From Firm Productivity Dynamics to Aggregate Efficiency

(firm productivity), establishing a link between firm productivity dynamics and aggregate production efficiency.[3] Previous work in development and financial frictions has mostly ignored the role of endogenous productivity growth of the firm or considered a one-time technological adoption choice (two exceptions are the recent work of Cole, Greenwood and Sanchez, 2012; and Caggese, 2014). The empirical literature has already stressed the relative lack of growth of firms in developing countries (see for example Hsieh and Klenow, 2012). The model with endogenous productivity accumulation can partially account for the lower life-cycle productivity growth of firms in an economy with underdeveloped financial markets.

How do financial constraints affect firm productivity growth? Investment in innovation is a costly and uncertain enterprize. As the capacity to obtain external

Additionally, financially underdeveloped economies will be characterized by a lower average ability of entrepreneurs, many of which have relatively low prospects of generating productivity growth through innovation. This is due to the lower demand for workers and the lower wages they receive, a larger mass of individuals opt to set up firms or become self-employed. These individuals, in the margin, tend to

3 Empirical Motivation

After a brief description of the data, this section documents the empirical evidence that motivates this study.[7] Relative to what has been documented for the US we can summarize the empirical facts for Colombia and Mexico as follows: (1) establishments grow less in terms of employment and productivity, (2) there is a larger share of employment in smaller establishments, (3) small establishments in the informal sector account for a large share of employment.

3.1 Data Description

For Colombia, the data is from the Annual Manufacturers Survey (AMS) for the period 1982-1998, constructed as a project of technical cooperation between the national statistics agency (DANE) and J. Haltiwanger (see Eslava et al., 2004). The AMS consists of an unbalanced panel of plants[8] with more than 10 employees or sales above a certain limit (approximately 35 thousand US dollars in 1998). The data-set includes information for each plant on output value and prices, input costs and prices, energy consumption in units and prices, number of production and non-production workers, book value of equipment and structures and four digits industry classification codes (CIIU). The AMS underwent changes in methodology of sampling and identification of plants, the creation of longitudinal linkages was necessary to consolidate plant identifiers through three different periods: 1982-1991, a transition period in 1991-1993 and 1991-1998. Plant-level TFP was generated through the estimation t6iTd [(the)-436(nd)-382(8.)-thestrucn-thestrucn7iTd [(u-I--334(p)-3als-327(unit

500 workers is 25.6% (Camacho and Conover, 2010), while in the US, the equivalent figure (considering manufacturing firms with over 10 workers) is 31.7%. The informal sector in Colombia accounts for 52% of non-agricultural employment (ILO Statistics).

3.3 Establishment Life-Cycle Dynamics

This subsection documents the life-cycle growth of manufacturing firms in the US, Colombia and Mexico.[11] In the US most firms are born small: approximately 96.2 percent of firms that are 0-1 years have less than 20 workers.[12] Younger/smaller firms have higher exit rates, but those that survive tend to grow faster than older/larger firms (Klette and Kortum, 2004).

Table 2. The Life-Cycle of Establishments: Employment.

	USA[1]		Colombia[3]		Mexico[1]
relative size	surv.	all	surv.	all	all
age 5-9/age 1-4	1.6	2.0	1.5	1.4	1.4
age 10-14/age 1-4	2.0	3.0	1.7	1.7	1.5
age 15-19/age 1-4	2.3	4.1	1.8	2.1	1.6
	USA[2]		Colombia[3]		Mexico
growth in %	surv.		surv.	all	–
age 6/age 1	106.1		62.7	50.2	–
age 8/age 1	135.2		84.4	73.5	–
age 10/age 1	154.8		104.8	101.1	–

Source: [1]Hsieh and Klenow (2012), [2]Audretsch (1995),

Table 2).

Table 3. The Life-Cycle of Establishments: Productivity.

	USA[1]	Colombia[2]		Mexico	
relative avg.	all	surv.	all	all[3]	all[1]
age 5-9/age 1-4	1.6	1.0	1.0	1.4	1.5
age 10-14/age 1-4	2.1	1.2	1.1	1.5	1.6
age 15-19/age 1-4	2.8	1.3	1.2	1.5	1.6

Source: [1]Hsieh and Klenow (2012),
[2]computed w/AMS-DANE (1982-1998), age 15-16 only,
[3]computed w/INEGI Census (2009), cross section.

The life-cycle growth of establishments for Colombia is computed using the AMS panel database for the period 1982-1998. We are able to follow establishments up to age 16 (we cannot impute the age of establishments born in 1982 or earlier). For the growth rate of *all* establishments in the lower panel first I compute, in every year, the average size of all establishments of a particular age. Then I calculate the growth rate of this average for each cohort. Finally, for each age I take the median across cohorts. For example, to calculate growth at age 4, I have 13 observations representing cohorts of establishments born between 1983 and 1995. There is variation across cohorts, taking the average across cohorts instead of the median results in slightly lower life-cycle growth. To compute the growth of *survivors* in the lower panel, I compute the growth of each individual establishment at each age, I take the average of establishment growth within a cohort and then the median across cohorts (Table 2). This procedure is equivalent to the one in Audretsch (1995) but repeated for different cohorts.

For the upper panel of Table 2, first I take the average of all establishments age 1-4 for each given year. To calculate the relative size at age 5-9, I can start in 1991 (the first year where we have establishments of age 9) resulting in 8 observations, for age 10-14 we can start in 1996, resulting in 3 observations. This procedure is comparable to that in Hsieh and Klenow (2012) but repeated for different cohorts. For Colombia, Table 3 uses firm TFP computed by Eslava et al. (2004).

For Mexico, we have data available from the 2009 Economic Census (a cross section). Hsieh and Klenow (2012) are able to use the Census data for 1999, 2004,

4 Stylized Model of Innovation and Financial Constraints

In this section a stylized two-period model is presented to highlight the interaction between financial constraints and innovation along the intensive and extensive margins.[13] The intensive margin considers how financial constraints affect innovation for a firm with a given productivity level. The extensive margin refers to the impact on firms with different productivity: general equilibrium effects may lead to changes in the composition of firms.

For simplicity I assume that in the first period no production takes place, the entrepreneur is endowed with financial assets $b > 0$ which can be allocated to consumption c in the first period, to savings b' for the second period (in this section we assume there is no interest rate on savings), or invested in the innovation good x. In this set-up, innovation investment is fully financed with internal funds (evidence supporting this assumption is discussed below).

In the second period knowledge capital can take low and high levels, $n \in \{\underline{n}, \overline{n}\}$ respectively, determining the production possibilities. There is a stochastic innovation technology that determines the probability $P(\overline{n} | x) \in [0, 1]$ depending on the amount invested in the innovation good x. This function is6576 10.9091 Tf 6.235 0 Td [(.)]TJ -393.83

The intertemporal optimality equation for assets b' is given by:

$$u_c(c) = \quad \sum_{\{n'\}} P(n' | x)\, u_{c'} \quad (n'; b') + b' \quad (\;\; _{b'}(n'; b') + 1)$$

Where u_c refers to marginal utility and $\;\; _{b'}$ is the derivative of profits in the second period with respect to assets. This derivative will be positive when the collateral constraint is binding. In addition to the standard consumption smoothing motive for savings, there is an incentive to save to relax the collateral constraint in the second period.

Consider the function $P(\overline{n} | x) = \quad x$ with parameters $\;\; \in (0; 1)$ and $\;\; > 0$, the intertemporal optimality equation for innovation investment x is (in an interior solution):

$$u_c(c) = \qquad x^{\quad 1} \;\; u(\;\; (\overline{n}; b') + b') \quad u(\;\; (\underline{n}; b') + b')$$

We are interested in understanding how financial constraints affect investment in innovation. The left hand side on the intertemporal optimality condition of innovation investment does not depend directly on $\;\;$. The derivative of the right hand side, defining $\;\; u = u(\;\; (\overline{n}; b') + b') \quad u(\;\; (\underline{n}; b') + b')$ is:

$$\frac{\partial \;\; u}{\partial \;\;} = u_{c'} \quad (\overline{n}; b') + b' \quad \frac{\partial}{} \;\; (\overline{n}; b') \, ($$

Suppose now that there are individuals with heterogeneous entrepreneurial ability, which a□ects the production technology of the firm they manage. The production function is $('n)^{1} \quad k$ where $'$, the entrepreneurial ability, varies across individuals. To isolate the role of the extensive margin consider a risk neutral utility function and no collateral constraint. The static profit maximization problem is given by:

$$(' \, n) = \max_{fkg} \; ('n)^{1} \quad k \qquad (r + \quad) \, k$$

The inter-temporal problem, simplified to isolate the role of the extensive margin, is now given by:

$$\max_{fxg} \quad x + \sum_{fn^{0}g} P(n^{0} j \, x) \quad (' \, n^{0})$$

With a small amount of algebra it can be shown that the optimal first order condition for innovation investment in an interior solution is:

$$x^{1} \quad = \qquad ' \, (\overline{n} \quad \underline{n}) \, (1 \qquad) \, (\;\; =(r + \quad)) \; ^{=1}$$

This condition implies that x is increasing in $'$ when $\; < 1$. In the quantitative model financial constraints lower the demand for labor resulting in lower wages. This leads to individuals with lower entrepreneurial ability $'$ to set-up a firm.

5 Quantitative Model

The model builds upon the frameworks of occupational choice and heterogeneous entrepreneurial ability[15] of Lucas (1978) and industry dynamics of Hopenhayn (1992). There is a continuum of individuals who possess heterogeneous innate entrepreneurial ability and every period decide whether to be workers or establish a firm and become entrepreneurs. The operations of the firm are subject to transitory stochastic shocks which are observed at the beginning of each period, before production and occupation decisions are made. All individuals earn the same wage as workers, since there is no heterogeneity in their e□ective units of labor and workers are perfectly mobile.[16]

The firm is a *storehouse of information* (Prescott and Visscher, 1980; Atkeson and Kehoe, 2005), or *knowledge capital* (Klette and Kortum, 2004; Corrado et al. 2009). Entrepreneurs in the formal sector can, while the firm is in operation, allocate resources to investment in technology through a controlled stochastic process. Innovation is an uncertain enterprize, as in Klette and Kortum (2004) and Atkeson and Burstein (2010): entrepreneurs decide every period the amount of resources devoted to improving firm productivity, which determines the probability of an increase in

[15] Di□erences in management quality are an important determinant of productivity di□erences across firms (see Bartelsman and Doms, 2000; Foster et al., 2001; Syverson, 2011).

[16] The evidence on whether labor markets are segmented across informal and formal sector firms suggests mixed results at best, see the discussion in Perry et al. (2007, Ch. 3 and 4).

firm productivity. Knowledge capital summarizes the history of past investment and innovation success of the firm.[17]

The entrepreneur, who is both owner and manager of the firm, can opt to conduct operations in the formal or informal sector. The trade-off is the following: formal sector firms have to pay an initial registration cost and taxes but they have better access to external finance. Informal sector firms do not pay taxes or the initial registration cost, but have no access to external finance and cannot accumulate knowledge capital. Additionally informal sector firms face a specific convex cost of production. This cost represents the inability to engage in legal contracts, the cost

Their operations are subject to productivity shocks a that follow an AR(1) process discretized in a Markov matrix denoted $(a' | a)$. Additionally, entrepreneurs are

trepreneur are given by:

$$(s; f) = q \quad (\quad + r) k \quad w l$$

To register in the formal sector, entrepreneurs have to pay a fixed cost c_e. Once in the formal sector, the entrepreneur may go back to being a worker and c_e

income from financial assets:

$$\max_{\{l\}} (1 \quad) (q \quad w l \quad (r + \quad) k \quad p_x x) + (1 + r) b \tag{7}$$

In the case of default the entrepreneur would receive (off-equilibrium):

$$\max_{\{l\}} (1 \quad) ((1 \quad) (q \quad w l) + (1 \quad) k) \quad (1 \quad) p_x x \tag{8}$$

Capital rental is said to be enforceable if and only if it satisfies (7) (8). Note that equation (8) is specified so that investment in innovation $p_x x$ does not distort the bound of enforceable capital.[24]

The borrowing limit is increasing in financial wealth since the loss of collateral is greater in the case of default. It is also increasing in productivity and entrepreneurial ability, as only a share of output is kept in the case of default (see Amaral and Quintin, 2010; Buera et al., 2011).

5.7 Informal Sector Entrepreneurs

Informal sector entrepreneurs do not pay taxes but have no access to external finance. In addition, there is a sector specific marginal cost that is increasing in output, determined by parameter . Profits for the informal sector firm are:

$$(s; i) = q (1 \quad q) \quad (r + \quad) k \quad w l$$

The problem of the informal sector entrepreneur is:

$$v_i(s) = \max_{\{l; k; b' \quad 0\}} u(c) + \quad (1 \quad) \sum_{\{a'\}} (a' | a) v(s') \tag{9}$$

$$\text{s.t.} \quad c + b' = \quad (s; i) + (1 + r) b \quad \text{and} \quad k \quad b$$

and face the same occupational decision as workers (with $n = \underline{n}$):

$$v(s) = \max \{ v_i(s); v_f(\,'; \underline{n}; a; b \quad c_e); v_w(s) \}$$

The convex marginal cost specific to the production technology of informal sector firms makes it increasingly costly for larger firms to remain informal and is therefore a key determinant of the size of this sector and the size of firms in the sector. The literature has documented the worse access of informal sector firms to different types of public services and enforcement of property rights and the fact that informal sector firms are relatively small and unproductive.

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[24] The following timing assumptions within a period imply that investment in innovation does not affect $\bar{k}(s; z)$: (1) entrepreneur observes shocks and rents capital, (2) production takes place, (3) capital is returned to the intermediary and financial assets are returned to the entrepreneur, (4) investment in the innovation good is ame

5.8 Equilibrium

The state space is given by $(\varphi; n; a; b; z)$, we previously defined $s = (\varphi; n; a; b)$ and $z \in \{i; f; w\}$. Given taxes and registration costs $(\tau; c_e)$ and interest rate r, a small-open economy stationary competitive equilibrium consists of:

- optimal quantities $\{q(s; z)\}_{z \in \{i; f\}}$, production inputs $\{l(s; z); k(s; z)\}_{z \in \{i; f\}}$,
- savings policy functions $\{b'(s; z)\}_{z \in \{i; f; w\}}$,
- policy function of investment in the innovation good $\{x(s; f)\}$,
- wage w, values $\{v(s); v_f(s); v_i(s); v_w(s)\}$, profits $\{\pi(s; z)\}_{z \in \{i; f\}}$,
- invariant measure $M(s; z)$

Table 4. Predetermined Parameters.		
parameter	value	description
(1)	0.92	effective discount factor
	! 1	risk aversion
r	0.04	interest rate (open economy)
	0.85	span-of-control
	1/3	income share of capital
	0.08	capital depreciation rate
	0.50	autocorrelation coefficient
"	0.40	standard deviation of shocks

For the parameters and " that govern the idiosyncratic productivity process I take the mid-range of the values estimated by Abraham and White (2006) for a plant-level data-set that covers the manufacturing sector in the US for the period 1976-1999. The standard deviation is approximately equal to the median of the firm-level cross country estimates by Asker et al. (2012).

We now turn to the calibrated parameters in Table 5. The exogenous exit rate is set to match a total firm exit rate of 0.10. In the model the total exit rate equals the sum of the rate of entrepreneurs deciding to close their firms and the exogenous exit rate. Entrepreneurial ability is distributed according to a discrete Pareto distribution (truncated, with 15 possible values), its parameter is set to match the average size of firms in the US in the period 1995-2005 (Helfand et al., 2007).

Table 5. Calibrated Parameters - US Moments.		
parameter	par.	value
exogenous exit rate		0.08
Pareto dist. (truncated, discrete, scaled)	$h(')$	0.72
innovation technology - level		25
innovation technology - curvature		0.69
prob. *down* negative shock	"	0.15
size innovation steps		0.36
target	target	model

size of firms that are 15-19 years relative to firms that are younger than 5 years old for US manufacturing firms. With these parameters, the model underestimates the growth of firms, in particular at the earlier stages. Additionally, Midrigan and Xu (2013) find that for Korea (a developed economy), the ratio of total investment in intangibles over value added is 0.046 for a data-set of manufacturing firms. This value, however, is 0.01 in my model.

6.2 Country Specific and Institutional Parameters

Next, we need to specify parameters that are country specific or determined by institutions. The registration cost is from Djankov et al. (2002): it represents the cost of obtaining legal status to operate a firm, expressed as a share of per capita GDP in 1999. It includes all identifiable o□cial expenses (fees, costs of procedures and forms, fiscal stamps, legal and notary charges, etc.) as well as the monetized value of the entrepreneur's time. The time of the entrepreneur is valued as the product of time required for registration and per capita GDP in 1999 expressed in per business day terms. Ignoring the time value component, the cost is 0.57 in terms of GDP per capita for Mexico and 0.15 for Colombia.

Table 6. Institutional/Country Specific Parameters.

description	par.	US	Mex.	Col.
total tax rate (% profits)		0.46	0.55	0.74
registration cost formal sector	c_e	0.02	0.83	0.34
collateral constraint		1.00	0.25	0.34
informal sector convex cost		1.00	0.01	0.02
targets	**par.**	**US**	**Mex.**	**Col.**
private credit/output (formal sector)		2.3	0.2	0.2
% share of informal sector labor		0	46	49

Source: World Bank and Djankov et al. (2002).
Reg. cost in terms of GDP per capita.

Parameter determines financial development. As is standard in the literature, to set its value I target the ratio of private credit provided by financial institutions and private bond markets over GDP (Beck et al., 2009). For Colombia and Mexico the target corresponds to the middle of the period of the AMS-DANE dataset and for the formal sector following Midrigan and Xu (2013). The value for the US results in an economy with perfect financial markets (the average of the ratio for the 10 years between 1992-2001 is 2.3 which covers the period of the data used to impute firm life-cycle growth in Hsieh and Klenow, 2012).[25]

[25]Note that the amplification of misallocation refers to a comparison within a country keeping the level of financial development fixed and not a cross-country comparison. These exercises are discussed below.

The parameter that determines the convex marginal cost specific to the informal sector affects the optimum production scale of informal sector firms. The target is the share of employment in the informal sector, equal to 0.45 for Mexico and 0.50 for Colombia. A lower value of is necessary for Mexico relative to Colombia, since taxes are much higher in the latter case.

The tax rate , taken from the World Bank Doing Business Survey, is a measure of the total amount of taxes and mandatory contributions expressed as a share of commercial profits for a standardized business (after accounting for allowable deductions and exemptions). This measure considers taxes at all levels of government and includes the profit or corporate income tax, social security contributions, labor taxes paid by the employer and dividend taxes, among others. Taxes withheld (such as the personal income tax) or collected and remitted to tax authorities (such as value added taxes, sales taxes) are excluded. This measure simplifies a more complex tax structure that would distort capital labor ratios in the model.

7 Quantitative Analysis

In this section, the main quantitative results of the paper are presented and discussed.

7.1 Main Results

The main result of this paper is that misallocation losses in a model of financial constraints are amplified when we introduce endogenous firm-productivity accumulation. For exposition, we can equivalently define the potential gains from eliminating the dispersion across firms in the marginal productivity of capital. The focus is on the formal sector to avoid concerns related to measurement in the informal sector. Let J be the set of firms producing in the formal sector. It can be shown that TFP in the case of no financial constraints is:[26]

$$TFP = \left[\sum_{\{j \in J\}} (e_j^a)^{\frac{1}{1-}} (\varphi_j n_j) \right]^{1-} \tag{10}$$

With financial constraints the marginal productivity of capital, and therefore the output-capital ratios, vary across firms and aggregate TFP is:

$$TFP = \frac{\left[\sum_{\{j \in J\}} (e_j^a)^{\frac{1}{1-}} (\varphi_j n_j) (q_j/k_j)^{\frac{}{1-}} \right]^{1(1-)}}{\left[\sum_{\{j \in J\}} (e_j^a)^{\frac{1}{1-}} (\varphi_j n_j) (q_j/k_j)^{\frac{(1-)1}{1-}} \right]} \tag{11}$$

An efficient allocation implies equalizing the marginal product of capital and therefore the average product as well. The gains from eliminating misallocation in

[26] See Midrigan and Xu (2013) and Buera et al. (2011).

the model are computed as $TFP\ =TFP\quad 1$, with the following interpretation: keeping the set of firms and their productivity constant, this number represents the gains of eliminating differences in the marginal product of capital across firms. This exercise is analogous to the empirical studies in Hsieh and Klenow (2009) and Busso, Madrigal and Pages (2012).[27] Note that this is different from the comparison of aggregate TFP across countries, which I label the potential (total) TFP gain in Table 7. The latter comparison takes into account the fact that financial frictions also affect the distribution of firm productivity. For example, aggregate TFP is 19% lower in Mexico (formal sector) compared to the US.

Table 7. General Results.

variable	US	Mex.	Col.
potential misallocation gain	–	14.7%	15.8%
potential (total) TFP gain	–	19.0%	23.4%
output per capita total	1.00	0.44	0.39
output per capita formal	1.00	0.47	0.42
output per capita informal	–	0.39	0.36
wage	1.00	0.47	0.43
capital/output total	2.34	0.58	0.56
total exit rate	0.10	0.13	0.13
total average firm size	22.0	6.3	5.8

TFP and misallocation refer to the formal sector.

To decompose misallocation gains first define the following variables:

$$X = (e^{a})^{1=1} \quad (' \, n) \qquad Y = \frac{q}{k}^{\frac{}{1}} \qquad Z = \frac{q}{k}^{\frac{(1 \quad) \quad 1}{1}}$$

Without financial constraints, the unconstrained equivalents of Y and Z (derived from the first order conditions of the static profit maximization problem of the firm) are:

$$Y = \frac{r +}{}^{\frac{}{1}} \qquad Z = \frac{r +}{}^{\frac{(1 \quad) \quad 1}{1}}$$

We can rewrite TFP in the model with financial constraints in the following manner:

$$TFP = J^{1} \frac{[\; (X;Y) + \mathrm{E}(X)\,\mathrm{E}(Y)]^{1 \; (1 \quad)}}{[\; (X;Z) + \mathrm{E}(X)\,\mathrm{E}(Z)]} \tag{12}$$

We can now decompose potential misallocation gains into two steps:

(1) Set Y and Z equal to its optimal unconstrained levels Y and Z. For Colombia, for example, this step generates a gain of 3.2% in the model without knowledge capital and 9.6% in the model with knowledge capital.

(2) Eliminate the covariances by setting $(X;Y) = (X;Z) = 0$. For Colombia, this step generates a gain of only 0.6% in the model without knowledge capital and 6.1% in the model with knowledge capital, given that $(X;Y)$ and $(X;Z)$ are more negative in the latter model. For Mexico, this step generates a gain of 2.1% in the model without knowledge capital and 6.9% in the model with knowledge capital.

The covariance terms reflect the fact that it is not only the variance in the marginal-productivity of capital that determines misallocation, but it is also important which firms are constrained. This is related to the discussion of the role of the correlation between firm productivity and distortions in Restuccia and Rogerson (2008) and Hopenhayn (2012). In the model without knowledge capital, due to the fact that shocks are mean-reverting, a firm that is highly constrained in one period is likely to be less constrained in the following period. In a model with knowledge capital, a firm that is very constrained in one period can again be very constrained in the following period if the endogenous productivity component increases (this is further discussed below).

7.2 Firm Life-Cycle Productivity and Employment Growth

In Table 9 I compute the life-cycle growth and accumulation of knowledge capital for the three baseline model economies. By age 15, the ratio of $n f\mathrm{age}{=}15 g{=}\underline{n}$ is on average 15.7 in the US, but it is less than half this number for Colombia and Mexico. These differences in endogenous productivity accumulation translate into lower life-cycle growth of firms, as shown in the lower panel.

Table 9. Baseline Results: Firm Knowledge Capital and Size.

knowledge cap.[1]	USA all	Mexico formal[2]	Mexico all	Colombia formal[2]	Colombia all
age 5/age 1	2.8	1.6	1.2	1.5	1.1
age 10/age 1	7.9	3.9	3.5	3.6	2.7
age 15/age 1	15.7	7.0	6.9	7.9	7.4
# workers[3]	USA all	Mexico all		Colombia all	
age 6-10/age 1-5	1.4	1.2		1.2	
age 11-15/age 1-5	2.5	2.1		1.3	

[1]Average across firms of $n\{age=x\}/\underline{n}$.
[2]Firms that are formal at age x. [3]Includes manager.

Figures 3 and 4 show the model cross-section of log(n ') including formal and informal sector firms with respect to age: the x-axis corresponds to the age of the firm and y-axis corresponds to log(n '). I fit a quadratic polynomial to this relationship, where the number of simulated firms was increased until the results were unchanged. The range of log(n ') incorporates an extensive-margin effect: in Mexico managers with lower entrepreneurial ability ' set up firms, specially in the informal sector (these firms are not included in the TFP/misallocation computations). The fitted value of log(' n) is lower at every age in Mexico. To isolate the life-cycle component of knowledge capital, Figures 5 and 6 show the model cross-section of log(n) with respect to age for Mexico and US only for formal sector firms.

7.3 Firm Dynamics in the Model and Data

As previously discussed, the joint dynamics of output-capital ratios and firm productivity have implications for the impact of financial constraints on misallocation. In the model without knowledge capital, productivity shocks are purely stochastic and mean-reverting. In this case, a firm that is highly constrained in one period is likely to be less constrained in the following period. In a model with knowledge capital, a firm that is constrained in one period can again be highly constrained in the following period if the endogenous productivity component increases. The table below shows that the model with knowledge capital is better able to replicate the dy-

Table 10. Regressions with Simulated Model and Data Firms.						
explained: output/cap.	data		knowledge		standard	
variables (logs)	(1)	(2)	(1)	(2)	(1)	(2)
lag - output/cap.*firm TFP	-0.02	–	-0.04	–	-0.43	–
lag - firm TFP	–	-0.06	–	-1.38	–	-3.38
lag - output/capital ratio	0.58	0.58	0.42	0.95	0.76	1.46
year-age controls, firm f. effects	yes	yes	yes	yes	yes	yes
industry controls	yes	yes	no	no	no	no
R^2 - within	0.37	0.37	0.49	0.52	0.56	0.64
Statistical significance 1%. (model regressions: all coefficients significant).						

In terms of firm productivity growth the model with knowledge capital also performs better than the standard model (Table 11).[28]

Table 11. Regressions with Simulated Model and Data Firms.						
explained: TFP growth	data		knowledge		standard	
variables[1] (logs)	(1)	(2)	(1)	(2)	(1)	(2)
firm TFP	-0.45	-0.56	-1.20	-1.10	-1.87	-1.75
output/capital ratio	0.05	0.06	0.27	0.22	0.40	0.34
age of firm	–	-0.03	–	-0.10	–	-0.11
year controls, firm f. effects	yes	yes	yes	yes	yes	yes
industry controls	yes	yes	no	no	no	no
R^2 - within	0.19	0.24	0.33	0.34	0.44	0.45
Statistical significance 1%. (model regressions: all coefficients significant).						
[1]TFP growth computed between t and $t+1$, regressors in period t.						

7.4 Sensitivity Analysis

Introducing knowledge capital can affect the stochastic properties of firm proseem independently responsible for the increase in misallocation: in the baseline calibration of the model with knowledge capital for Mexico, the variance of the marginal productivity of capital is 0.15, close to the lower bound of 0.14 in Midrigan and Xu (2013) and slightly above the 0.12 for my model without knowledge capital.

8 Conclusions

The objective of this paper is to contribute to the understanding of the link between firm productivity dynamics and aggregate production efficiency. In particular I focus on TFP losses attributed to misallocation, which the empirical literature finds to be quantitatively important.

The underdevelopment of financial markets has been proposed as a source of misallocation. However, in a quantitative calibrated model, misallocation losses generated by financial underdevelopment are modest, as pointed out by Midrigan and Xu (2013). I find that considering a model with endogenous firm-productivity accumulation, the misallocation losses are amplified. In the case of Mexico financial constraints generate losses of 7.3% in a model without endogenous firm-productivity and 14.7% in a model with firm-productivity accumulation. This result suggests that the life-cycle accumulation in firm productivity can be important for understanding how financial constraints can generate misallocation. Furthermore, financial constraints affect the distribution of firm productivity and the level of aggregate TFP by distorting the accumulation of productivity at the firm level.

9 References

Abraham, A. and K. White (2006). "The Dynamics of Plant-Level Productivity in U.S. Manufacturing," Center of Economic Studies, U.S. Census Bureau, # 06-20.

Aghion, P., P. Howitt and D. Mayer-Foulkes (2005). "The Effect of Financial Development on Convergence: Theory and Evidence," *Quarterly Journal of Economics*, 120 (1), pp. 173-222.

Alfaro, L., A. Charlton and F. Kanczuk (2009). "Plant Size Distribution and Cross-Country Income Differences," NBER International Seminar on Macroeconomics.

Amaral, P.S. and E. Quintin (2006). "A Competitive Model of the Informal Sector," *Journal of Monetary Economics*, 53 (7), pp. 1541-1553.

Amaral, P.S. and E. Quintin (2010). "Limited Enforcement: Financial Intermediation, and Economic Development: A Quantitative Assessment," *International Economic Review*, 51 (3), pp. 785-811.

Arellano, C., Y. Bai and J. Zhang (2012). "Firm Dynamics and Financial Development," *Journal of Monetary Economics*, 59 (6), pp. 533-549.

Asker, J., A. Collard-Wexler and J. De Loecker (2012). "Productivity Volatility and the Misallocation of Resources in Developing Economies," WP.

Atkeson, A. and A.T. Burstein (2010). "Innovation, Firm Dynamics and International Trade," *Journal of Political Economy*, 118 (3), pp. 433-484.

Atkeson, A. and P.J. Kehoe (2005). "Modeling and Measuring Organization Capital," *Journal of Political Economy*, 113 (5), pp. 1026-1053.

Audretsch, D.B. (1995). "Innovation, Growth and Survival," *International Journal of Industrial Organization*, 13 (4), pp. 441-457.

Ayyagari, M., A. Demirgüç-Kunt and V. Maksimovic (2007). "Firm Innovation in Emerging Markets," World Bank Policy Research WP. # 4157.

Bartelsman, E.J. and M. Doms (2000). "Understanding Productivity: Lessons from Longitudinal Microdata," *Journal of Economic Literature*, 38 (3), pp. 569-594.

Bartelsman, E.J., J. Haltiwanger and S. Scarpetta (2009). "Measuring and Analyzing Cross-country Differences in Firm Dynamics," in T. Dunne, B. Jensen and M.J. Roberts (Eds.), Producer Dynamics: New Evidence from Micro Data. University of Chicago Press.

Beck, T. and A. Demirgüç-Kunt (2006). "Small and medium-size enterprises:

Access to finance as a growth constraint," *Journal of Banking and Finance*, 30 (11), pp. 2931-2943.

Beck, T., A. Demirgüç-Kunt and R. Levine (2009). "Financial Institutions and Markets across Countries and over Time - Data and Analysis," Policy Research Working Paper #4943, The World Bank.

Bhattacharya, D., N. Guner and G. Ventura (2013). "Distortions, Endogenous Managerial Skills and Productivity Differences," *Review of Economic Dynamics*, 16 (1), pp. 11-25.

Buera, F.J., Y. Shin (2011). "Self-insurance vs. self-financing: a welfare analysis of the persistence of shocks," *Journal of Economic Theory*, 146 (3).

Buera, F.J., J. Kaboski and Y. Shin (2011). "Finance and Development: A Tale of Two Sectors," *American Economic Review*, 101 (5), pp. 1964-2002.

Busso, M., M.V. Fazio and S. Levy (2012). "(In)Formal and (Un)Productive: The Productivity Costs of Excessive Informality in Mexico," Inter-American Development Bank WP-341.

Busso, M., L. Madrigal and C. Pagés (2012). "Productivity and Resource Misallocation in Latin America," Inter-American Development Bank WP-306.

Caggese, A. (2012). "Entrepreneurial Risk, Investment, and Innovation," *Journal of Financial Economics*, 106 (2), pp. 287-307.

Caggese, A. (2014). "Financing Constraints, Radical versus Incremental Innovation, and Aggregate Productivity," WP.

Camacho, A. and E. Conover (2010). "Misallocation and Productivity in Colombia's Manufacturing Industries," Inter-American Development Bank WP-123 Bank WP-306.

in China and India," *Quarterly Journal of Economics*, 124 (4), pp. 1403-1448.

Hsieh, C.T. and P.J. Klenow (2012). "The Life Cycle of Plants in India and Mexico," WP.

Klette, J. and S. Kortum (2004). "Innovating Firms and Aggregate Innovation," *Journal of Political Economy*, 112 (5), pp. 986-1018.

Leal Ordoñez, J.C. (2013). "Tax collection, the informal sector, and productivity," *Review of Economic Dynamics*, (forthcoming).

Levine, R. (2005). "Finance and Growth: Theory and Evidence," Handbook of Economic Growth, Vol. 1A, Ch. 12.

Levine, O. and M. Warusawitharana (2014). "Finance and Productivity Growth: Firm Level Evidence," FEDS WP #2014-17, Federal Reserve Board.

Lopez-Martin, B. (2013). "Informal Sector Misallocation," WP.

Lucas, R.E. (1978). "On the Size Distribution of Business Firms," *Bell Journal of Economics*, 9 (2), pp. 508-523.

McGrattan, E.R. and E.C. Prescott (2005). "The Regulation and Value of US and UK Corporations," *Review of Economic Studies*, 72 (3), pp. 767-796.

Midrigan, V. and D.Y. Xu (2013). "Finance and Misallocation: Evidence from Plant-Level Data," WP (forthcoming, *American Economic Review*).

Nishida, M., A. Petrin and T.K. White (2013). "Are We Undercounting Reallocation's Contribution to Growth?" WP.

Parente, S.L. and E.C. Prescott (2000). Barriers to Riches. Cambridge, Massachusetts: MIT Press.

Perry, G.E., W.F. Maloney, O.S. Arias, P. Fajnzylber, A.D. Mason, J. Saavedra-Chanduvi (2007). *Informality, Exit and Exclusion*. The World Bank.

Prescott, E.C. and M. Visscher (1980). "Organization Capital," *Journal of Political Economy*, 88 (3), pp. 446-461.

Quintin, E. (2008). "Contract Enforcement and the Size of the Informal Economy," *Economic Theory*, 37 (3), pp. 395-416.

Ranasinghe, A. (2014). "Impact of policy distortions on firm-level innovation, productivity dynamics and TFP," *Journal of Economic Dynamics and Control*, 46 (C), pp. 114-129.

Restuccia, D. and R. Rogerson (2008). “Policy Distortions and Aggregate Productivity with Heterogeneous Establishments,” *Review of Economic Dynamics*, 11 (4), pp. 707-720.

Steinberg, J. (2013). “Information, Contract Enforcement, and Misallocation,” WP.

Syverson, C. (2011). “What Determines Productivity?” *Journal of Economic Literature*, 49 (2), pp. 326-365.

Tauchen, G. (1986). “Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions,” *Economic Letters*, 20 (2), pp. 177-181.

Tybout, J.R. (2000). “Manufacturing Firms in Developing Countries: How Well Do They Do, and Why?” *Journal of Economic Literature*, XXXVIII, pp. 11-44.

A Output-Capital Ratios and Financial Constraints

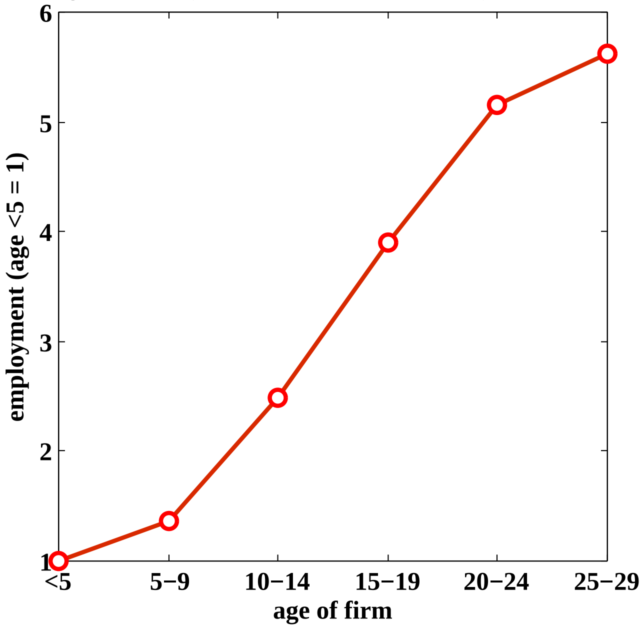
Consider a standard profit maximization problem of a firm with access to a production technology with decreasing returns to scale (as the one in the quantitative framework) and productivity z:

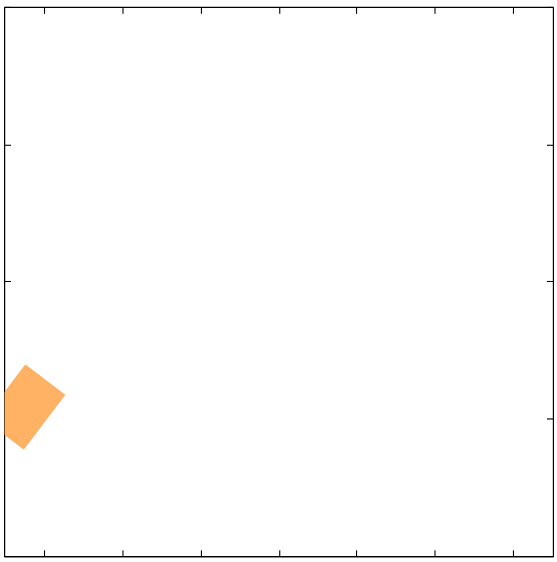
max

D Micro-Enterprizes in Mexico

The National Survey of Micro-Enterprizes (ENAMIN) is conducted every two years and includes data on firms with up to 15 workers in manufacturing, and up to 10 workers in construction, transportation, retail and services. INEGI estimates that approximately 41.6% of the labor force belongs to firms in this scale of production (approximately 18.1 million workers). The data collected by this survey includes information on the manager/owner of the firm: education, experience, time in present position and reasons for setting up a business, among other variables. Regarding the firm itself, the information collected includes: year the business was established, accounting and registry, equipment, expenditures, investment, income, access to fi-

Fig. 1. Employment Growth over Life Cycle − Model





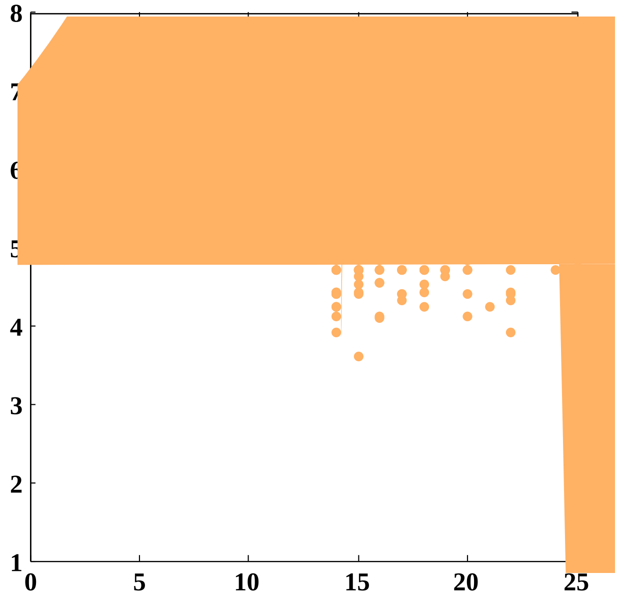

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Fig. 5. log(knowledge) - Mexico (formal sector)

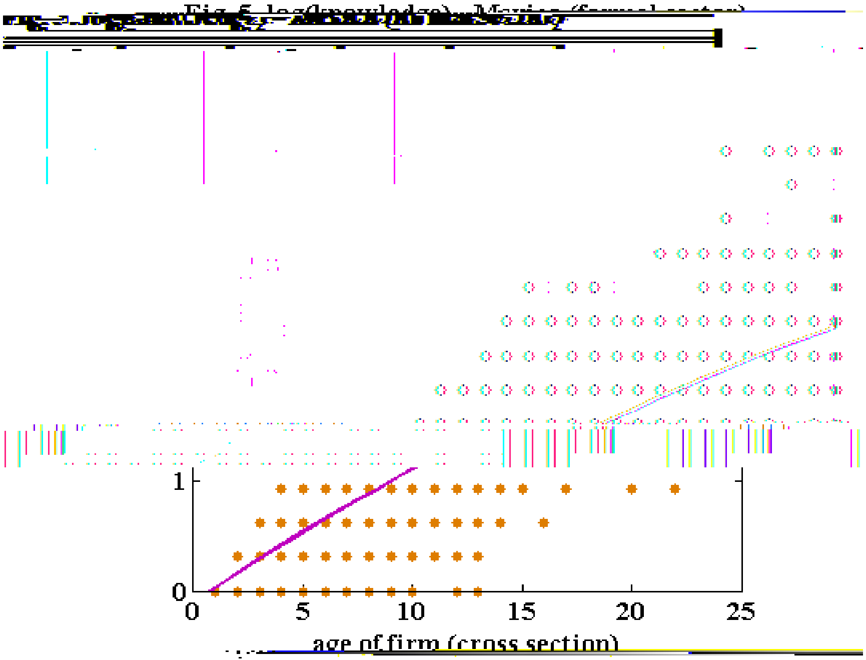

Fig. 6. log(knowledge) - US (formal sector)