1%, ** 5%, * 10%.
Data sources: INEGI (Mexico), ERF (for Egypt and Turkey).

Table 2 shows the probit estimates for informality (unavailable variables are excluded for Mexico). The probability of informality status is decreasing in education and work experience of the manager,[16] age of the firm, the number of workers, years of current management, the ratio of skilled to total number of workers and revenue per worker. The probability of informality status is increasing in the number of relatives of the manager working in the firm and whether the entrepreneur was born in a rural area.

[16]La Porta and Shleifer (2008), among others, emphasize the evidence on the differences in terms of human capital of managers between the registered and the unregistered firms. For Mexico, the education variable consists of the following categories: no instruction, elementary education, secondary ed., vocational instruction, undergraduate degree, master's level education and doctorate.

Table 3. Regressions of Capital/Labor Ratios (OLS).

	Turkey	Egypt	Mexico
informal	-0.263***	-0.261***	-1.181***
years of educ. manager	0.056***	0.033***	0.340***
working experience	0.005*	0.005***	0.002
years current management	0.009***	0.001	−−
age of firm	0.014***	-0.005**	0.001
skilled workers/total	0.381***	0.089	0.476***
revenue/workers (log)	0.429***	0.552***	0.590***
constant	11.034***	8.784***	6.213***
industry controls	3 dig.	3 dig.	3 dig.
geographic controls	−	#8 gov.	#33 ent.
R2	0.33	0.28	0.55
n. observations	3,265	4,746	1,799

Statistical significance: *** 1%, ** 5%, * 10%.
Data sources: INEGI (Mexico), ERF (for Egypt and Turkey).

Table 3 shows the results of OLS regressions with the log of capital-labor ratios as the dependent variable. Capital is defined as the book value of structures, buildings, tools, equipment and inventories of the firm. Again, different definitions of informality were used with similar results: for Egypt, for example, defining informality simply as firms not registered with the tax administration implied even larger coefficients of informality on the regressions of the capital labor ratios. Regressions on revenue per worker as the dependent variable also showed clear significant and negative coefficients of informality.[17]

4 The model

The model builds upon the frameworks of occupational choice and industry equilibrium of Lucas (1978) and Hopenhayn (1992). There is a continuum of individuals that differ in their ability as entrepreneurs but are homogeneous in terms of their productivity as workers. Individuals are born as workers and, with some probability in every period, face the opportunity of becoming entrepreneurs.

[17]The general lack of book-keeping, recalling errors, volatility of production and fungibility of production inputs with household production make the estimation of productivity of informal sector firms a challenging task (La Porta and Shleifer, 2008). Regardless of this difficulty, basic measures of productivity, as well as additional variables such as revenue per worker, are negatively correlated with informality. These differences across sectors can be due to self-selection in addition to intrinsic characteristics of informal and formal sector firms.

Entrepreneurs have access to a decreasing returns to scale technology and have the possibility of conducting their business in the informal or formal sectors. The trade-off for this decision is as follows: firms in the informal sector do not pay taxes and avoid the fixed cost of registration and the initial minimum capital requirement. However, there is a cost specific to production in the informal sector, motivation for which is provided below. Formal sector entrepreneurs have better access to external finance as determined by collateral constraints.

Time is discrete and the problem of individuals is dynamic: they are able to accumulate financial assets and may find optimal to start their enterprize in the informal sector until they reach a certain level of financial wealth and then register to operate as a formal sector firm. The decision to register also depends on a transitory productivity shock and permanent entrepreneurial ability. The analysis is restricted to the steady state of a small open economy,[18] with no aggregate uncertainty.

4.1 Production technology

Firms produce an homogeneous final good that serves as the numeraire. Firms in the formal sector have access to a standard production technology with decreasing returns to scale, but they differ in the entrepreneurial parameter φ, as given by the owner and manager of the firm:

$$q(s,f) \;=\; \varphi\, e^{a}\, f(k,l)^{\gamma} \quad \text{with} \quad f(k,l) \;=\; k^{\alpha}\,(l+\psi)^{1-\alpha} \tag{1}$$

where k is capital equipment, total labor input is the sum of hired labor $l \geq 0$ and the work of the entrepreneur $\psi \geq 0$,[19] $\gamma \in (0,1)$ is the span-of-control parameter of Lucas (1978), which determines the returns to scale. In addition to the differences in the permanent ability component, the firm is subject to productivity shocks a, which follow a discrete state Markov process with transition density $\Lambda(a' \mid a)$. This matrix is constructed as a discrete representation of an AR(1) process. Individuals are indexed by variables $s = \{\varphi, a, b\}$, where b are financial assets, and $z \in \{w, i, f\}$ denotes whether the individual is a worker

[18] Credit conditions in developing countries have been largely associated with factors such as policy-controlled interest rates, conditions in international financial markets and intermediation efficiency and market power in the financial sector (Catão et al., 2009). Higher interest rates typically observed in developing countries have been attributed to inefficient and uncompetitive financial markets (Greenwood, Sanchez and Wang, 2013). Note that Midrigan and Xu (2013) find larger misallocation losses for a closed economy relative to a small open economy model.

[19] This technology accounts for the labor input of managers in micro-firms, a segment that accommodates a large part of the labor force in developing economies (Gollin, 2008).

or an entrepreneur in the informal or formal sectors, respectively. $M(s,z)$ is the mass of individuals over the set of variables $\{s,z\}$.

4.2 Workers

Every period a mass of individuals is born and their permanent entrepreneurial ability is drawn from a density distribution $n(\varphi)$. The initial shock a is drawn from the unconditional distribution derived from $\Lambda(a' \mid a)$. Individuals value consumption of the final good through their lifetime utility $\mathbb{E}_0 \sum_{t=0}^{\infty} (\beta\,(1-\delta))^t\, u(c_t)$, with period utility $u(c) = c^{1-\phi}/(1-\phi)$,[20] discount factor β and probability δ that the individual dies in any period. An individual that dies is immediately replaced by a newly born with the same entrepreneurial ability, the mass of individuals remains constant.

Individuals are born as workers with no initial wealth and offer their labor services inelastically at a wage w. In every period, with probability $P(x)$, they may receive a shock $x = 1$ which gives them the option to become entrepreneurs, otherwise x equals to zero implies that this is not possible. As workers, they are homogeneous and free to move between the informal and formal sectors, thus there is a unique wage.[21] The problem of workers amounts to a savings decision, written as the policy function $b' = g_w(\varphi, a, b)$, and their occupation choice:

$$v_w(\varphi,a,b) = \max_{\{c,\, b' \geq 0\}} u(c) + \beta\,(1-\delta) \sum_{\{a',\, x'\}} P(x')\,\Lambda(a' \mid a)\, v(\varphi\, x', a', b') \qquad (2)$$

$$\text{s.t.} \quad c + b' = w + (1+r)\, b$$

and the occupation choice is:

$$v(\varphi\, x, a, b) = \max\{\, v_w(\varphi\, x, a, b)\,,\; v_i(\varphi\, x, a, b)\,,\; v_f(\varphi\, x, a, b - c_e \mid b - c_e \geq \underline{b})\,\} \qquad (3)$$

where v_f and v_i refer to entrepreneurship in the formal and informal sectors respectively, c_e is the cost of entering the formal sector (there are no fixed costs of entering the informal

[20] I follow a standard assumption in the literature in considering risk averse individuals. See, for example, Buera, Kaboski and Shin (2011) and references therein contained. Given the focus on occupational choice and the problem of small-firm entrepreneurs in developing countries this seems to be the relevant approach. In Egypt, for example, approximately 92% of all enterprizes have only one proprietor and firms with less than 10 workers account for well over 70% of employment.

[21] The evidence on whether labor markets are segmented between informal and formal sector firms suggests mixed results at best. See the discussions in Maloney (2004), Pratap and Quintin (2008) and Perry et al. (2007, Ch. 3). Wage inequality is a topic outside the scope of this essay, see Busso, Neumeyer and Spector (2012) for a model that introduces heterogeneity in units of effective labor across workers.

sector). To register in the formal sector there is a minimum capital requirement condition (after paying the registration cost), $b - c_e \geq \underline{b}$.[22] We turn next to the problem of the entrepreneurs in the formal and informal sectors.

4.3 Formal sector entrepreneurs

At the beginning of every period the entrepreneur relinquishes his financial wealth b to a financial intermediary. This deposit earns a net interest rate r. Within the period the entrepreneur is able to collateralize this deposit to obtain capital $k(s, f)$. A collateral constraint restricts the level of capital used in any given period by $k \leq \lambda_f b$, where λ_f is a parameter that determines the extent to which the formal sector entrepreneur is able to collateralize his financial wealth.[23] At the end of the period the entrepreneur makes total factor payments $w\,l$ for hired labor input and $(r + \nu)\,k$ (which includes the capital depreciation rate ν) and receives $b\,(1 + r)$ from his deposit. We can define within period debt as $d = k - b$, which determines net interest rate payments. The entrepreneur also faces an intertemporal decision to save, the solution to which is given by the optimal policy function $b' = g_f(\varphi, a, b) \geq 0$. The dynamic problem of this type of entrepreneur is written as:

$$v_f(s) = \max_{\{c,\, b' \geq 0\}} u(c) + \beta\,(1-\delta) \sum_{\{a'\}} \Lambda(a' \mid a)\, \max\{\, v_f(s')\,,\, v_w(s')\,\} \tag{4}$$
$$\text{s.t.} \;\; c + b' = (1-\tau)\,\pi(s,f) + (1+r)\,b$$

with firm profits as follows:

$$\pi(s,f) = \max_{\{l,\,k\}} q(s,f) - w\,l - (r+\nu)\,k \quad \text{s.t.} \quad k \leq \lambda_f\, b \tag{5}$$

Entrepreneurs in the formal sector face taxes to profits τ.[24] An entrepreneur in the formal sector may choose to become a worker, registration status is lost, but cannot switch directly into the informal sector.

[22] In many countries it is possible to withdraw the minimum capital requirement immediately after registration and is therefore recoverable (Djankov, 2009; Barseghyan and DiCecio 2011).

[23] As described by Buera and Shin (2013) and Moll (2014), this collateral constraint can be motivated as arising from a limited enforcement problem, where $\lambda_f = 1$ implies that financial markets are shut down and $\lambda_f \to \infty$ achieves perfect capital markets. In the limited enforcement interpretation $1/\lambda_f$ is the fraction of capital that the entrepreneur can steal, but this would result in loss of financial wealth. In equilibrium, the financial intermediary will lend up to the point where no individual will renege on the financial contract, that is $k/\lambda_f \leq b$. The specification captures, in a parsimonious way, that credit is limited by wealth of the individual, a common prediction from models of limited enforcement (Buera and Shin, 2011).

[24] An alternative structure with size-dependent taxes on output and labor is specified below.

4.4 Informal sector entrepreneurs

In the informal sector, entrepreneurs face a collateral constraint with the same specification as in the formal sector, but the extent to which they are able to collateralize their financial wealth is lower and given by $\lambda_i < \lambda_f$ (as a benchmark λ_i equals one). The policy function $b' = g_i(\varphi, a, b) \geq 0$ is the optimal solution to their savings problem. The dynamic problem for an informal sector entrepreneur is:

$$v_i(s) = \max_{\{c,\, b' \geq 0\}} \; u(c) + \beta\,(1-\delta) \sum_{\{a'\}} \Lambda(a' \mid a)\, v(\varphi, a', b')$$
$$\text{s.t.} \;\; c + b' = \pi(s,i) + (1+r)\, b \tag{6}$$

where $v(s)$ has been previously defined: informal sector firms have the option to register and operate in the formal sector at the beginning of every period after observing their shock a. This decision will depend on the productivity shock, permanent ability and assets of the entrepreneur. Profits for informal sector firms are:

$$\pi(s,i) = \max_{\{l,\,k\}} \; q(s,i) - w\, l - (r+\nu)\, k \quad \text{s.t.} \quad k \leq \lambda_i\, b \tag{7}$$

where $q(s,i) = \varphi\, e^a\, f(k,l)^\gamma\, (1 - h(\varphi, a, k, l))$ is the production technology in the informal sector. The specification of this production technology implies an additional cost relative to formal sector firms $h(\,\cdot\,)$, which becomes increasingly important with output volume. This cost generates an incentive for informal sector firms to operate at an otherwise suboptimal scale and represents the inability to engage in legal contracts (and transaction costs in general), bribes to corrupt officials, the cost of enforcing their property rights when not protected by the government, worse access to infrastructure facilities and services, lack of a fixed location, impediments in supplying larger formal firms, etc. (De Soto, 1989; Fortin et al., 1997; Levenson and Maloney, 1998; Straub, 2005; Perry et al., 2007; World Bank, 2010; Bruhn and McKenzie, 2013).[25]

[25] De Soto (1989) very graphically describes a number of practices followed by informal sector entrepreneurs in Peru to avoid detection by the authorities as well as additional costs of informality: dispersion of employees among a number of smaller and less visible workplaces, lack of enforcement of commercial contracts, bribes to corrupt officials (10-15% of gross income compared to 1% paid by formal small business). See also Perry et al. Ch. 5 (2007) for further evidence.

4.5 Aggregation

The state space is, with a slight abuse of notation,[26] given by $\{\varphi, a, b, z\} \in S_\varphi \times S_a \times S_b \times Z$, where $S_\varphi = [\underline{\varphi}, \overline{\varphi}]$, $S_b = [0, \infty)$, $Z = \{w, i, f\}$, $a \in S_a$ takes on a finite number of values. Let $M : \mathcal{S}_\varphi \times \mathcal{S}_a \times \mathcal{S}_b \times \mathcal{Z} \to \mathbb{R}_+$ denote the measure of individuals over the state space and $\overline{M}$ be the total measure of individuals. A mass of individuals is born every period (equal to the mass of individuals that die) and draw entrepreneurial ability φ from a density function $n(\varphi)$. The labor market clearing condition is given by:

$$\sum_{z \in \{i,f\}} \left(\int l(s,z)\, M(s,z)\, ds \right) = \int M(s,w)\, ds \tag{7}$$

Total output in this economy is:

$$Q = \sum_{z \in \{i,f\}} \left(\int q(s,z)\, M(s,z)\, ds \right) \tag{8}$$

Government revenues are destined to projects that do not affect the production technology or utility of individuals.

4.6 Equilibrium

Given government policies $\{\tau, c_e, \underline{b}\}$ and interest rate r, a small-open economy stationary competitive equilibrium consists of: quantities $\{q(s,z)\}_{z \in \{i,f\}}$ and production inputs $\{l(s,z), k(s,z)\}_{z \in \{i,f\}}$, savings functions $\{g_z(s)\}_{z \in Z}$, equilibrium wage w, values $\{v(s), v_i(s), v_f(s), v_w(s)\}$, profits $\{\pi(s,z)\}_{z \in \{i,f\}}$, an invariant measure $M(s,z)$, such that: workers solve (2), formal sector entrepreneurs solve (4) and informal sector entrepreneurs solve (6), the market clearing condition for labor (7) holds, the proceeds from taxation are dissipated, the measure $M(s,z)$ is consistent with policy functions of workers and entrepreneurs, optimal decision rules and the exogenous stochastic processes for productivity and entrepreneurial possibilities.

5 Firm dynamics and misallocation

In an economy with an informal sector occupational choice is depicted as in Fig. 1, which graphs the occupation decision function for a worker with an entrepreneurial

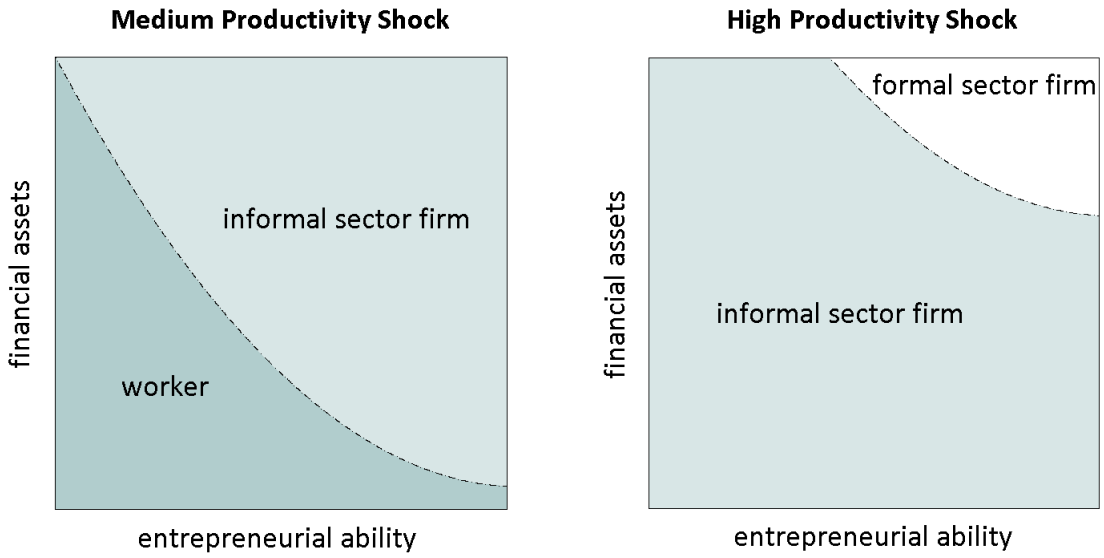
[26] For any entrepreneur $\varphi \cdot x$ is equal to φ, for a worker with no entrepreneurial opportunity or with the decision to remain a worker $\varphi \cdot x$ is equal to zero (occupation status is provided by z).

opportunity:

$$v(\varphi, a, b) = \max\{\, v_w(\varphi, a, b)\,,\; v_i(\varphi, a, b)\,,\; v_f(\varphi, a, b - c_e \,|\, b - c_e \geq \underline{b})\,\}$$

where the value of the idiosyncratic productivity shock is fixed in each panel. Individuals with relatively low entrepreneurial ability φ and little financial assets decide to become workers. Those with high enough entrepreneurial ability choose to run a firm depending on the level of assets and the productivity shock. Entrepreneurs may opt to start in the informal sector and eventually transition to the formal sector. Informal sector entrepreneurs may register in any period as long as condition $b - c_e \geq \underline{b}$ is satisfied, on average more able entrepreneurs will move earlier to the formal sector. In the model, this is due to the specification of the informal sector specific costs, which is more costly (relative to the linear taxes of the formal sector) for the higher ability individuals: more productive entrepreneurs are the ones likely to expand and benefit from a formal status.

Figure 1. Occupational Choice



Additionally, given the levels of ability and productivity, entrepreneurs with more assets will transition to the formal sector.[27] This result is derived from the combination of financial constraints and the informal sector specific marginal cost: for high en-

[27] In the appendix I estimate probit models of the formal/informal firm status with model simulated data; the sign on all state variables are as expected given the analysis in this section and consistent with the empirical model in Section 2.

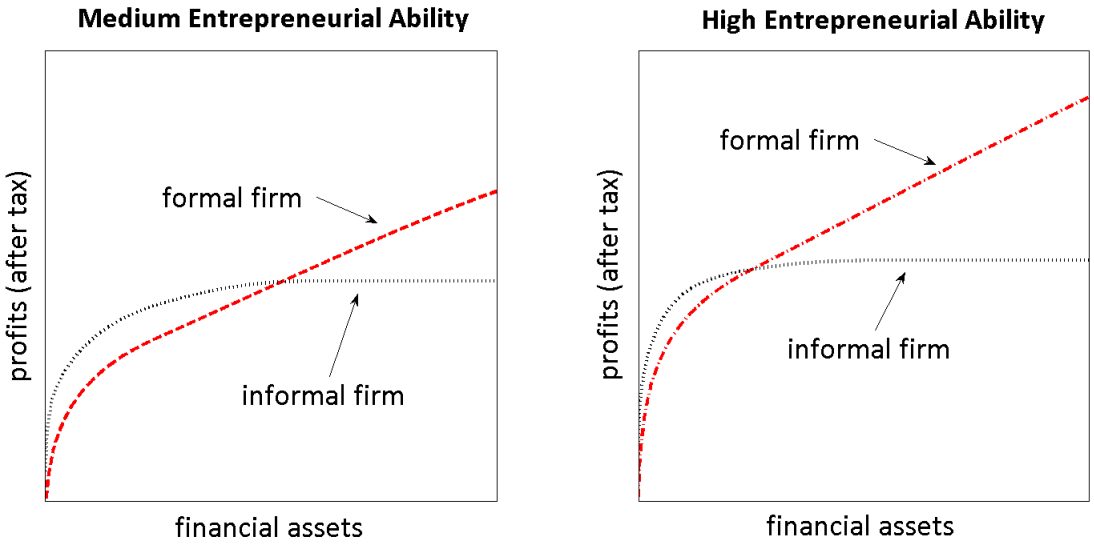
trepreneurial ability the after-tax profits of a formal firm becomes higher than profits for an informal firm at a lower level of financial assets (Fig. 2 in logs).[28]

Aggregate productive efficiency requires equal marginal product of capital across firms.[29] For firms in the formal sector the first order condition for capital is (abstracting from taxes):

$$q_k(s, f) = r + \nu + \mu(s, f)$$

where $\mu(s, f)$ is the Lagrange multiplier on the borrowing constraint. Collateral constraints can generate dispersion in marginal productivity to the extent that the entrepreneurs are credit constrained and there is dispersion in $\mu(s, f)$ due to differences in productivity and financial assets. In the case of informal sector firms, input decisions are distorted by the sector-specific marginal cost of production.

Fig. 2. Formal and Informal Sector Profits



We additionally need to consider a general equilibrium effect of financial constraints on productivity: in economies where λ_f is decreased there will be a lower equilibrium wage level due to the constraints faced by entrepreneurs and reduced capital accumulation. As a result, more individuals in the economy will turn to entrepreneurship (or

[28]This property is inherited from the profit functions of the formal and informal sectors. This is in contrast with Antunes and Cavalcanti (2007) where, all else equal, wealthier agents are more likely to opt for the informal sector (see their Figure 1).

[29]The discussion of misallocation generated by financial frictions in this section borrows from Hsieh and Klenow (2009) and Midrigan and Xu (2013).

self-employment) and these marginal entrepreneurs will have lower managerial ability. Finally, minimum capital requirements and formal sector entry costs may impede entrepreneurs from producing at their optimal scale of production in the formal sector until they accumulate sufficient financial wealth to comply with these requirements.

6 Parameters and taxes

The parameters of the model are divided into three sets. A first set of standard parameters is predetermined. A second set of parameters is calibrated to match key economic aspects of a developing economy.[30] Finally, country specific institutional parameters (taxes, minimum capital requirements and registration costs) are specified.

6.1 Predetermined parameters

The standard parameters taken from the literature are enumerated in Table 4. A period in the model represents a year, $\beta(1-\delta)$ is the effective discount factor (the exogenous exit rate δ is a calibrated parameter), r is the risk free interest rate, ϕ governs the intertemporal elasticity of substitution (Buera et al., 2011), ν is the capital depreciation rate (Barseghyan and DiCecio, 2011; Restuccia and Rogerson, 2008). The values for the production parameters α and γ are from Restuccia and Rogerson (2008). As a benchmark, ψ is set so that the entrepreneur can fully exploit his effective units of labor. In the baseline specification informal sector firms do not have access to credit (see, among many others, Perry et al., 2007).

[30] Most of the discussion below is focused on Mexico due to data availability, additional results are available upon request.

Table 4. Predetermined Baseline Parameters.

description of parameter	parameter	value
income share of capital	α	1/3
span-of-control (returns to scale)	γ	0.85
labor input of entrepreneur	ψ	1.00
capital depreciation rate	ν	0.08
intertemporal elasticity of substitution	ϕ	1.50
effective discount factor	$\beta(1-\delta)$	0.92
risk free interest rate	r	0.04
autocorrelation coefficient	ρ	0.85
standard deviation of shocks	σ	0.38
informal sector collateral constraint	λ_i	1.00

The idiosyncratic shock a follows an AR(1) process with autocorrelation coefficient ρ with innovations that have a standard deviation of σ. Asker et al. (2012) estimate the productivity process of firms for a large set of emerging economies using different data sets. I take the median of the cross-country estimates for each of these two parameters.[31]

6.2 Model calibration

I turn next to the calibrated parameters of the model in Table 5. The exogenous annual exit rate for firms, parameter δ, is set to match a total entry rate of 0.15 (Bartelsman et al., 2009).[32] In the model, the total exit rate is determined by the endogenous exit of firms in addition to the stochastic exit shock.

[31]The autocorrelation parameter applied here is at the top of the range relative to alternative quantitative models that evaluate the misallocation costs of financial constraints. This implies a conservative approach since, as explained by Moll (2014), if shocks are persistent steady-state losses generated by financial constraints are smaller. With an autocorrelation parameter of 0.60 (and re-calibrating 5 parameters) we find that the gains from full financial liberalization (λ_f equal to 125, as described below), increase by 2.5 percentage points in terms of aggregate productivity. The gains from eliminating registration requirements increase to 1.5 percentage points in terms of output (to be compared with the baseline results below).

[32]In the model, given our focus on the stationary equilibrium, total entry and exit rates are equal. The entry rate taken from Bartelsman et al. (2009) corresponds to the firms of the total business sector, including firms with at least one employee. I also compare the exit rate for firms with more than 20 employees in Table 6.

Table 5. Baseline Calibrated Parameters: Mexico.

description of parameter	parameter	value
exogenous annual exit rate	δ	0.040
ability dist. mean (log-normal)	μ	-0.465
ability dist. std. dev. (log-normal)	ε	0.045
probability of entrepr. possibility	ϑ	0.170
informal sector technology	ω	7.750
informal sector technology	ξ	1.0e-07
formal sector collateral constraint	λ_f	1.680

The permanent entrepreneurial ability is drawn from a discrete log-normal distribution with parameters μ and ε. The probability that a worker is given the option of becoming an entrepreneur is determined by parameter ϑ. These three parameters mainly govern statistics related to the distribution of firms and employment according to firm size. The total average of firm size and the share of employment at firms with more than 50 workers is computed using data from the Economic Census and the National Survey of Employment and Occupation (based on Busso, Fazio and Levy, 2012). Due to data availability, the shares of firms in different size categories are based on the Economic Census, while the share of employment according to firm age is from Hsieh and Klenow (2012) based on the Economic Census (see Table 6).

The function $h(\varphi, a, k, l) = \xi\,(\varphi\, e^a\, f(k,l)^\gamma)^\omega$ corresponds to the informal sector-specific cost of production, where the parameters ξ and ω govern the size of the informal sector in terms of total employment, and the size of these firms. The access to credit by formal firms in the economy is determined by λ_f. The target for this parameter is the ratio of total credit to non-financial private sector firms relative to total output for the period 1996-2005, which equals 0.185.[33]

[33]These statistics are from the Bank of Mexico. For the period 2000-2005 this value is equal to 0.156.

Table 6. Baseline Model (Mexico): Calibration Moments.

target statistics	data	model
total entry rate of firms	0.150	0.150
share of employment at firms with 50+ workers	0.163	0.162
total average firm size (workers)	3.550	3.645
share of firms with less than 10 workers	0.956	0.946
size informal sector (employment share)	0.450	0.452
median size informal sector firms (workers)	1.000	1.070
credit/total output (ratio)	0.185	0.193
non-target statistics	**data**	**model**
share of employment at firms with 15+ years	0.288	0.317
share of employment at firms with 5− years	0.336	0.249
share of firms with 50+ workers	0.009	0.008
average size new firms (1 year or less)	1.295	1.203
std. dev. size informal sector firms (workers)	0.962	1.035
median age informal sector firms	6.000	5.000
exit rate firms 20+ workers (formal sector)	0.039	0.046
Data source: INEGI (Mexico).		

In Table 6 we additionally register the ability of the model to replicate a set of non-target statistics related to the distribution of employment by age of the firm, the standard deviation of the size and the median age of firms in the informal sector, the average size of new firms and the exit rate of firms with more than 20 workers. The median age and size statistics of informal sector firms and the average size of new firms is from ENAMIN. Finally, for this calibration of the model the average capital-labor ratio of formal sector firms is 29.7 percent higher than for informal sector firms.[34]

6.3 Institutional parameters

Registration costs are obtained from Djankov et al. (2002). They compute the direct official costs of procedures plus the monetized value of the entrepreneur's time (as a fraction of GDP per capita in 1999) associated with meeting legal requirements that a start-up must bear in order to operate legally. Minimum capital requirements are from the World Bank's Doing Business Report (2004), also originally expressed in terms of GDP per capita. In the model, these figures are expressed in terms of GDP per worker using labor force data from the World Bank: the ratio of the labor force to total population is in the range of 0.30-0.44 of the total population for the developing economies under analysis

[34] We document below how these relative ratios change with taxes on labor applied to formal sector firms.

(I conduct robustness exercises below by increasing the value of entry costs).

Table 7. Institutional Parameters.

description of parameter	parameter	U.S.	Mexico	Turkey	Egypt
total tax rate as share of profits	τ	0.46	0.56	0.53	0.54
registration costs plus time value‡	c_e	0.02	0.83	0.37	1.17
minimum capital requirements‡	$\underline{b}$	0.00	0.88	0.13	7.88

Data source: World Bank. ‡expressed in terms of GDP per capita.

I first consider a simple tax structure where τ (computed by the World Bank Doing Business Survey, the earliest available data is for 2006) includes taxes paid by a standardized limited liability company expressed as a share of commercial profits. The taxes are measured at all levels of government and include profit or corporate income tax, social security contributions and labor taxes paid by the employer, property taxes, dividend and capital gains tax, etc. Taxes withheld (sales tax or value added tax) but not paid by the company are excluded.

7 Quantitative analysis

In this section I discuss different reform experiments for developing economies: the elimination of registration costs and minimum capital requirements and improvements in access to credit for formal sector firms. I also introduce an extension to the model by considering size-dependent taxation on output and labor for formal sector firms: the gains generated by different reforms are reduced by distortions that decrease the incentives to increase the size of the firm (I further discuss the implications of this result below).

7.1 Elimination of registration costs and capital requirements

For Mexico, the elimination of formal sector registration costs and minimum capital requirements generates a gain in aggregate TFP of 0.5 percentage points (see Table 8).[35] Additionally, output per capita increases by 0.7 percentage points and the size of

[35]TFP is computed from the expression $Y = A\,(K^{\alpha}\,L^{1-\alpha})^{\gamma}$, which is derived in an economy where the production technology at the firm level has decreasing returns to scale (see Midrigan and Xu, 2013). Similar results are obtained if we use $Y = A\,K^{\alpha\,\gamma}\,L^{1-\alpha\,\gamma}$ as in Guner et al. (2008) and Barseghyan and DiCecio (2011).

the informal sector as a share of total employment decreases from 0.452 to 0.440. The increase in wages is 1.2 percent while the increment in welfare is 0.9 percent (see below for the definition of consumption equivalence).[36]

Table 8. Elimination of Entry Cost and Minimum Capital Requirement.

	Mexico		Egypt	
model variables	initial	reform	initial	reform
equilibrium wage	1.000	1.012	1.000	1.006
aggregate productivity (TFP)	1.000	1.005	1.000	1.003
output per person	1.000	1.007	1.000	1.003
capital per person	1.000	1.001	1.000	1.004
welfare (consumption equiv.)	1.000	1.009	1.000	1.004
share informal sector employment	0.452	0.440	0.484	0.466
share formal sector firms	0.081	0.087	0.065	0.075
average size of firms (total)	3.645	3.686	4.242	4.297

For the case of Egypt, we set λ_f to 3.1 and reduce ω to 5.5, so that the ratio of the volume of credit to GDP is 0.44 and the informal sector conservatively accounts for 48 percent of total employment.[37] We then find that the quantitative impact of eliminating formal sector entry costs and minimum capital requirements is limited. The logic behind this result is that even though these obstacles are larger for Egypt, both the ratio of credit to GDP and the size of the informal sector are larger, this requires a smaller ω, i.e. lower costs of informality. Given the low costs of informality, less productive entrepreneurs are better off in the informal sector in spite of a large reduction in the requirements to enter the formal sector (access to credit remains unchanged in this exercise).

We can graph a histogram of the potential welfare gains (in terms of consumption equivalence) for informal sector entrepreneurs, given by their possible transition to the formal sector when entry costs are eliminated. I take all informal sector firms at a given period in time and compute $(v_f(\varphi, a', g_i(\varphi, a, b))/v_i(\varphi, a, b))^{1/1-\phi}$, where $g_i(\varphi, a, b)$ are

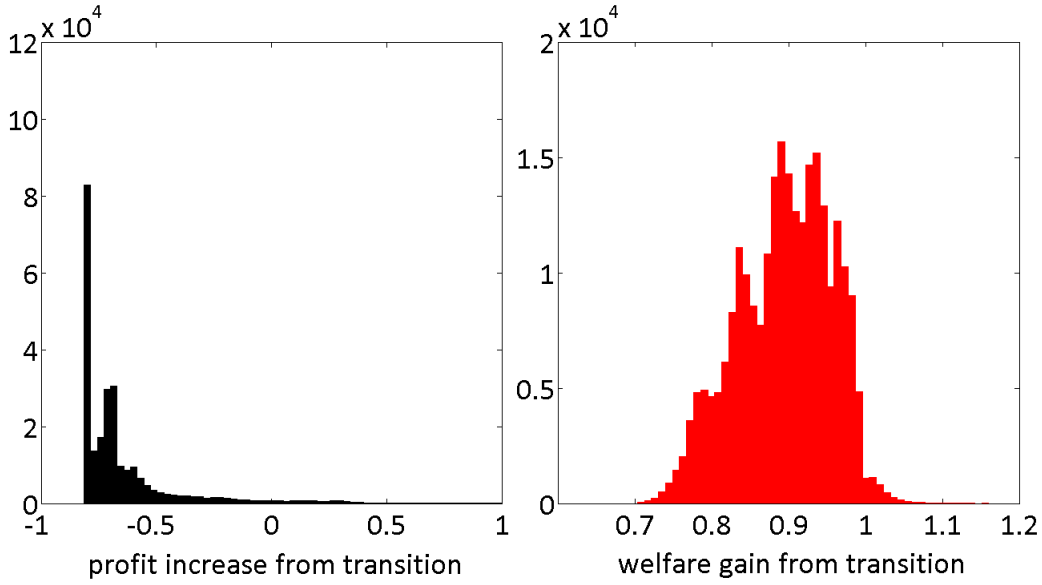
[36] I have also performed an exercise where the initial level of entry costs is equal to four and a half times the original entry costs in the case of Mexico. Eliminating this level of entry costs results in an increase in output of 2.2 percent.

[37] For conciseness and given data availability we perform a more comprehensive set of exercises for Mexico throughout the quantitative analysis section. For Egypt, in the model (data) the share of firms with less than 10 workers is 0.96 (0.957), with the parameters for entrepreneurial ability as calibrated for Mexico (Table 5). Additional information is available upon request.

financial assets in the next period according to the policy function of informal sector entrepreneurs. Most informal sector entrepreneurs will not find it optimal to transition (right panel, Fig. 3), and this number does not differ significantly from the original baseline scenario (numbers below one imply a loss in welfare). For most informal sector entrepreneurs transition implies significant losses in terms of profits (left panel, Fig. 3). We should note that informal sector entrepreneurs are allowed in the model to transition in any period, subject to entry costs and minimum capital requirements. With respect to transition rates for workers, even with the elimination of entry costs and minimum capital requirements less than 1 percent of workers that initiate a firm opt to do so in the formal sector.[38]

7.2 Financial sector reform

Fig. 3 Gains from Transition after Elimination of Entry Cost (histograms)



We turn next to the impact of the improvement of access to credit for formal sector firms. Table 9 shows the baseline scenario for Mexico, as initially calibrated, and the

[38]The calibrated probability of entrepreneurial opportunities for workers generates a firm turnover rate at the high range of available international statistics: available entry rates are only higher for transition economies (which would be reasonable to expect): Slovenia, Hungary, Romania and Latvia (see Fig.1.2.D in Bartelsman, 2009). I conducted a robustness exercise with ϑ equal to 1/4 (an arguably high rate of entrepreneurial opportunities), resulting in an entry rate of 0.168: the impact of eliminating entry costs and minimum capital requirements are quantitatively unchanged from the baseline exercise (results are available upon request).

impact on different aggregate variables as the volume of credit to GDP expands by increasing the parameter that determines the ability of formal sector firms to collateralize assets, while entry costs and minimum capital requirements remain fixed.

Table 9. The Impact of Financial Reforms (Mexico).

model variables	base	#1	#2	#3
collateral parameter λ_f	1.68	1.00	2.50	5.00
private credit/total output	0.193	0.000	0.396	0.816
equilibrium wage	1.000	0.904	1.078	1.213
aggregate productivity (TFP)	1.000	0.962	1.019	1.040
output per person	1.000	0.942	1.056	1.165
capital per person	1.000	0.927	1.130	1.490
welfare (consumption equivalent)	1.000	0.925	1.060	1.170
share informal sector employment	0.452	0.619	0.364	0.244
share formal sector firms	0.081	0.047	0.106	0.152
average size of firms (total)	3.632	3.035	4.140	5.244

We can compute the gains in expected lifetime welfare for newly born individuals (with the initial level of financial assets $\overline{b}$, equal to zero) in terms of the consumption equivalence $1+\Delta$, derived as follows:

$$1+\Delta = \left[\int_{\{\varphi,a\}} v_w^{new}(\varphi,a,\overline{b})\, dG(\varphi,a) \;/\; \int_{\{\varphi,a\}} v_w^{base}(\varphi,a,\overline{b})\, dG(\varphi,a)\right]^{1/(1-\phi)}$$

where $G(\varphi,a)$ is the distribution determined by the log-normal distribution for φ and the unconditional distribution derived from $\Lambda(a' \,|\, a)$, with φ and a being two independent variables.

Table 10 presents different statistics related to the size distribution of firms, productivity and the marginal product of capital (for weighted statistics, weights are given by output). As we increase the ability of formal sector firms to collateralize assets there is an increase in the average size of firms and in the average productivity of firms in both the formal and informal sectors. Furthermore, the dispersion in the marginal product of capital across firms is reduced as entrepreneurs are able to produce with a level of capital closer to the optimal unconstrained level.[39]

[39]We can alternatively specify the ability to collateralize assets as a function of financial wealth. For example, setting $\lambda_f(b) = 1 + b \cdot 0.023$ implies that firms with no assets cannot obtain credit and the

Table 10. The Impact of Financial Reforms (additional results).

model variables	base	#1	#2	#3
collateral parameter λ_f	1.68	1.00	2.50	5.00
private credit/total output	0.193	0.000	0.396	0.816
average firm size (total)	3.632	3.035	4.140	5.244
share firms w/less than 10 workers	0.946	0.966	0.933	0.900
empl. firms w/less than 10 workers	0.489	0.636	0.402	0.273
avg. formal firm productivity	1.000	0.978	1.001	1.037
avg. informal firm productivity	1.000	0.958	1.035	1.084
weighted formal mg. product cap.	0.356	0.458	0.296	0.225
var. ln(mg. product cap.) formal	0.376	0.476	0.298	0.201
weight. capital-lab. ratio/optimal	0.430	0.351	0.496	0.616

For weighted statistics weights are given by output.

7.3 Size-dependent taxation

In this section we consider the possibility that taxes depend on the size of the firm. The tax structure consists of a tax $T(l)$ on labor and $T(q)$ on the output of firms.[40]

value 0.023 generates a ratio of total credit to output in the economy of 0.21. Relative to the baseline economy, the informal sector is 5 percentage points larger in terms of employment, output per capita is 1.1 percent lower (the same levels of registration costs and minimum capital requirements are considered). With this specification for financial constraints, highly productive firms with low financial wealth are more constrained relative to the baseline model.

[40] As emphasized by Kanbur and Keen (2014), firms may face multiple forms of tax and non-tax obligations with different thresholds, which can generate complex patterns in terms of compliance, adjustment and evasion. In other words, there may be many reasons for which effective tax rates can depend on the size of the firm, here I focus on one specific source of this size-dependency. The objective of the tax structure analyzed here is to evaluate how the main results may be modified by distortions that depend on the size of the firm, while keeping the model tractable. For example, Ulyssea (2014) introduces the *intensive margin* in informal decisions in a theoretical model, by considering the decision of the firm of partial reporting of its workforce. Note that the parameters in Table 5 are re-calibrated for this version of the model (see the appendix).

Table 11. Size-Dependent Taxation: Calibration.

	Mexico		Turkey	
targets: *effective* tax rates	data	model	data	model
on labor: small firms	0.110	0.111	0.188	0.187
on labor: medium size firms	0.129	0.130	0.210	0.212
on corp. income: small firms	0.195	0.194	0.218	0.218
on corp. income: medium size firms	0.226	0.228	0.250	0.251
description of parameter	parameter		Mex.	Trk.
labor tax level parameter	λ_l		0.097	0.173
labor tax curvature parameter	τ_l		0.067	0.048
corp. income tax level parameter	λ_q		0.843	0.810
corp. income tax curvature parameter	τ_q		0.018	0.017

Data sources: OECD Tax Database, World Bank (WBES).
Due to data availability, for Mexico (Turkey) small firms have
5-10 (2-10) workers, medium size firms have 70-80 (50-99) workers.

I follow the specification described in Guner, Kaygusuz and Ventura (2008) where the average tax rate on output is $T(q) = 1 - \lambda_q\, q^{-\tau_q}$. Under this specification the parameter λ_q controls the level of the tax rate, if τ_q equals zero then average and marginal tax rates are constant. The after-tax revenue of the firm is $(1 - T(q))\, q = \lambda_q\, q^{1-\tau_q}$.

The OECD Tax Database documents a corporate income tax rate of 0.28 for Mexico. This value is close to the level of the average tax-rate on firm output estimated by Leal-Ordoñez (2014): the total tax revenue from the formal sector amounted to 11 percent of GDP in 2008, while the value added associated to firms in this sector amounted to 44 percent of GDP, resulting in an average tax rate of 0.25. For Turkey, the average corporate income tax for the period 2000-2005 was 0.32.

For labor taxes I follow a similar specification, $T(l) = \lambda_l\, l^{\tau_l}$, total labor costs for formal sector firms are $w\, l\, (1 + T(l))$.[41] For Mexico, the average *total labor tax wedge* for the period 2001-2010 was 0.153.[42] For Turkey, I take the labor tax wedge and subtract employee social security contributions, the average for this labor tax wedge during 2000-2005 was 0.274.

[41] The tax on labor increases the capital-labor ratio of formal sector relative to informal sector firms (as well as output per worker): for Mexico, in the size-dependent tax model the ratio of total capital to labor in the formal and informal sectors are 1.81 and 1.29, respectively.

[42] The *total tax wedge* is taken from the OECD Tax Database and consists of the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labor costs defined as gross average wage earnings plus employer social security contributions.

Table 12. Elimination of Entry Cost and Minimum Capital Requirement: The Role of Size-Dependent Taxes.

	Mexico		Turkey	
model variables	initial	reform	initial	reform
equilibrium wage	1.000	1.006	1.000	1.003
aggregate productivity (TFP)	1.000	1.005	1.000	1.002
output per person	1.000	1.007	1.000	1.003
capital per person	1.000	1.005	1.000	1.002
welfare (consumption equiv.)	1.000	1.006	1.000	1.001
share informal sector employment	0.433	0.416	0.332	0.327
share formal sector firms	0.144	0.155	0.224	0.229
average size of firms (total)	3.540	3.586	3.126	3.155

Next I exploit survey data from the World Business Environment Survey (WBES by the World Bank), which provides information on the percent of sales not reported to tax authorities.[43] In the case of Mexico, for example, this data suggests that firms that have between 5 and 10 workers report on average 69.7 percent of their sales and declare 71.7 percent of their workforce. For firms that have between 70 and 80 workers, these numbers are 80.6 and 84.5 percent, respectively. I use these values to determine the parameters in Table 11. I report the results of eliminating formal sector entry costs and minimum capital requirements in Table 12.

Table 13. Elimination of Entry Requirements and Financial Reform: The Role of Size-Dependent Taxes.

model variables	relative gains*
equilibrium wage	0.813
aggregate productivity (TFP)	1.018
output per person	0.933
capital per person	0.735
welfare (consumption equiv.)	0.852

*gains in the model with size dependent taxes relative to the baseline model.

The benefits of financial development are reduced with size-dependent tax rates. In the baseline model increasing λ_f to 125 results in an increment of output per capita of

[43] Dabla-Norris et al. (2008) summarize the information contained in the firm level survey responses for over 4,000 firms in 41 countries: the average percentage of sales reported to tax authorities is 80.8 for small firms (5-50 workers), 84.8 for medium sized firms (51-500 workers) and 88.1 percent for large firms (500 workers).

approximately 60 percent (the ratio of the volume of credit to total output is close to 2) while in the model with size-dependent tax rates this same value for λ_f increases output per capita by 50 percent (the ratio of credit to total output is approximately 1.43).[44] In the size-dependent taxation model firms are penalized for producing more and this distorts the incentives to utilize more capital and hire workers: the average size of firms increases from 3.54 to 5.73, which is a considerably smaller increment relative to the impact of financial development in the baseline model, while capital per person also increases by less in the economy with size-dependent taxes (see Table 13).

7.4 Credit in the informal sector

In our baseline model I have ignored the possibility of access to credit in the informal sector. Increasing λ_i to 1.17 raises output per capita by 1.65 percent, which is accounted for by an increase of capital in the economy, as aggregate productivity remains approximately unchanged. In the new equilibrium, credit in the informal sector is equivalent to 5.1 percentage points of GDP and employment in the informal sector increases to 47 percent.[45]

8 Conclusion

Significant aggregate productivity losses have been attributed to the existence of large informal sectors in developing economies. It is therefore not surprising that remarkable efforts have been dedicated to the implementation of policies intended to ameliorate these losses. Reforms aimed at simplifying formal sector entry regulation have become widespread (Djankov, 2009). However, recent empirical studies that exploit firm-level data to evaluate the consequences of these reforms have found relatively modest results

[44] I start in both economies with a ratio of private credit to total output of approximately 0.195. The results in Table 13 show the joint impact of eliminating registration costs and minimum capital requirements and increasing the ability to collateralize assets in the formal sector (the results from Table 12 already show that the impact of the first reform is marginal, alternative results are available upon request).

[45] This new parameterization overemphasizes the volume of credit in the informal sector as suggested by the data. The new value for λ_i implies that the capacity to collateralize assets in the informal sector is approximately one quarter relative to that in the formal sector. Hernandez-Trillo et al. (2005) document that the average loan size from moneylenders and friends or relatives (associated with informal credit) is less than one fifth relative to those from banks. Additionally the average term is 1 and 4 months for loans from friends or family and moneylenders, respectively, and 17 months for bank loans. Nominal annual interest rates can be in the range of 120 to 240 percent for loans from moneylenders. For these reasons it is unlikely that informal sector credit has significant aggregate effects and we conduct this exercise only to further illustrate the mechanisms of the model.

(as discussed in the survey by Bruhn and McKenzie, 2013). I construct a framework of firm dynamics with financial constraints, and quantify the consequences of the elimination of formal sector registration costs and minimum capital requirements and of improving access to credit for formal sector firms. In line with the empirical evidence, I find that the impact of eliminating registration costs and minimum capital requirements are modest relative to those generated by previous theoretical models or the gains generated by financial development.

In terms of financial development, improving the ability of formal sector firms to collateralize their assets and access more credit generates significant gains in aggregate productivity, output and welfare in general. Nevertheless, caution is warranted as introducing size-dependent distortions in the model reduces the gains from financial development, suggesting the importance of obstacles faced by the more productive firms in the economy to quantitatively assess the potential gains generated by financial development.[46]

[46] Among alternative motivations for size-dependent labor costs is the existence of strong labor unions which can affect larger firms disproportionately. Following this line, additional factors that can influence the size of the informal sector include lack of competition and the existence of protected sectors. We leave these topics for future research.

9 References

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A Size distribution of firms

The data for the U.S. distribution of firms is from Helfand et al. (2007), taking the average 1990-2000. These statistics account for 97% of the total number of employees in private industries (code *USPRIV*, Federal Reserve Economic Data). For Turkey, the data is from World Bank (2010) and OECD (2002) (similar numbers are obtained from TurkStat, Household Labour Force Survey). Data for registered workplaces is available from the Social Security Institution (see Kenar, 2009).

For Egypt, data for non-agricultural activities is from the Central Agency for Public Mobilization and Statistics (CAPMAS), the main statistics agency of the Egyptian government, Establishment Census 1996 (see Tables 1 and 4 in Ministry of Foreign Trade, 2003). Figures for formal sector establishments and workers are available from the 2006 Economic Census. For Mexico, the size distribution of firms is obtained from Busso et al. (2012), computed with data from INEGI, the national statistics institute. Considering multi-plant firms does not alter the results (see Appendix Table 22). The distribution of employment by firm size is based on Table 4 of Busso et al. (2012).

B Probit estimates of informality: model simulations

Table A1. Probit Estimates of Informality (simulations).

	simple tax		size dep. tax	
variables in logs	Egypt	Mexico	Turkey	Mexico
entrep. ability	-5.637***	-5.418***	-3.634***	-4.017***
firm productivity	-2.316***	-2.375***	-2.086***	-1.737***
financial assets	-3.012***	-3.005***	-1.544***	-1.574***
pseudo R2	0.788	0.771	0.695	0.711
n. observations	106,620	123,674	142,363	126,081
variables in logs	*alternative specification*			
entrep. ability	-8.460***	-6.402***	-4.483***	-4.977***
firm productivity	-1.449***	-1.514***	-1.787***	-1.517***
age of firm	-1.444***	-1.394***	-1.326***	-1.368***
pseudo R2	0.431	0.422	0.522	0.532
n. observations	106,620	123,674	142,363	126,081

***statistical significance at 1%.

We simulate different versions of the model, with calibrated registration costs and minimum capital requirements and baseline financial development, and estimate probit models on the formal/informal status of the firm with the state variables of the model. The sign on all state variables are as expected and consistent with the empirical probit model. The age of the firm is a proxy for the time the entrepreneur has had to be able to accumulate assets.

C Size-dependent taxation: calibration

Table A2. Size-Dependent Taxation: Calibration.

description of parameter	parameter	Mex.	Trk.
exogenous annual exit rate	δ	0.040	0.040
ability dist. mean (log-normal)	μ	-0.457	-0.457
ability dist. std. dev. (log-normal)	ε	0.230	0.230
probability of entrepr. possibility	ϑ	0.210	0.210
informal sector technology	ω	7.400	13.000
informal sector technology	ξ	1.0e-07	1.0e-07
formal sector collateral constraint	λ_f	1.560	1.370
	Mexico		Turkey
targets statistics	data	model	data	model
total entry rate of firms	0.150	0.150	$--$	0.144
share of employment at firms w/50+ workers	0.163	0.186	0.170	0.172
total average firm size (workers)	3.550	3.540	$--$	3.126
share of firms with less than 10 workers	0.956	0.937	0.950	0.944
size informal sector (employment share)	0.450	0.433	0.320	0.332
median size informal sector firms (workers)	1.000	1.000	2.000	1.000
credit/total output (ratio)	0.185	0.197	0.155	0.156

Data sources: INEGI (Mexico), ERF (Turkey), World Bank (2010).

In Table A2 we enumerate the parameters for the size-dependent taxation exercises for Mexico and Turkey and their respective target moments. For Turkey, ω is 13 and λ_f is 1.37, the rest of the parameters are the same as for Mexico. The estimates for the size of the informal sector for Turkey are between 25 to 39 percent of employment (see the discussion in Section 3), we target the midrange of these estimates. The target of the credit to output ratio is the average for 1995-2005.

D Algorithm outline

Given the interest rate and government policies, computing the equilibrium amounts to finding the wage w that clears the labor market. The grid for the ability variable φ consists of 20 values, with weights given by a discretized log-normal distribution. The Markov matrix $\Lambda(a' \mid a)$ is constructed following Tauchen (1986), with 9 possible state values. The grid for financial assets b has up to 800 points (as necessary depending on parameters and ability of the entrepreneur). The algorithm can be summarized as follows:

(1) Guess the wage level w. Solve for quantities $\{q(s,z)\}_{z\in\{i,f\}}$, production inputs $\{l(s,z), k(s,z)\}_{z\in\{i,f\}}$ and profits $\{\pi(s,z)\}_{z\in\{i,f\}}$ subject to credit constraints.

(2) Through value function iteration, until a desired level of precision is reached, obtain policy and value functions $\{g_z(s)\}_{z\in\{i,f,w\}}$, $\{v(s), v_i(s), v_f(s), v_w(s)\}$.

(3) Run 150 simulations of 25,000 individuals for 350 periods (it is verified that increasing the number of simulations/individuals/periods does not change the results). An individual that dies is replaced by another individual with the same entrepreneurial ability.

(4) Compute the aggregates using the cross section of the last period of the simulations and verify that the market clearing condition for labor is satisfied, otherwise return to step (1) and adjust w and parameters as necessary.