DISTORSIONS, RESOURCE ALLOCATION AND PRODUCTIVITY IN LATIN AMERICA

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DISTORSIONES, ASIGNACIÓN DE RECURSOS Y PRODUCTIVIDAD EN AMÉRICA LATINA
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CAF Documento de Trabajo N° 2012/14
Agosto, 2012

RESUMEN

Este trabajo desarrolla un modelo de span-of-control donde las habilidades gerenciales son endógenas y resultan de inversiones hechas por los propios gerentes a lo largo de la vida laboral. El modelo es calibrado con datos de Estados Unidos y luego es usado para evaluar cómo interactúan las distorsiones idiosincráticas con la productividad agregada (exógena) para determinar las diferencias en las distribuciones de tamaño de plantas y de producto por trabajador en México. Se encuentra que las distorsiones idiosincráticas –tales como los subsidios implícitos a establecimientos pequeños y grandes- son fundamentales para generar la distribución de tamaños de planta observada en los datos para México. La productividad agregada exógena es el principal determinante de las diferencias en el producto por trabajador entre Estados Unidos y México.

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ABSTRACT

We develop a span-of-control model where managerial skills are endogenous and the outcome of investments over the life cycle of managers. We calibrate such model to U.S. data, and use it to evaluate the interplay between idiosyncratic distortions and exogenous productivity in accounting for plan-size differences and output per worker in Mexico. We find that idiosyncratic distortions, as heavier implicit subsidies on small and large establishments, are essential to generate a plant-size distribution in line with Mexican data. Differences in exogenous productivity drive the bulk of output per-worker differences between the U.S. and Mexico.

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Distortions, Resource Allocation and Productivity in Latin America

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August 17, 2012

Abstract

We develop a span-of-control model where managerial skills are endogenous and the outcome of investments over the life cycle of managers. We calibrate such model to U.S. data, and use it to evaluate the interplay between idiosyncratic distortions and exogenous productivity in accounting for plan-size differences and output per worker in Mexico. We find that idiosyncratic distortions, as heavier implicit subsidies on small and large establishments, are essential to generate a plant-size distribution in line with Mexican data. Differences in exogenous productivity drive the bulk of output per-worker differences between the U.S. and Mexico.

Key Words: Distortions, Size, Skill Investments, Productivity Differences.
JEL Classification: O40, E23.

1 Introduction

Why are some countries so much richer than others? From development accounting exercises, the answer depends heavily on Total Factor Productivity (TFP) differences across countries (Klenow and Rodriguez-Clare, 1997; Prescott 1998; Hall and Jones, 1999; Caselli, 2005). Consequently, much work in the last decade or so has been devoted to understanding the determinants of these measured TFP differences. As part of this effort, a growing body of recent literature has studied the consequences of distortions that alter the efficient allocation of resources across production units, and show the extent to which these distortions can have substantial effects on aggregate productivity.[1]

Latin American economies are ideal cases for the study of the effects of distortions in the allocation of resources, and their effects on output and productivity measures. There are several, interconnected reasons for this. First, Latin American countries are relatively poor and they have appeared stagnated when observed over long horizons. This is documented in Restuccia (2011), among many others. From 1960 to 2009, output per capita of Latin American countries as a group grew by about 1.5% annually, while the U.S. per capita output by about 2.1% in the same period. Likewise, some countries (e.g. Venezuela, Argentina) experienced sharp declines in their standard of living relative to the U.S. Development accounting exercises, as in Cole, Ohanian, Riascos and Schmitz (2005) and Cavalcanti-Ferreira, De Abreu Pesso and Veloso (2012), indicate that differences in TFP, not factors of production, drive the bulk of output per capita or per worker differences. Second, as documented by Cole et al (2005) and other authors, Latin American countries have been a laboratory for the introduction of policies that are commonly viewed as distortionary in terms of resource allocation, and considered likely culprits of low levels of aggregate productivity. Finally, the recent literature on the role of distortions on aggregate productivity connects distortions and plant size in a critical way. Distortions that are correlated with plant productivity lead usually to lower mean plant size and a concentration of production in smaller production units. As documented in Pages (2010), this occurs precisely in Latin American economies, suggesting, in turn, a fundamental role for micro distortions.

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[1]See Bartelsman, Haltiwanger and Scarpetta (2008), Barseghyan and DiCecio (2011), Buera, Kabowski and Shin (2011), Caselli and Gennaioli (2005), D'Erasmo and Moscoso-Boedo (2012), Guner, Ventura and Xu (2008), Hsieh and Klenow (2009), Midrigan and Xu (2010), Restuccia and Rogerson (2008), among others.

In this paper, we develop a framework to assess the role of distortions and other factors as contributors to differences in economic performance. As in Bhattacharya, Guner and Ventura (2012), we depart from the standard assumption that plant-level productivity is exogenous and develop a model where productivity across establishments is instead *endogenous* and driven by investments in managerial quality. We use the model to quantify the effects of distortions that are correlated with the size of production units, the role of economy-wide differences in productivity for aggregates and size-distribution statistics, and the interplay between these. We then ask: what structure of distortions and of exogenous productivity generates the observed plant-size distributions and levels of output? For these purposes, we use Mexican data and conclude that differences in exogenous productivity, not distortions, drive the bulk of output differences. Distortions, nonetheless, are key in generating the observed distribution of plant size for Mexico.

We study a span-of-control model with a life-cycle structure. Every period, a large number of finitely lived agents are born. These agents are heterogeneous in terms of their initial endowment of managerial skills. The objective of each agent is to maximize the lifetime utility from consumption. In the first period of their lives, agents make an irreversible decision to be either workers or managers. If an agent chooses to be a worker, her managerial skills are of no use and she earns the market wage in every period until retirement. If an agent chooses to be a manager, she can use her managerial skills to operate a plant by employing labor and capital to produce output and collect the net proceeds (after paying labor and capital) as managerial income. Moreover, managers invest resources in skill formation, and as a result managerial skills grow over the life cycle. This implies that a manager can grow the size of her production operation and managerial income by investing a part of her current income each period in skill formation. As managers age and accumulate managerial skills, the distribution of skills (and productivity of production units) evolves endogenously, and could be affected by distortions and features of the environment.

In the model, the evolution of managerial skills and hence plant size depends not only on initially endowed skills, but also on skill investment decisions. These investment decisions reflect the costs (resources that have to be spent rather than being consumed) and the benefits (the future awards associated to being endowed with better managerial skills). A central assumption in our model is that there are *complementarities* between skills and investments: managers born with high skills find it optimal to invest more in skills over

their lifetime than managers born with low skills. This model property amplifies initial heterogeneity in skills, and leads to increasing dispersion with age in the size of production plants that managers can operate.

We subsequently introduce idiosyncratic distortions in the model. At the start of life, all agents draw an implicit output subsidy (or tax) that applies if they become managers. They draw this distortions from a distribution that is conditioned on their endowment of managerial ability: a higher initial managerial ability implies that particular levels of distortions are more or less likely. This results in distortions that are *correlated* with the productivity and size of production units in different ways. In this context, idiosyncratic distortions have broadly two effects. First, a standard *reallocation effect*, as the introduction of distortions implies that capital and labor services flow across production units in response due to the distortions. Second, a novel *skill accumulation effect*, as distortions affect the patterns of skill accumulation and thus, the overall distribution of managerial ability (plant productivity).

We calibrate the model to match macroeconomic statistics as well as cross sectional features of the U.S. plant data. We assume for these purposes that the U.S. economy is relatively free of the distortions that we focus on. We find that the model can capture central features of the U.S. plant size distribution, including the upper and lower tails. This is critical; on the one hand, the upper tail of the size distribution accounts for the bulk of the employment and output in the economy. On the other hand, the lower tail of the size distribution accounts for the bulk of the plants in the economy.

We first consider idiosyncratic *subsidies*, that are negatively correlated with managerial ability (i.e. less able managers receive larger subsidies), and evaluate their effects on output, plant size and notions of productivity. The range of these subsidy distortions is given by the magnitude of the subsidy transfers generated in stationary equilibrium. Introducing subsidies that transfer 6% of output lead to a reduction in aggregate (per worker) output of about 6.3% and output per establishment by about 43.7%. The effects on Total Factor Productivity (TFP) are, however, small and amount to about 0.7%. The most significant effects of such distortions are in terms of the plant-size distribution. Idiosyncratic subsidies lead to a sizeable changes in mean plant size and to a drastic drop in the share of employment in large plants (100 workers or more). Mean size drops by 43.8% from the undistorted (U.S.) value, and the employment share of large plants drops from about 46% of the total in the undistorted benchmark to about 35.9% in the distorted case.

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Our results also indicate non-trivial effects on the size distribution of establishments stemming from variation in exogenous aggregate productivity (common to all establishments). Unlike a traditional span-of-control model, our model implies that changes in exogenous aggregate productivity, as they affect the returns to investments in managerial skills, have effects on occupational choice. We find that reducing exogenous productivity by 25% (50%) leads to a reduction in mean establishment size of about 14.2% (26.2%), and a reduction in the share of employment at large units; from about 46% of total employment in the benchmark case to 37.9% (28.1%). Reductions in exogenous productivity of these magnitude are not implausible given the observed levels of output per worker in Latin America. Indeed, as we elaborate later, levels close to 50% are needed to reproduce Mexican observations.

We finally proceed to use the model to study the interplay between distortions and exogenous productivity differences, focusing in detail on the case of Mexico. As we document below, Mexico has had a lower output per worker than the U.S. for several years, averaging about 35% of the U.S. level, and noticeable plant-size differences in relation to the United States. Mean size in Mexico is much lower than the U.S. (5.8 to 17.9 employees) and there is substantial fraction of plants in Mexico with less than ten employees ('small' plants); about 94.8% where in the U.S. this amounts to 72.5%. And very interestingly, plants with one hundred or more employees ('large' plants) account for a large share of employment in Mexico, in levels comparable to richer countries: 31.9%. What structure of distortions generates these observations? We find that implicit subsidies that are larger for small and large production units are needed to reconcile the model with data. In other words, implicit subsidies are V-shaped in relation to initial managerial productivity. This structure requires implicit subsidies that average to 43.3% on all operating plants, while being non negligible at large plants (about 14.4%). We also find that differences in economy-wide productivity are the main driver of output per worker differences: while idiosyncratic subsidies and productivity differences together deliver the level of relative level of output per worker of Mexico (35%) productivity differences alone imply a level of about 38% of the U.S.

The paper is organized as follows. Section 2 presents facts about plant size-distributions in Latin America for selected countries. Section 3 presents the model and the modeling of idiosyncratic distortions. Section 4 discusses the calibration of the benchmark model. Section 5 presents the findings associated to the introduction of distortions and exogenous changes in economy-wide productivity. Section 6 studies the quantitative implications of the

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model when applied to Mexico via variation in economy-wide productivity and idiosyncratic subsidies. Finally, section 7 concludes.

2   Plant-Size and Development: Latin American Evidence

We document in this section variation in the size of production units across Latin America countries. For these purposes, the unit of observation is generically a *plant* or establishment, which amounts to unit where production (including distribution or sales) takes place. Since the number of multi-plant firms is small in the data, a plant coincides in most instances with a firm.

There is substantial variation in the size of plants across economies, even across economies with similar levels of development. Nonetheless, mean size appears to be negatively correlated with the level of development. For instance, mean plant size in the United States amounts to nearly 18 employees. Meanwhile, it amounts to about 15 employees in Norway, 9.7 employees in Japan and about 9 in Spain. As we elaborate below, mean size is of about 5.8 employees in Mexico. Mean size is even lower in poorer countries, with values of around 4 and 3 for India and Pakistan, respectively.[2]

A comparison between rich countries and Latin American countries is somewhat difficult due to the availability of data. We present in Table 1 comparable data for the *manufacturing* sector for four Latin American countries (Boliva, El Salvador, Argentina and Mexico).[3] Since we will later use the U.S. as a basis of calibration and comparison, we show in the table the corresponding data for the U.S. as well. We also show the levels of output per worker in each economy (at PPP values), as an a measure of the development level. Some features of the data are immediately evident. First, employment is highly concentrated in the United States and elsewhere. 'Large' establishments account for nearly two thirds of employment in the U.S., while they represent less than 9% of all establishments. Second, in all cases Latin American economies appear to contain a fraction of 'small' establishments (1-9 employees), that is substantially higher than in the U.S. Nearly 90.5% and 84% of all plants in Mexico and Argentina, respectively, belong to the 'small' category. Finally, there are differences in

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[2]See Bhattacharya (2010) for a documentation of plant size differences across countries.
[3]The data is summarized from various sources in Pages (2010), chapter 4.

the concentration of employment at the top across Latin American economies. In Argentina, 'large' plants account for about 18% of employment in the manufacturing sector. In Mexico, the value is about 56%, much closer to the U.S. value (67.7%).

2.1 All Plants: Mexican Data

We now present data for *all* plants. We present it for the cases of Mexico and the United States, as Mexico is only Latin American country for which we have access to data from all, non-agricultural production units. The source of the data for Mexico is Leal-Ordoñez (2010) for the year 2005, and includes formal as well as informal establishments. The data for the United States is from the Bureau of Census for the year 2007. Table 2 summarizes the data.[4]

The data reveals substantial differences in terms of plant size between the two economies. Notice first that mean plant size is less than a third in Mexico relative to the U.S. (5.8 versus 17.7 employees). Second, as in the case of the manufacturing sector, large plants are a small fraction of the total but account for rather substantial fraction of total employment. In the U.S., large plants are 2.6% of the total and their share of total employment is of about 46%; in Mexico, they constitute 0.5% of the total and account for nearly 32% of employment. Finally, Mexico has a large fraction of small plants (nearly 95% of the total) and a rather small fraction of large ones. Nonetheless, large plants in Mexico account for a disproportionate share of employment as indicated above. Indeed, the share of employment accounted for by large plants in Mexico appears to be at par with those from developed economies. Bhattacharya (2010) reports that the share of large plants in other developed economies. For instance, the shares in Norway and Taiwan amount to about 33.0% and 31.5%, respectively. For Japan the share employment share at large plants is about 24.9%.[5]

3 Model

The model economy follows closely Bhattacharya et al (2012). Consider the following life-cycle version of Lucas (1978) span-of-control model. Each period, an overlapping generation

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[4]The data for Mexico in Leal-Ordoñez (2010) does not include self-employed workers (1 worker establishment. It is constructed by combining data from the Mexican Census and the Encuesta Nacional de Ocupación y Empleo (ENOE).

[5]Based on Japanese Establishment and Enterprise Census for year 2005.

of heterogeneous agents are born into economy that lives for J periods. The objective of each agent is to maximize the present value of lifetime utility from consumption

$$\sum_{j=1}^{J} \beta^{j-1} \log(c_j), \tag{1}$$

where $\beta \in (0, 1)$ and c_j is the consumption of an age-j agent.

Each agent is born with an initial endowment of managerial ability. We denote managerial ability by z, and assume that initial (age-1) abilities are drawn from an exogenous distribution with cdf $F(z)$ and density $f(z)$ on $[0, z^{\max}]$. Until retirement age J_R, each agent is also endowed with one unit of time which she supplies inelastically as a manager or as a worker. In the very first period of their lives, agents must choose either to be *workers* or *managers*. This decision is irreversible. A worker inelastically supplies her endowed labor time to earn the market wage every period until retirement. The decision problem of a worker is to choose how much to consume and save every period.

A manager's problem, however, is more complicated. A manager has access to a technology to produce output, which requires managerial ability in conjunction with capital and labor services. Hence, given factor prices, she decides how much labor and capital to employ every period. In addition, in every period, a manager decides how much of his net income to allocate towards current consumption, savings and investments in improving her/his managerial skills.

We assume that each cohort is $1 + n$ bigger than the previous one. These demographic patterns are stationary so that age-j agents are a fraction μ_j of the population at any point in time. The weights are normalized to add up to one, and obey the recursion, $\mu_{j+1} = \mu_j/(1+n)$.

Technology Each manager has access to a span-of-control technology. A plant comprises of a manager with ability z along with labor and capital,

$$y = Az^{1-\gamma} \left(k^{\alpha} n^{1-\alpha}\right)^{\gamma},$$

where γ is the span-of-control parameter and $\alpha\gamma$ is the share of capital. The term A is productivity term that is common to all establishments.[6] Every manager can enhance her future

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[6]In referring to production units, we use the terms *establishment* and *plant* interchangeably.

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skills by investing current income in skill accumulation. The law of motion for managerial skills is given by

$$z' = z + g(z, x) = z + z^{\theta_1} x^{\theta_2},$$

where z' is next period's ability and x denotes investment in skill accumulation. The skill accumulation technology described above satisfies three important properties, of which the first two follow from the functional form and the last one is an assumption. First, the technology shows *complementarities* between current ability and investments in next period's ability; i.e. $g_{zx} > 0$. Second, $g(z, 0) = 0$. That is, investments are essential to increase the stock of managerial skills. Finally, there are diminishing returns to skill investments: $g_{xx} < 0$. This naturally requires $\theta_2 < 1$.

3.1 Decisions

Consider a stationary environment with constant factor prices R and w. Let a denote assets that pay the risk-free rate of return $r = R - \delta$.

Managers The problem of a manager of age j is given by

$$V_j(z, a) = \max_{x, a'} \{\log(c) + \beta V_{j+1}(z', a')\} \tag{2}$$

subject to

$$c + x + a' = \pi(z, r, w, A) + (1 + r)a \quad \forall 1 \le j < J_R - 1, \tag{3}$$

$$c + a' = (1 + r)a \quad \forall j \ge J_R, \tag{4}$$

and

$$z' = z + g(z, x) \quad \forall j < J_R - 1, \tag{5}$$

with

$$V_{J+1}(z, a) = \begin{cases} 0 \text{ if } a \ge 0 \\ -\infty, \text{ otherwise} \end{cases}.$$

Given her state (z, a), a j-years old manager decides how much to save, a', and how much to invest to enhance her skills. Up to the retirement age J_R, a manager's income consists of

her managerial profits and her assets, while after age J_R her only source of income is from her assets. We assume that agents (managers as well as workers) can lend or borrow at the interest rate r as long as they do not die in debt.

Since there are no borrowing constraints, factor demands and per-period profits of a manager only depend on her ability z. Managerial income for a manager with ability z is given by

$$\pi(z,r,w,A) \equiv \max_{n,k} \ \{Az^{1-\gamma}\left(k^\alpha n^{1-\alpha}\right)^\gamma - wn - (r+\delta)k\}.$$

Factor demands are given by

$$k(z,r,w,A) = (A(1-\alpha)\gamma)^{\frac{1}{1-\gamma}}\left(\frac{\alpha}{1-\alpha}\right)^{\frac{1-\gamma(1-\alpha)}{1-\gamma}}\left(\frac{1}{r+\delta}\right)^{\frac{1-\gamma(1-\alpha)}{1-\gamma}}\left(\frac{1}{w}\right)^{\frac{\gamma(1-\alpha)}{1-\gamma}} z, \qquad (6)$$

and

$$n(z,r,w,A) = (A(1-\alpha)\gamma)^{\frac{1}{1-\gamma}}\left(\frac{\alpha}{1-\alpha}\right)^{\frac{\alpha\gamma}{1-\gamma}}\left(\frac{1}{r+\delta}\right)^{\frac{\alpha\gamma}{1-\gamma}}\left(\frac{1}{w}\right)^{\frac{1-\alpha\gamma}{1-\gamma}} z. \qquad (7)$$

Substituting these into the profit function, one can show that profits (managerial income) is given by

$$\pi(z,r,w,A) = A^{\frac{1}{1-\gamma}}\ \Omega\ \left(\frac{1}{r+\delta}\right)^{\frac{\alpha\gamma}{1-\gamma}}\left(\frac{1}{w}\right)^{\frac{\gamma(1-\alpha)}{1-\gamma}} z, \qquad (8)$$

where Ω is a constant equal to

$$\Omega \equiv (1-\alpha)^{\frac{\gamma(1-\alpha)}{(1-\gamma)}}\ \alpha^{\frac{\gamma\alpha}{(1-\gamma)}}\ (1-\gamma)^{\frac{1}{1-\gamma}}. \qquad (9)$$

Note that since profits are linear function of managerial ability, z, the impact of additional skills on profits is independent of z, and a function only of parameters, exogenous productivity and prices.

The solution to the dynamic programming problem of a manager is characterized by two conditions. First, the solution for next-period assets, a', is characterized by the standard Euler equation for asset accumulation

$$\frac{1}{c_j} = \beta(1+r)\frac{1}{c_{j+1}}. \qquad (10)$$

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Second, the optimality condition for x and (10) imply the following no-arbitrage condition for investing in physical capital and skills

$$(1+r) = \pi_z(r, w, A) \, g_x(z_j, x_j). \tag{11}$$

The left-hand side of the above equation is next period's gain in income from one unit of current savings. The manager can also use this one unit as an investment on her skills. Hence, the term $g_x(z_j, x_j)$ on the right-hand side stands for the additional skills available next period from an additional unit of investment in the current period. The term $\pi_z(r, w, A)$ is the additional profit generated from an additional unit of managerial skills. Therefore, the right-hand side is the gain in utility by the j-period old manager from investing one unit of the current consumption good in skill accumulation. To get a unique interior optimum g_{xx} must be negative, as assumed earlier. This implies that the marginal benefit of investing in skill accumulation is monotonically decreasing in the level of skill investment while the marginal cost, given by $(1+r)$, is constant.

Figure 1 illustrates the optimal decision for skill investments x at a given age j. As the figure illustrates, a higher level of current (age j) managerial ability leads to higher skill investments as the result of complementarities built into the production of new managerial skills. Since this occurs at all ages, given prices, initial heterogeneity in skills is *magnified* by investments in skill acquisition.

The manager's problem generates decision rules for savings $a' = a_j^m(z, a)$, investment in managerial skills, $x = x_j(z, a)$, as well as the associated factor demands given by $k = k(z_j, r, w, A)$ and $n = n(z_j, r, w, A)$.

Workers The problem of an age-j worker is simpler and is given by

$$W_j(a) = \max_{a'}\{\log(c) + \beta W_{j+1}(a')\}$$

subject to

$$c + a' = w + (1+r)a \qquad \forall 1 \le j < J_R - 1 \tag{12}$$

and

$$c + a' = (1+r)a \qquad \forall j \ge J_R, \tag{13}$$

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with

$$W_{J+1}(a) = \begin{cases} 0 \text{ if } a \geq 0 \\ -\infty, \text{ otherwise} \end{cases}.$$

Let the associated savings decision of a worker be $a' = a_j^w(a)$. Like managers, workers can borrow and lend without any constraint as long as they do not die with negative assets.

The objective of each agent born every period is to maximize lifetime utility by choosing to be a worker or a manager. Let z^* be the ability level at which a 1-year old agent is indifferent between being a manager and a worker. This threshold level of z is given by (as agents are born with no assets)

$$V_1(z^*, 0) = W_1(0). \tag{14}$$

Given all the assumptions made, V_1 is a continuous and a strictly increasing function of z. Therefore, (14) has a well-defined solution, z^*. Figure 2 depicts the solution.

3.2 Equilibrium

As we mentioned above, members of each new generation are endowed with managerial ability levels distributed with cdf $F(z)$ and density $f(z)$ on $[0, z^{\max}]$. After the age-1, the distribution of managerial abilities is endogenous since it depends on investment decisions of managers over their life-cycle.

Let managerial abilities take values in set $\mathcal{Z} = [z^*, \overline{z}]$ with the endogenous upper bound $\overline{z}$. Similarly, let $\mathcal{A} = [0, \overline{a}]$ denote the possible asset levels. Let $\psi_j(a, z)$ be the mass of age-j agents with assets a and skill level z. Given $\psi_j(a, z)$, let

$$\widetilde{f}_j(z) = \int \psi_j(a, z) da,$$

be the skill distribution for age-j agents. Note that $\widetilde{f}_1(z) = f(z)$ by construction.

Each period those agents whose ability is above z^* work as managers, whereas the rest are workers. Then, in a stationary equilibrium with given prices, (r, w), labor, capital and goods market must clear. The labor market equilibrium condition can be written as

$$\sum_{j=1}^{J_R-1} \mu_j \int_{z^*}^{\overline{z}} n(z, r, w, A)\widetilde{f}_j(z) dz = F(z^*) \sum_{j=1}^{J_R-1} \mu_j \tag{15}$$

where μ_j is the total mass of cohorts of age j. The left-hand side is the labor demand from $J_R - 1$ different cohorts of managers. A manager with ability level z demands $n(z, r, w, A)$

units of labor and there are $\widetilde{f}_j(z)$ of these agents. The right-hand side is the fraction of each cohort employed as workers times the total mass of all non-retired cohorts in the economy.

In the capital market, the demand for savings is not only generated by managers renting physical capital. There is an additional demand for savings from managers borrowing funds from the capital market to invest in skill accumulation. The capital market equilibrium condition can be written as

$$
\sum_{j=1}^{J_R-1} \mu_j \int_{z^*}^{\overline{z}} k(z, r, w, A)\widetilde{f}_j(z)dz = \sum_{j=1}^{J-1} \mu_j \int_0^{z^*} \int_{\mathcal{A}} a_j^w(a)\psi_j(z,a)dzda
$$
$$
+ \sum_{j=1}^{J-1} \mu_j \int_{z^*}^{\overline{z}} \int_{\mathcal{A}} a_j^m(z,a)\psi_j(z,a)dzda
$$
$$
- \sum_{j=1}^{J_R-2} \mu_j \int_{z^*}^{\overline{z}} \int_{\mathcal{A}} x_j(z,a)\psi_j(z,a)dzda \qquad (16)
$$

The left-hand-side of the equation (16) above is the capital demand from $J_R - 1$ different cohorts of managers. The first two terms on the right-hand-side are the supply of savings from $J - 1$ different cohorts of managers and workers. The third term is the demand for skills investments from $J_R - 2$ different cohorts of managers (a manager will stop investing in his skills the period right before his retirement).

The goods market equilibrium condition requires that the sum of undepreciated capital stock and aggregate output produced in all plants in the economy is equal to the sum of aggregate consumption and savings across all cohorts, and skill investments by all managers across all cohorts.

3.3   Idiosyncratic Distortions

We now present a modified version of the environment, in which managers face distortions to operate production plants. We model these distortions as implicit output *subsidies* that are dependent on the initial ability level of the manager.

As the size of production that a manager can operate is (strictly) increasing in her ability, on average, relatively larger plants will be more or less distorted than smaller ones depending on the different cases that we consider. As a result, distortions will be *correlated* with productivity and size in different ways.

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At age 1, each agent with ability level z makes a draw of an idiosyncratic subsidy s from a distribution $D(s)$, with support $[s^{\min}(z), s^{\max}(z)]$. Once a manager is attached to a particular tax (distortion), this implicit subsidy remains constant over his/her life cycle, and he/she obtains managerial rents $\pi(r, w, s, A)$ that obey

$$\pi(z, r, w, s, A) \equiv \max_{n,k} \ \{(1+s)Az^{1-\gamma}\left(k^{\alpha}n^{1-\alpha}\right)^{\gamma} - wn - (r+\delta)k\}.$$

To summarize, with distortions the timing of events is as follows: (i) agents are born with managerial skills z; (ii) a distortion level is drawn from distribution D; (iii) occupation choice and decisions take place.

We note that our formulation delivers plant-specific, correlated distortions in a simple, parsimonious way. Managers facing with the same initial ability can face different distortions. Similarly, as managers invest at different rates, our formulation allows for the coexistence of managers of similar managerial skills who face different distortions.

Our formulation implies that implicitly subsidies distort the choice of capital and labor hired, and thus change the optimal size measured in either capital or labor used, but leave the capital-labor ratio unaltered. Since distortions affect managerial rents, they matter for skill accumulation. The key condition for skill accumulation is now

$$(1+r) = \pi_z(r, w, s, A)g_x(z_j, x_j). \tag{17}$$

As managerial rents are increasing in the subsidy rate, the marginal benefit from skill investment increases as the subsidy rate increases. Therefore, keeping prices fixed, higher subsidy lead to higher levels of managerial skills.

3.4   Discussion

We start by noting that as we model the acquisition of *general* managerial skills, our modeling of distortions captures the effects of distortions that affect the acquisition of such skills; our framework cannot capture the effects of distortions that have consequences on investments on firm of plant-specific productivity. Our formulation roughly captures, for instance, the role of political connections (or lack thereof) that are tied to individuals, that can generate higher or lower subsidies that a manager can collect, and that are potentially transferable across production units.

Idiosyncratic Subsidies What do the idiosyncratic subsidies that we model actually capture? There are basically two ways to interpret such subsidies. First, they can represent explicit or implicit subsidies provided by the government. Government policies that support small and medium size enterprises (SMEs), either firms or establishments, are very common, if not universal, both in developing and developed countries. The particular attention to SMEs is perhaps justified by their sheer number: they represent, for example, between 96% and 99% of the total number of enterprises in the whole economy and between 60 to 70% of total manufacturing employment in most OECD countries.[7] The size-dependent policies that provide special provisions for SMEs takes several forms:

1. Financial Subsidies. Both developed and developing, provide special financing arrangements to SMEs, either in the form of loan grantees or interest rate subsidies. Prominent examples of such programs are Korea and Japan. Korean Credit Guarantee Fund (KCGF) and Korea Technology Credit Guarantee Fund (KOTEC) provide credit guarantees to SMEs that are otherwise ineligible for regular bank loans. Japan Finance Corporation for Small and Medium Enterprises (JASME), National Life Finance Corporation (NLFC), and Shoko Chukin Bank, provide both direct, low interest, uncollateralized loans as well as credit grantees to SMEs.[8] According to the recently created Secretariat of Small and Medium-Sized Enterprises (Secretaría de Pequeñas y Medianas Empresas, SEPyME), a part of the Ministry of Economy, Argentina has approximately 300 programs and lines of credit to support SMEs, implemented by national, provincial, and municipal governments as well as non-government organizations for SME programs.[9]

2. Special Tax Treatments. Most OECD countries have lower corporate tax rates for SMEs. These countries include Belgium, Canada. France, Germany, Ireland, Japan, Korea, Luxembourg, Mexico, the Netherlands, Portugal, Spain, the UK, and the U.S. Several countries also provide tax incentives for investment, like tax credits and more generous depreciation allowances, that are specific to SMEs.[10] Gomez Sabaini and Jimenez (2012) document that Latin America is characterized by wide spread tax exemptions. These exemptions, that are designed to favor specific sectors, regions or economic agents result in

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[7]O.E.C.D. (2002). SMEs are usually defined as enterprises with less than 250 employees, although the U.S. definition is less than 500.

[8]Ministry of Economy, Trade and Industry (2004).

[9]See World Bank (2000).

[10]O.E.C.D. (2002)

large losses of tax revenues. In 2007, they accounted for 2.2%, 4.9% and 5.4% of GDP in Argentina, Chile and Mexico, respectively (Gomez Sabaini and Jimenez 2012, Table 9).

3. Other direct support and services for SMEs: Possibly, the most notorious example of such policies is the case of India where, under the Small Business Coordination Act of 1961, certain sub-sectors are reserved for SMEs, and the entry or expansion of large-scale enterprises requires government approval. Furthermore, under the SMEs Products Procurement Act of 1981 the government agencies are obliged to purchase certain products from SMEs.[11]

As Pages (2010) points out, all Latin American countries have special policies for SMEs, such as simplified tax regimes, differential labor regulations, programs to facilitate access to credit and direct subsidies and services to support SMEs. As documented by Ibarraran, Maffioli and Stucchi (2009), however, the track record of these policies in term of their empirical effects on productivity, however, has been rather disappointing.

Second, implicit subsidies can stand for tax evasion and imperfect enforcement of tax laws. Gomez Sabaini and Jimenez (2012) document that a key feature of taxation in Latin America is heavy reliance on corporate taxation as corporations generate about 70% of tax revenue generated by income taxes, and tax evasion is very widespread. Tax evasion rates for corporations were as high as 48% and 46% in Chile and Mexico, respectively (Gomez Sabaini and Pablo Jimenez 2012, Table 10).

Amplification and Heterogeneity As we detail in Bhattacharya et al (2012), it is important to emphasize that distortions as modeled here, as well as changes in economy-wide productivity, have consequences on skill investments, size and the overall productivity distribution as goods are required in the technology to augment skills. This implies that the effects of changes in those variables are amplified by skill investments.[12]

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[11]Both programs were reduced in their scope, but not completely eliminated, during the economic liberalization of the 1990s. See Garcia-Santana and Pijoan-Mas (2011) for a macroeconomic evaluation of India's Small Scale Reservation Laws.

[12]This connects our paper to the recent development and trade literature that considers amplification effects of productivity differences or distortions due to investments in skills and R&D, such as Manuelli and Seshadri (2010), Erosa, Koreshkova and Restuccia (2010), Cubas, Ravikumar and Ventura (2012), Rubini (2011) and Atkeson and Burstein (2010, 2011), among several others.

TFP   Our model has important implications for *Total Factor Productivity* (TFP) that we explore in subsequent sections. Note that since the production structure of the model allows for aggregation, the model implies an aggregate production technology

$$Y = \underbrace{AZ}_{\equiv \text{TFP}} K^{\alpha\gamma} L^{\gamma(1-\alpha)}, \tag{18}$$

where K is aggregate capital, L is the aggregate fraction of the population engaged in regular work (see equation 15) and the term Z is the level of endogenous managerial skills raised to the power $1 - \gamma$, i.e.,

$$Z \equiv \left(\sum_{j=1}^{J_R-1} \mu_j \int_{z^*}^{\overline{z}} z_j \psi_j(a, z) da dz \right)^{1-\gamma}. \tag{19}$$

Hence, TFP is *endogenous* and amounts to AZ. Both distortions and the level of economy-wide productivity A affect TFP. Distortions potentially change the lowest productivity level, z^*, and through their effects on skill investments, the entire distribution of managerial skills. Similarly, changes in the level of exogenous productivity affect TFP in two ways. First, a change in A reduce TFP directly. Second, since managerial skills are endogenous and depend on the level of A, changes in the economy-wide productivity level affect the distribution of managerial skills due to the amplification effects that we discuss above and induce further changes in TFP.[13]

Overall, it is worth emphasizing that the effects of distortions on the model-based notion of TFP depend critically on the endogeneity of managerial skills. As we show later, idiosyncratic subsidies increase the number of establishments and lead to a concomitant increase in aggregate managerial skills for a *fixed* distribution. Therefore, potential reductions in TFP driven by distortions require that the effects of distortions on managerial investments dominate the effects stemming from the increase in the number of production units.

4   Parameter Values

We assume that the U.S. economy to be distortion free and calibrate the benchmark model parameters to match central aggregate and cross sectional features of the U.S. plant data.

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[13]There is a growing literature that emphasizes the importance of managerial inputs for firm's productivity; see Bloom and Van Reenen (2010). See also Burtein and Monge (2009) for the importance of international reallocation managerial know-how in income and welfare differences across countries.

Before discussing the calibration strategy, it is worthwhile to emphasize important features of the U.S. plant size data collected from the 2004 U.S. Economic Census. The average size of a plant in the U.S. was about 17.9. The distribution of employment across plants is quite skewed. As many as 72.5% of plants in the economy employed less than 10 workers, but accounted for only 15% of the total employment. On the other hand, less than 2.7% of plants employed more than 100 employees but accounted for about 46% of total employment. These are key features of the data for our analysis of distortions that are correlated with the size of production units.

We assume that the exogenous skill distribution of newborn agents, z_1, follows a log normal distribution. Specifically, we assume that $\log(z_1)$ is normally distributed with parameters μ_z and σ_z. We let the model period correspond to 10 years. Each cohort of agents enter the model at age 20 and live until they are 80 years old. Agents retire at age 60. Hence, in the model agents live for 6 model periods; 4 as workers or managers and 2 as retirees. There is a total of 9 parameters to calibrate, as listed in Table 3. The product of two of these parameters, importance of capital (α) and returns to scale (γ), determine the share of capital in output. We determine the values of capital share in output and the depreciation rate from the data. A measure of capital consistent with the current model on business plants should include capital accounted for by the business sector. Similarly a measure of output consistent with our definition of capital should only include output accounted for by the business sector. The measure of capital and output discussed in Guner et al (2008) is consistent with the current plant size distribution model. Hence we use the value of capital output ratio and the capital share reported in that paper. These values are 2.325 (at the annual level) and 0.317, respectively, with a corresponding investment to output ratio of about 0.178. We choose the population growth rate in the model such that the annual population growth rate is 1.1%. Given a capital output ratio and an investment ratio, our (stationary) law of motion of capital implies a depreciation rate of about 6.7% at the annual level.

After calibrating the depreciation rate and the population growth rate, we have 7 more parameters to calibrate: importance of capital, the parameter governing returns to scale, the discount factor, two parameters of the skill accumulation technology and the mean and variance of the skill distribution. Note that the capital share in the model is given by $\gamma\alpha$, and since this value has to be equal to 0.317, a calibrated value for γ determines α as well. Hence we have indeed 6 parameters to determine: $\gamma, \beta, \theta_1, \theta_2, \mu_z$ and σ_z. The resulting parameter

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values are displayed in Table 3.

At the aggregate level, we want the benchmark model to replicate the capital output ratio in the U.S. economy. At the cross sectional level, the model implied distribution of plants should capture some of the important features of the U.S. plant size distribution discussed in the beginning of this section. We normalize the mean of the skill distribution to zero and jointly calibrate the 5 remaining parameters to match the following 5 moments of the U.S. plant size distribution: mean plant size, fraction of plants with less than 10 workers, fraction of plants with more than 100 workers, fraction of the labor force employed in plants with 100 or more employees, and the aggregate capital output ratio.[14] These moments together with their model counterparts are given in Table 4.

The benchmark model is successful in replicating multiple features of the U.S. plant size distribution. The coefficient of variation of the plant size distribution implied by the skill accumulation model is 3.32 which is close to the corresponding value (3.98) in the data. Indeed, the model is able to replicate properties of the entire plant size distribution fairly well as illustrated in Figures 3 and 4. The success of the model in accounting for the tail of the plant-size distribution is important; as we argued earlier, the bulk of employment is *there*.

Skill Investments In our calibration, the fraction of resources that are invested in skill accumulation is of about 2.5% of GDP in the benchmark economy. Viewed as an intangible investment, this is a relatively small fraction of available estimates for these type of investments. McGrattan and Prescott (2010) calculations, for instance, yield an investment rate in a broad notion of intangibles of about 10.8% of output.

Despite the relatively small fraction of resources devoted to the improvement of managerial skills, the incomes of managers grow significantly with age. In the model economy, a manager who is in his 40s (age 3) earns about 2.7 times as much as a manager who is in his 20s (age 1). How does this compare to U.S. data? To answer this question, we first have to take a stand on who is a manager and who is a worker in the data. On one extreme, one can consider 'chief executives', which amount to about 0.9% of the labor force in 2000. A more comprehensive definition can include all those individuals who are categorized in executive,

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[14]We approximate the initial distribution of managerial skills using gridpoints that range from $-3\sigma_z$ and $3\sigma_z$.

administrative or managerial occupations.[15] This group amounts to about 9.2% of the labor force in 2000. About 5.3% of the workforce are managers in the model, which is right in the middle of these two estimates.

In order to calculate the growth rate of managerial incomes over the life-cycle, we use the broader definition of managers above. In an attempt to control for cohort effects, we use the 1980 U.S. Census to construct real managerial incomes for ages 20-29, the 1990 Census for ages 30-39, and the 2000 Census for ages 40-49. The income measure is the total personal income deflated by the Consumer Price Index (CPI). This procedure reveals that managers' incomes indeed grow significantly with age, as they grow by a factor of about 2.8, from ages 20-29 to ages 40-49. Alternatively, if we normalize managerial incomes by the aggregate level of labor income in each year in Census data, we obtain a growth factor of about 2.2. If instead we control for potential factors affecting all managers as a group, by normalizing managerial incomes by the overall level of managerial incomes in a given year, we obtain a growth factor is of about 2.1. Our model, estimated exclusively with plant-level data, produces an estimate in the range implied by the Census income data.[16]

5   Results

In this section, we present and discuss the central quantitative findings of the paper. We first introduce distortions along the lines presented in section 3.3. Subsequently, we explore the implied responses of our model economy to variations in economy-wide productivity. We finally discuss the implications of some of the findings for Latin America.

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[15]We used OCC 1990 classification with occupation codes 4 to 22 counted as managers in the U.S. Census. The set of occupations that are classified as managers include `Chief executives and public administrators, Financial Managers, Human resources and labor relations managers, Managers and specialists in marketing and advertising and public relations, Managers in education and related fields, Managers of medicine and health occupations, Postmasters and mail superintendents, Managers of food-serving and lodging establishments, Managers of properties and real estate, and Funeral directors. Managers of service organizations, Managers and administrators.`

[16]The data also shows that size grows over the life-cycle of plants. Hsieh and Klenow (2012), among others, document that U.S. manufacturing plants that are more than 40 years old are about 7 times larger than those that are less than 5 years old. These authors also show that the growth rate is much lower in Mexico, where older plants are about twice as large as the younger ones, and nearly absent in India.

5.1 Effects of Idiosyncratic Distortions

We now evaluate the effects of idiosyncratic distortions by concentrating on the simple case of implicit subsidies that depend *negatively* on the initial ability draw of the manager. We assume that the distribution of distortions $D(s|z)$ is uniform, with support in $[0, s^{\max}(z)]$. We further assume that the upper bound is given by

$$s^{\max}(z) \equiv \bar{s} \, \frac{z^{\min}}{z} \tag{20}$$

Hence, higher values of z reduce the implicit subsidy, and at the lowest possible level of ability, $z^{\min}$, the highest possible subsidy rate amounts to $\bar{s}$. In other words, lower values of z make higher subsidy rates more likely.

We evaluate the effects of idiosyncratic distortions by changing the parameter $\bar{s}$ that governs the distribution of distortions, and comparing results across steady-state equilibria. We vary $\bar{s}$ across steady states so that resources transferred in terms of subsidies achieve certain values. We consider variation in $\bar{s}$ from zero to the values that imply 3% and 6% of output in terms of implicit production subsidies. To keep the experiments simple, we do this without considering the budget implications and later we evaluate the implications of revenue neutrality.

Table 5 and 6 show the main findings. As Table 5 demonstrates, implicit subsidies that amount to 6% of output imply a reduction in aggregate output of about 3.8%, and lead to a substantial increase in the number of production establishments of about 70.9%. Mean size falls from the benchmark value of 17.7 employees to about 9.9. As a result of these changes, output per establishment drops by much more than the reduction in aggregate output, by about 43.7%. This occurs as with the introduction of implicit subsidies, establishments receiving subsidies increase their demand for capital and labor services, which translates into an increase in the wage rate across steady states. These effects are reinforced by the emergence of new production units that are smaller on average, as individuals with low initial managerial ability become managers if they receive a subsidy large enough.

The effects outlined above are also present in the analysis in Guner et al (2008), in the context of a standard span-of-control model with capital accumulation. In the current context with skill investments, the consequences of distortions that affect the size of production establishments are potentially more severe. Distortions can have detrimental consequences

on skill investments. On the one hand, individuals facing an implicit subsidy, all the same, have stronger incentives to invest in managerial skills as the marginal contribution of a unit of managerial skill increases due to the presence of the subsidy. On the other hand, relatively high initial ability managers, who are less likely to receive a subsidy, face now different prices for inputs and in particular higher prices for labor services. This leads to lower incentives on their side to invest in skills. Overall, average managerial ability declines by about 43% under implicit subsidies capturing 6% of aggregate output.

The level of mean ability of managers declines due to two reasons. The first reason is a standard *reallocation effect*: subsidies lead to a reallocation of resources across establishments that translates into a higher demand for labor from subsidized establishments and the emergence of new ones relative to the benchmark case. This results in the higher wage rates mentioned above. As managers of these new establishments have initial skills below the cutoff level in the benchmark economy, they reduce average managerial skills. The second reason, a *skill accumulation effect*, is due to the forces that we highlight in this paper. Managers who do not receive a subsidy, who tend to be the initially most able ones, reduce their investments in managerial skills, leading in turn to a further reduction in the economy-wide level of managerial ability. Investment in managerial skills declines from about 2.5% of output in the benchmark economy to about 2% when subsidies amount to 6% output. Both forces contribute to the decline in aggregate output, and the degree of reallocation of resources from large establishments to small ones.

Indeed, as Table 5 shows, the introduction of subsidies leads to a substantial redistribution of production across establishments. Idiosyncratic subsidies that capture 6% of output lead to a drop in the share of employment accounted for by large establishments (100 and more workers) from about 45.8% to 35.9% of total employment, and an increase in the share of small ones (less than 10 workers) from 17.8% to 30.7%. These changes take place in conjunction with increases in the fraction of small plants, that sharply increases from about 73.6% in the benchmark, to about 85.9% when transfers in terms of subsidies amount to 6% of output.

TFP   Very interestingly, the effects discussed above imply only a *minor* reduction in the model-based notion of TFP. This occurs due to two reasons. On the one hand, the substantial occupational shift, from workers to managers, of less initially able individuals

leads to an *increase* in the integral in equation 19. On the other hand, as discussed earlier, the change in factor prices (mainly the decline in the wage rate) leads to a reduction in the skill investments of those (typically of high initial ability) who do not receive the subsidy. This latter effect implies a reduction in the integral in equation 19. As Table 3 demonstrates, the two effects nearly balance each other, and TFP drops only marginally.

Revenue Neutrality The quantitative experiments discussed above are conducted without taking into consideration its budget consequences. To what extent our findings are driven by the absence of taxes required to finance the subsidy experiments? To answer this question, we introduce a flat-rate *tax* on either labor income or managerial income, applied to all individuals, so that taxes collected effectively amount to the subsidy transfers.

The bottom panel of Table 5 presents the findings for the case of output, TFP, mean size and the resulting tax rates. Non-trivial tax rates are needed to pay for the subsidies; 4.6% and 8.5%, respectively. The findings show that the introduction of taxes to finance the subsidies magnifies their effects. For the case of 6% of output devoted to subsidy transfers, the case without budget balance discussed above result only about 60% of the total effects on output when we impose revenue neutrality. It appears that for relatively low levels of subsidies in the aggregate, the distorting effects from idiosyncratic subsidies – not the feedback effects associated to revenue neutrality – are the dominant force in our results. However, as the results show, the consequences of revenue neutrality are not trivial. Hence, we conduct revenue-neutral experiments in our analysis in section 6.

5.2   Variation in Economy-wide Productivity

We now consider the effects of changes in economy-wide productivity levels; the term A that is common to all establishments. We do this for multiple reasons. First, as we mentioned earlier, when goods matter for the acquisition of skills, variation in exogenous productivity affects managerial skills and have effects on occupational choice and plant size. Second, there is substantial variation in the size of establishments across countries that is correlated to the level of development. As it is well documented, productivity differences are a central factor in accounting for the large observed disparities in income across countries. While the mean size of establishments is about 17.9 employees in the U.S. and 15.0 in Norway, it amounts to about 9.7 in Japan. As we discussed earlier, mean size is lower in poorer countries and is

around 5.8 employees in Mexico. To what extent plant size, output and TFP are affected by exogenous aggregate productivity is a question that can be addressed in the current setup.

We consider two exogenous reductions in productivity (A) relative to the benchmark case: 25% and 50%. Results are presented in Table 7. Not surprisingly, reducing productivity by 50% leads to a substantial reduction in output across steady states of 68.3%. Changes in the level of productivity also affect the distribution of plant size: reducing productivity by 50% leads to an increase in the number of establishments by about 32.8% with a corresponding decline in the mean size of establishments.

Quantitatively, the size-distribution effects associated to a reduction in productivity are not trivial. As Table 7 demonstrates, a 50% reduction in productivity reduces mean managerial ability by 49.4%. It leads to a reduction in the share of employment accounted for by establishments with 100 workers or more from about 46% to 28.1%, and to an increase in the share of establishments of less than 10 workers from 17.8% to 24.5%. Nevertheless, as the table demonstrates, the bulk of endogenous TFP changes are driven by the changes in exogenous productivity A.

Overall, changes in aggregate productivity concentrate employment at smaller production units as idiosyncratic distortions do. As a result, they can matter in quantitatively accounting for the observed cross-country differences alongside idiosyncratic distortions correlated with plant's productivity.

5.3   Implications for Latin America

The results in this section contain a number of implications for Latin America that are worth discussing. First, idiosyncratic subsidies that are negatively related to productivity do *not* lead to large effects on aggregate productivity. Alternative formulations, using implicit taxes instead of subsidies, as considered in Bhattacharya et at (2012), lead also to consequences on aggregate TFP that are of second-order importance in light of the large gaps in output per worker and TFP of Latin-american economies in relation to developed countries. Hence, it appears that the main drivers of such large differences in aggregate productivity are due to other reasons.

Second, distortions modeled as implicit subsidies have substantial effects on the size distribution of plants. Idiosyncratic distortions as implicit subsidies concentrate production

in smaller production units; they lead to an increase in the fraction of small plants and to a sharp decrease in the employment share of large plants. As such, they can be central in rationalizing the differences between Latin American economies and the U.S.

Third, changes in exogenous productivity lead to the expected large differences in output per worker, and also, help concentrate production in smaller units through their effects on skill accumulation. It follows that there is a natural interplay between exogenous productivity and idiosyncratic distortions. The consequences of the interplay between these forces help shed light on the potential structure of distortions, and the level of exogenous productivity that are needed to reproduce the data. We explore this theme in detail in the next section.

6   Distortions and Exogenous Productivity Differences: The Case of Mexico

In previous sections, we showed the quantitative implications of the model in terms of output, productivity measures and the size distribution of establishments. We now proceed to use Mexican data to make inferences about the potential structure of distortions, and the magnitude of exogenous productivity differences from the perspective of our model.

Despite the limitations of data for other Latin American countries, Mexico is an important case to consider for a host of reasons. First, Mexico is substantially poorer than the United States, with level of output per worker of about 35% of the U.S. level.[17] Second, Mexico is also an stagnated economy. Its level of output per worker has been roughly *constant* in relation to the United States for several years. Using data from the Penn World Tables, we calculate that Mexico's output per worker was about 34.1% of the U.S. in 1995, 35.1% in 2000 and about 35.5% in 2005. Thus, there are no a-priori transitional issues that may complicate the analysis. Third, as we documented in section 2, there are substantial differences in the plant-size distribution in comparison with the U.S. Mean size is substantially lower and the data features a large fraction of small plants. This picture is complicated by the fact that the small set of Mexican 'large' plants account for a disproportionate fraction of employment (nearly 32%). Overall, given our analysis in previous sections, our framework provides a natural vehicle to analyze jointly the differences between the U.S. and Mexico, both in terms of relative income levels as well in terms of plant size, in order quantify the importance of

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[17]See, among others, Hanson (2010) for a discussion.

distortions and their interplay with exogenous productivity differences.

Our analysis in this section is contained in two cases, distinguished by the structure of distortions that we impose. In our first case, the uniform distribution of idiosyncratic subsidies $D(s|z)$ has support

$$[0, s_1 \; \frac{\widehat{z} - z}{\widehat{z} - z^{\min}}] \;\; \text{if } z \leq \widehat{z},$$

where $\widehat{z}$ is an exogenously given threshold level. Hence, for levels of initial managerial ability z that are below $\widehat{z}$, potential subsidies are a decreasing function of z. At $z = \widehat{z}$, the level of subsidy is effectively zero. At $z = z^{\min}$, subsidies are uniformly distributed between 0 and s_1. As the level of z increases, the maximum level of the subsidy declines linearly. This formulation allows us to select a level of initial ability such that above that level, access to subsidies is not possible. Put differently, subsidies are available only up to initial managerial ability $z = \widehat{z}$. We refer to this case as *Mexico I*.

In our second case, we impose a more general structure of distortions, that permits implicit subsidies that are larger for low as well as high skilled managers. For this case, a manager of type z draws distortions from a uniform distribution

$$[0, s_1 \; \frac{\widehat{z} - z}{\widehat{z} - z^{\min}}] \;\; \text{if } z \leq \widehat{z},$$

and

$$[0, s_2 \; \frac{z - \widehat{z}}{z_{\max} - \widehat{z}}] \;\; \text{if } z > \widehat{z}.$$

Hence, at $z = \widehat{z}$, the level of subsidy is zero. For levels of ability below $z = \widehat{z}$, we have the same formulation as above with a maximum subsidy rate of s_1 and potential subsidies increase as ability declines. To the right of $z = \widehat{z}$, potential subsidies increase as ability increases. At $z = z_{\max}$, the highest possible level of ability, subsidies are drawn from the interval from zero to s_2. Hence subsidies are V-shaped with respect to the managerial ability levels. We refer to this more general case as *Mexico II*.

Mexico I Using the calibrated parameters of the benchmark economy, we proceed to find the levels of economy-wide productivity (A) and the two distortion parameters $\widehat{z}$ and s_1 to reproduce in steady state: (i) the level of output of Mexico relative to the United States

(0.35); (ii) mean size in Mexico (5.85); (iii) the fraction of small plants in Mexico (0.948). In doing so, we impose a tax on the earnings of all workers and managers that pays for the aggregate magnitude of the implied subsidies. We then contrast the model implications for other properties of the size distribution in Mexico, and quantify the importance of aggregate productivity differences vis-a-vis idiosyncratic distortions.

The findings from the experiment are shown in Table 8. As the table illustrates, the model can capture well the three targets that we imposed. In particular, the model economy generates a mean plant size and a fraction of small plants in line with data, 5.9 and 5.9, respectively. This is accomplished via a level of exogenous productivity of 0.57, a threshold level $z = \hat{z}$ that is slightly less than four times the mean level of initial ability, and a maximum possible subsidy s_1 of 0.9. The required idiosyncratic subsidies are large and amount to an average of about 28%. These subsidies require a tax on all managers and workers at the rate of about of about 15%. Overall, the structure of subsidies and exogenous productivity imply a level of TFP for Mexico of about 51.7% of the U.S.

While the model succeeds in creating the large fraction of small plants, it fails in this case to capture the concentration of employment at the top of the distribution. Note that the model implies a share of employment at large plants of about 13.4%, while the data dictates 31.9%. A straightforward conclusion from these findings is that given the size-distribution distribution data, our model-based inference suggests that implicit subsidies should *also* be applied to more relatively productive managers. This is attempted next in our *Mexico II* case.

How large are contribution of exogenous productivity differences vis-a-vis distortions in order to generate the results in Table 8? The last column in the Table answers this question. Using the previously found values of A, we compute the effects of changes in exogenous productivity *only*. The results reveal that differences in A play a substantial role: they capture the bulk of the changes in output and nearly all the changes in TFP. Exogenous productivity differences also have noticeable effects on the size distribution; they account for nearly a third of the changes in mean size relative to benchmark economy.

Mexico II We now implement our second, more general structure of distortions. As before, we do so in the context of revenue neutrality across steady states. We proceed to find the levels of economy-wide productivity (A) and three distortion parameters, $\hat{z}$, s_1

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and s_2, so as to reproduce the same targets as in the previous case, plus the the share of employment in large plants (31.9%). Hence, we look for a structure of distortions and exogenous productivity differences that reconciles the model predictions with Mexican data, including now the high concentration of employment at the top.

Table 9 displays the results. The model is now relatively successful in terms of the targets we impose, by introducing a structure of distortions that implicitly subsidizes the operation of plants run by managers that are initially highly prod. The model now implies a share of employment at the top in line with data (33.3%). We accomplish this via a level of exogenous productivity of 0.56, a threshold level $z = \widehat{z}$ that is about two times the mean level of initial ability, and levels of maximum possible subsidies of $s_1 = 1.2$ and $s_2 = 0.255$.[18] The subsidy rates averaged across all plants are high, and amount to about 43%. Note also managers operating plants at the top are subsidized as well at non-trivial rates, with an average subsidy rate of about 14.4%. The model determines an endogenous level of TFP of about 50.2%, slightly lower than the case Mexico I.

Overall, the results show again that variation in exogenous productivity is critical in understanding differences in output per worker and TFP. The results clearly indicate that idiosyncratic distortions are key for understanding differences in the size distribution of plants; without them the model is unable to generate a size distribution in line with data. Moreover, the comparison between the two cases clearly indicates that idiosyncratic distortions *cannot* be exclusively concentrated at the bottom of the managerial ability distribution. From the perspective of our model economy, the plant-size data dictates that units at the top also require implicit subsidies. Otherwise, their size in equilibrium becomes too small in relation to data.

6.1 The Amplifying Effects Skill Investments

The introduction of distortions changes the incentives to accumulate managerial skills, and thus, the productivity of managers in production. Hence, a natural question to ask is how large are the amplifying effects on output, productivity and the distribution stemming from managerial investments.

For these purposes, we conduct experiments under the structure of subsidies from the

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[18]For computations, we restrict the maximum subsidy to be 0.99.

Mexico I and *Mexico II* cases, without changes in exogenous productivity. We compare the effects of such subsidies, to cases where the introduction of such subsidies is done under fixed decision rules for skill investments from the undistorted case. Specifically, we use the decision rules for skills from the benchmark case and make them *invariant* to changes in the environment and prices. In these circumstances, we calculate stationary equilibria in the presence of idiosyncratic subsidies. By construction then, the distorted economies have the *same* levels of managerial productivity across individuals than in the benchmark economy without distortions.

We find that under the structure of subsidies from the *Mexico I* case, output per worker drops by 8.8%, TFP drops by 2.9%, and mean size falls from the benchmark level of 17.7 employees to 7.6 employees. Aggregate investment in skills drops from 2.5% of output to 1.8%. The number of plants goes up by about 118% and the fraction of small plants increases, from the benchmark value of 73.6% to 90.3%. Under fixed decision rules for skills, the corresponding effects on output are 3.2% and the effects on TFP are nearly zero. Mean size drops to 8.8 employees, the number of plants increases by 90.5% and the fraction of small plants becomes 88.7%.

If instead we use the structure of subsidies from the *Mexico II* case without changes in exogenous productivity, we find that output per worker drops by 5.7%, TFP drops by 3.1%, and mean size falls from the benchmark level of 17.7 employees to 11.6 employees. Not surprisingly, the investment rate in skills is nearly unaffected and amounts to 2.2%. The number of plants goes up by about 47.6% and the fraction of small plants increases to 88.2%. How large the amplifying effects are in this case? Under fixed decision rules for skills, the corresponding effects on output are about 2% and the effects on TFP are again, very small (0- 0.7%). Mean size drops to 12.6 employees and the fraction of small plants becomes 85.5%.

We conclude from these findings that the amplification effects can be substantial. In first case, the effects on output under fixed decision rules are of about less than 40% than in the unrestricted case. The consequences on the size of plants are, however, of similar magnitudes regardless on whether decision rules are fixed or not. In the *Mexico II* case, again without changes in exogenous productivity, the effects on output are of about 35% than the ones observed in the unrestricted case. The findings indicate that the amplification effects are larger in the *Mexico II* case; i.e. when subsidies are concentrated in managers of low and

high initial productivity. This is not surprising, as in this case, both high and low initial ability managers are *directly* affected by the availability of subsidies.

7   Conclusion

We developed a span-of-control model where managers invest in the quality of their skills, and used it to quantify the significance of idiosyncratic, correlated distortions (subsidies) and their interplay with aggregate productivity levels. We used this model to draw quantitative implications for Latin American economies. We focus on the case of Mexico, for which we calibrate the level of exogenous, economy-wide productivity and the structure of idiosyncratic subsidies that can generate the observed size distribution and per-capita income relative to the U.S.

In our analysis of Mexico, our findings imply substantial differences in exogenous productivity in relation to the United States, and found that these differences account for the bulk of the differences in output per worker between the U.S. and Mexico. We also found that idiosyncratic subsidies have significant implications for the size of plants, and thus, are essential to account for differences in the distribution of plant size. Furthermore, we found that these subsidies need to have a particular structure: model and data dictate heavier subsidies for managers of small and large plants.

We close the paper with a simple observation. It is worth noting the fact that idiosyncratic distortions have second-order effects on output, does not imply that they are harmless. Indeed, our calculations imply that the structure of subsidies that reproduces Mexican data, dubbed *Mexico II*, leads to a reduction in aggregate output of about 5.7% across states. This a value that is quite substantial for the standards of the applied general equilibrium literature. Hence, subsidy distortions have second-order effects only in light of the large output gap with the U.S. (35%) that needs to be accounted for.

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Table 1: Plant-Size Distributions: U.S. and Latin America (manufacturing)

	United States	Bolivia	El Salvador	Mexico	Argentina
Small (1-9) Plants (%)	54.5	91.7	82.0	90.5	84.0
Large (100+) Plants (%)	8.9	0.6	2.9	1.6	0.2
Employment Share, Small (%)	4.2	43.6	17.7	22.7	22
Employment Share, Large (%)	67.7	23.0	59.7	56.3	18
Output Per Worker	100.0	10.0	19.0	35.0	25.0

Note: This Table presents summary facts on plant-size distributions for selected Latin American countries and the United States for the case of the manufacturing sector. Data for size distributions is condensed in Pages (2010), chapter 4. Data for output per worker at PPP is from the Penn World Tables 7.0.

Table 2: Plant-Size Distributions: U.S. and Mexico

	United States	Mexico
Small (10 or less) Plants (%)	72.5	94.8
Large (100+) Plants (%)	2.6	0.5
Employment Share, Small (%)	15.1	48.4
Employment Share, Large (%)	46.2	31.9
Mean Size	17.7	5.8
Output Per Worker	100	35.0

Note: This Table presents summary facts on plant-size distributions for Mexico and the United States for the entire economy. Data for the size distribution in Mexico is from Leal-Ordoñez (2010). Data for output per worker at PPP is from the Penn World Tables 7.0.

Table 3: Parameter Values (annualized)

Parameter	Value
Population Growth Rate (n)	0.011
Depreciation Rate (δ)	0.067
Importance of Capital (ν)	0.426
Returns to Scale (γ)	0.765
Mean Log-managerial Ability (μ_z)	0
Dispersion in Log-managerial Ability (σ_z)	2.285
Discount Factor (β)	0.946
Skill accumulation technology (θ_1)	0.932
Skill accumulation technology (θ_2)	0.405

Table 4: Empirical Targets: Model and Data

Statistic	Data	Model
Mean Size	17.9	17.7
Capital Output Ratio	2.325	2.332
Fraction of Small (0-9 workers) establishments	0.725	0.736
Fraction of Large (100+ workers) establishments	0.026	0.028
Employment Share of Large establishments	0.462	0.458

Table 5: Effects of Idiosyncratic Subsidies

Statistic	Benchmark	3% Output Collected	6% Output Collected
Aggregate Output	100.0	98.3	96.2
TFP	100.0	99.7	99.3
Number of Establishments	100.0	140.3	170.9
Mean Size	100.0	69.6	56.2
Output per Establishment	100.0	70.0	56.3
Mean Ability	100.0	70.5	56.3
Investment in Skills (% of GDP)	2.5	2.4	2.4
Small Establishments (%)	73.6	81.9	85.9
Employment Share (Small, %)	17.8	24.9	30.7
Employment Share (Large, %)	45.8	40.0	35.9
Revenue Neutrality			
Output	100.0	96.9	93.7
TFP	100.0	99.1	98.1
Mean Size	100.0	68.1	54.7

Note: Entries show the effects on displayed variables associated to the introduction of idiosyncratic subsidies. The implicit subsidies are selected in order to generate an aggregate magnitude of transfers in terms of subsidies equal to 3% and 6% of aggregate output. 'Small' stands for establishments with less than 10 workers whereas 'Large' stands for establishments with 100 workers or more.

Table 6: Magnitude of Idiosyncratic Subsidies (%)

Statistic	Benchmark	3% Output Collected	6% Output Collected
Mean Distortion	0.0	21.6	34.4
Median Distortion	0.0	2.5	5.1
Mean Distortion (100+ workers)	0.0	0.0	0.0

Note: Entries show the effects on displayed variables associated to the introduction of idiosyncratic subsidies. The subsidies are selected in order to generate an aggregate magnitude of transfers in terms of subsidies equal to 3% and 6% of aggregate output.

Table 7: Role of Aggregate Productivity

Statistic	Benchmark	$A = 0.75$	$A = 0.5$
Aggregate Output	100.0	61.5	31.7
TFP	100.0	71.7	45.5
Number of Establishments	100.0	115.5	132.8
Mean Size	100.0	85.8	73.8
Output per Establishment	100.0	53.3	23.8
Mean Ability	100.0	71.6	50.6
Investment in Skills (% of GDP)	2.5	2.1	1.5
Employment Share (Small, %)	17.8	20.9	24.5
Employment Share (Large, %)	45.8	37.9	28.1

Note: Entries show the effects on displayed variables associated to exogenous reductions in the level of economy-wide productivity. 'Small' stands for establishments with less than 10 workers whereas 'Large' stands for establishments with 100 workers or more.

	Benchmark (U.S.)	Mexico Data	Mexico Model	Mexico Model (No Distortions)
Aggregate Output	100.0	35.0	35.8	39.2
Mean Size	17.7	5.8	5.9	13.7
Small Establishments (%)	74.7	94.8	91.9	75.3
Exogenous Productivity (A)	100.0	-	57.0	57.0
TFP	100.0	-	51.7	52.7
Number of Establishments (%)	100.0		271.1	126.9
Output per Establishment (%)	100.0	-	13.2	30.9
Mean Ability	100.0	-	24.4	56.2
Investment in Skills (% GDP)	2.5	-	1.1	1.7
Mean Distortion (%)	0.0	-	28.9	0.0
Large Establishments (%)	2.7	0.5	0.7	1.9
Employment Share (Large, %)	45.9	31.9	13.4	31.0

Note: Entries show the effects on displayed variables when the model is applied to the case of Mexico. The fourth column shows the effects when implicit subsidies and exogenous productivity are varied to match Mexico's output relative to the U.S., Mexico's mean plant size and Mexico's fraction of small plants. The fifth column shows the effects for the exogenous productivity level previously found, but without distortions. 'Small' stands for establishments with less than 10 workers whereas 'Large' stands for establishments with 100 workers or more.

Table 9: Mexico II

	Benchmark (U.S.)	Mexico Data	Mexico Model	Mexico Model (No Distortions)
Aggregate Output	100.0	35.0	35.0	38.1
Mean Size	17.7	5.8	7.6	13.4
Small Establishments (%)	74.7	94.8	91.0	75.8
Employment Share (Large, %)	45.9	31.9	33.3	30.6
Exogenous Productivity (A)	100.0	-	56.0	56.0
TFP	100.0	-	50.2	51.6
Number of Establishments (%)	100.0		215.9	129.9
Output per Establishment (%)	100.0	-	16.2	29.3
Mean Ability	100.0	-	29.0	54.6
Investment in Skills (% GDP)	2.5	-	1.3	1.6
Mean Distortion (%)	0.0	-	43.0	0.0
Mean Distortion (Large, %)	0.0	-	14.4	0.0
Large Establishments (%)	2.7	0.5	0.9	1.9

Note: Entries show the effects on displayed variables when the model is applied to the case of Mexico. The fourth column shows the effects when the distortions and exogenous productivity are varied to match Mexico's output relative to the U.S., Mexico's mean establishment size, fraction of small plants and the share of employment at large plants. The fifth column shows the effects for the exogenous productivity level previously found, but without distortions. 'Small' stands for establishments with less than 10 workers whereas 'Large' stands for establishments with 100 workers or more.

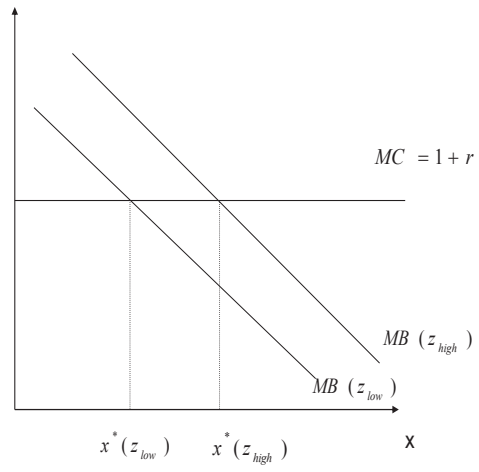Figure 1: Determination of Skill Investments

$MC = 1 + r$

$MB \ (z_{high})$

$MB \ (z_{low})$

$x^{*}(z_{low})$ $x^{*}(z_{high})$ X

Figure 2: Occupational Choice

$V_1(z)$

$W_1(0)$
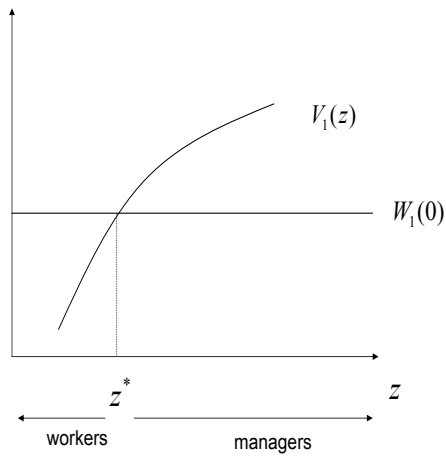
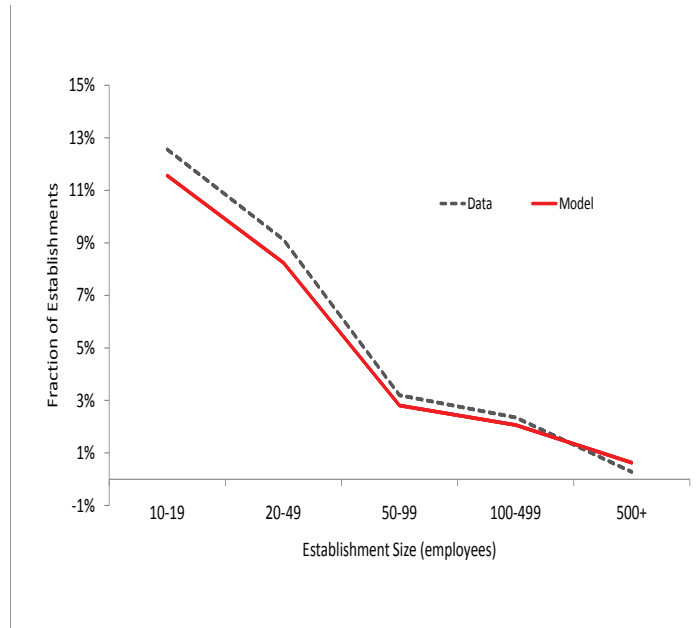z^{*} z

workers   managers

Figure 3: Size Distribution: Model and Data

Figure 4: Employment Shares: Model and Data

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