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THE AGGREGATE AND COMPLEMENTARY IMPACT OF MICRO DISTORTIONS

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Abstract

We explore how regulatory or institutional distortions to resource reallocation limit the ability of developing countries to adopt new technologies. An efficient economy innovates quickly; but when the economy is unable to redeploy resources away from inefficient uses, technological adoption becomes sluggish, growth is reduced, and income lags further behind the leading economy. We use a firm dynamics model to analyze income gaps between the U.S. and several developing countries. For the median country, the model accounts for one-third of the income gap with respect to the U.S., with 60% of the simulated gap explained by firm renewal distortions taken individually and 40% by their interaction.

JEL O1, O4

Keywords: firm dynamics, technological adoption, regulatory and institutional distortions, economic growth, and development gaps.

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1. Introduction

There is a large disparity among countries regarding the rate of adoption of even inexpensive technologies, and this is reflected in large differences in income levels. To understand why, we focus on impediments to firm dynamics. When firm renewal is not restrained, domestic enterprises are able to incorporate the advances of a rising technological frontier. In contrast, when the firms' natural dynamics are obstructed (for instance by red tape) a country's ability to adopt new technologies can be severely handicapped, with negative consequences for its long-run income. In this paper, we argue that a sizable fraction of the gap in income per capita between the U.S. and the typical developing country –about one-third-- is accounted for by regulatory or institutional obstacles. Moreover, we find that not just removing the distortions, but removing them jointly is critical: about 40% of the estimated gap between the U.S. and the typical developing country is explained by the interaction of different distortions, and the rest by the sum of their individual effects.

Starting with the work of Hopenhayn and Rogerson (1993), Caballero and Hammour (1994), and Davis, Haltiwanger, and Schuh (1996), and more recently Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), a large body of literature shows the key role of firm dynamics in driving microeconomic productivity and, consequently, aggregate output. The entry and exit of firms, involving the reallocation of resources from less to more efficient economic units, explain a substantial share of productivity improvements in the economy. Resource reallocation, however, implies costly adjustment: it requires the shredding of labor and capital by declining firms and the adoption of new technologies and the assimilation of production inputs by expanding firms. Without this costly process, economies would be unable to both reap the benefits of an expanding production possibilities frontier --the source of long-run growth - and absorb and accommodate negative shocks --the antidote to protracted recessions.

Some of the impediments to resource reallocation and firm renewal are related to the development status of the economy, such as poor governance and lack of human capital, which exacerbate the contractual, financial, and adaptation costs of new technologies (see Caballero and Hammour, 1998; and Acemoglu and Zilibotti, 2001). Not less important, other impediments result from government's distorting interventions in markets, such as excessive labor regulations, subsidies to inefficient sectors and firms, barriers to the establishment of new firms, and burdensome bankruptcy laws (see Blanchard and Giavazzi, 2003). These distortions, and their implied misallocation of resources, have been blamed for the observed differences in growth experiences and output levels across countries. In their influential book, Parente and Prescott (2000) argue that gaps in total factor productivity (TFP) among economies are produced by country-specific policies that restrict the set of technologies that individual production units can use. They ascribe them to monopoly-like denials of access to the best technology. Bernanke (2005) points to heavy regulatory burden as the reason why Europe lags behind the U.S. regarding productivity growth. Likewise, Nicoletti and Scarpetta (2003) conclude that the presence of government-owned firms with a degree of monopoly power, together with restrictions on the entry of new firms, diminishes competitive pressures that foster innovation and greater efficiency in the OECD. Also focusing on industrial countries, Gust and Marquez (2004) present empirical evidence that economies with highly regulated labor and product markets face greater difficulty in incorporating information technologies and suffer from lower productivity growth.

We analyze the process of technological innovation as the driver of economic growth from the perspective of developing countries, that is, as an adoption process. We model technological adoption as a process that requires firm renewal, which can be hindered by regulatory or institutional distortions to the entry of new investment projects and the exit of obsolete ones.[1] Moreover, we analyze how these regulatory or institutional impediments interact with each other to affect firm dynamics and, consequently, technological adoption. As we explicitly model the connection between micro distortions and technology adoption, we provide an explanation for endogenous productivity changes.[2]

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[1] Jovanovic (2009) provides an alternative explanation for the lack of technological innovation among developing countries. He argues that licensing costs keep technologies away from developing countries since their productivity is too low to warrant paying the fee.

[2] Although this paper is specifically concerned with the issue of technological innovation, the mechanism that we study (i.e., firm renewal to take advantage of exogenous shocks) can be applied to other externally generated events. One of them is related to trade prices. If world conditions induce a terms-of-trade shock, only countries that can shift resources towards the most profitable sectors will be able to take full advantage of the shock. The recent world economic crisis is another example. It has created an increase in the U.S. demand for certain products --such as low-end retail merchandising or fuel-efficient

Next, we present some motivating evidence on the importance of regulatory characteristics for technological adoption. Consider, for instance, the availability of personal computers and the number of internet users (both with respect to population) as proxies of technological progress in a country. Are the differences in the adoption rates of these technologies across countries related to their respective regulatory stance? Using information from the Fraser Institute (Gwartney and Lawson, 2006), we divide all countries with available data into three groups according to an index of business regulatory freedom. For each of them, we plot the group average of both personal computers and internet users per population for each year in the period 1990-2004 (see Figure 1). Countries in the top quartile of regulatory freedom (countries with lower regulations) have much higher levels and speeds of adoption of both technology indicators. Countries in the middle (inter-quartile) range of regulatory freedom also experience an increase over time but, having started their rise much later, show levels of technology adoption in the mid 2000s that are between one-third and one-half of those in the top quartile. Finally, countries in the bottom quartile of regulatory freedom start the adoption process much later and slowly than the others, resulting in enormous technology gaps with respect to the leaders.[3]

Indeed, the differences in regulatory freedom seem to be related to the rates of technological adoption across countries. But, what is the mechanism underlying this relationship? And, given that these distortions exist at various levels of the business process, how do they interact with each other to produce a given outcome of technological adoption? In order to propose an answer to these questions, we construct a stochastic general equilibrium model with heterogeneous firms. They differ on their level of productivity, which is determined by their initial technology and a history of idiosyncratic shocks. Old firms tend to become less productive than young firms with more advanced technologies, and eventually leave the market. In doing so, they release resources that may be then used to form new firms, which acquire the leading-edge technology and enter the market. The technological frontier expands according to a

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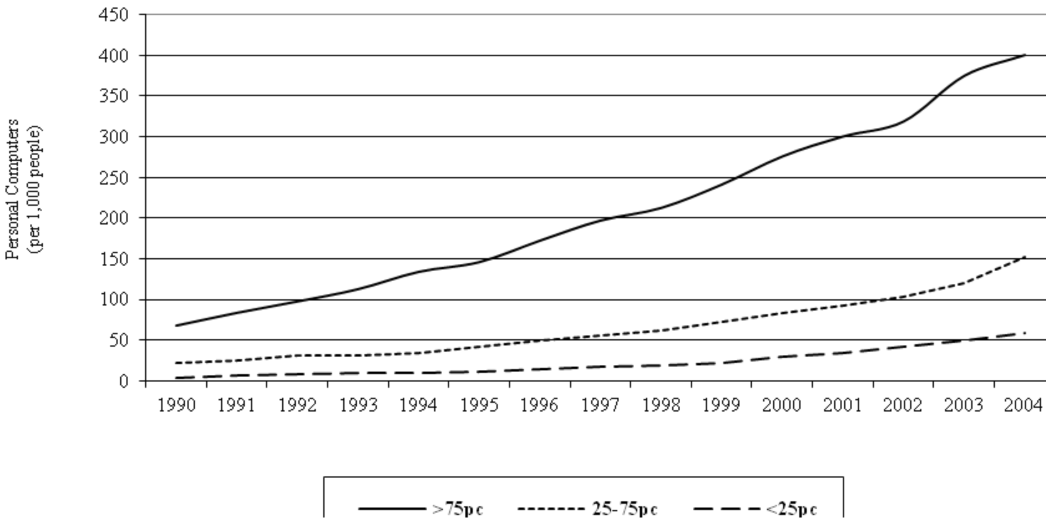
automobiles-- that can benefit the most dynamic developing countries, even in the middle of an international crisis.

[3] The relationship between technological adoption and regulatory freedom remains significant in regression analysis, where other determinants of technological adoption (such as income per capita, governance, and education) are controlled for. See Bergoeing, Loayza, and Piguillem (2010).

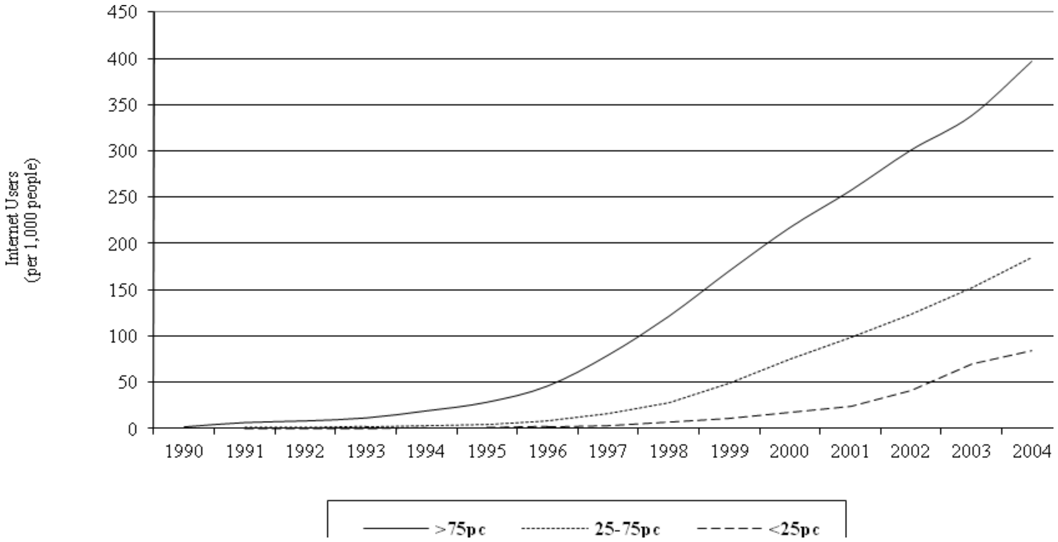
stochastic and exogenous process. This intends to capture the way developing countries relate to technological advances, that is, as takers and users rather than developers of new technologies.

Figure 1. Technological Innovation and Regulatory Freedom

Personal Computers by Level of Regulatory Freedom



Internet Users by Level of Regulatory Freedom



Notes: 1. Lines show average per group (top quarter, inter-quartile range, bottom quarter) according to Regulatory Freedom as of mid 90s. 2. Data on Personal Computers and Internet Users are from World Development Indicators. Data on Regulatory Freedom are from the Fraser Institute (Gwartney and Lawson, 2006).

Modeling regulatory and institutional distortions to firm renewal in the entry and exit margins, our model generates dynamics of adoption that are consistent with the data.[4] According to this model, differences in income levels are accounted for by accumulated differences in the rate of technological adoption (which determines the rate of economic growth). The process is exacerbated when world knowledge expands continuously –economies that suffer from obstacles to innovation lag further and further behind the leading-edge technology and, thus, the income per capita of the leaders. Using this framework, we calibrate the model economy to the U.S. and 107 developing countries around the world. The empirical counterpart of the model's exit and entry distortions is taken from the World Bank's *Doing Business* database.[5]

We then conduct simulation exercises to analyze the independent impact of entry and exit distortions and the interaction between them. The simulations show a slow adoption of new technologies by developing economies and a complementarity between the distortions at each margin of the firm renewal process. Our model accounts for about one-third of the income gap between the median less developed country (LDC) and the U.S, with 60% of this gap being explained by the distortions individually and 40% by their complementarity.

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[4] Samaniego (2006) also studies technological adoption within general equilibrium. However, that paper focuses exclusively on subsidies to incumbents. These distortions enable plants to survive longer allowing more of them to enter the stage of their life at which renewing their technology becomes optimal. Nonetheless, the economy spends a lot of resources on keeping alive plants that would otherwise have shut down, and this results in a reduction in both output and employment on the aggregate. Restuccia and Rogerson (2008) use a similar model to account for cross-country differences in income per capita. They show that policies that create heterogeneity in the prices faced by individual producers can lead to sizeable decreases in output and measured TFP in the range of 30% to 50%. Hsieh and Klenow (2009), using micro data on manufacturing establishments, calculate manufacturing TFP gains of 30-50% in China and 40-60% in India if labor and capital inputs are allocated as in the U.S.

[5] Some recent papers use the *Doing Business* database to simulate the effect of entry or exit costs on aggregate productivity across countries in industry-dynamics models. These papers, however, do not stress innovation as a transmission mechanism, neither the complementarity between distortions. See Barseghyan and DiCecio (2010), Moscoso and Mukoyama (2010), and Poschke (2010).

The remainder of the paper is organized as follows. Section 2 presents the model, and Section 3 discusses its calibration. Section 4 analyzes the dynamics of the model in order to highlight its firm dynamics mechanism. Section 5 uses the steady-state characteristics of the model to provide an explanation for long-run output gaps across countries. Section 6 concludes.

2. A model of plant selection

We develop a general equilibrium model of heterogeneous production units, vintage capital, and idiosyncratic shocks, based on Hopenhayn (1992), Campbell (1998) and Bergoeing, Loayza and Repetto (2004). There exists a distribution of plants characterized by different levels of productivity. In each period, plant managers decide whether to exit or stay in business. If a plant stays, the manager must decide how much labor to hire. If the plant exits, it is worth a sell-off value. Every period the incumbents receive an idiosyncratic productivity shock. In addition, new plants enter every period. The initial technology level of a newcomer is random, although increasing in the leading edge production technology. New plants are produced by a “construction” firm with a constant return to scale technology.

In this context, the economy is characterized by an ongoing process of plant entry and exit, and the corresponding creation and destruction. Plants exit if economic prospects loom negative. They may also exit if their current technology becomes obsolete and, by selling their capital off, owners gain access to the leading-edge technology –Schumpeter’s process of creative destruction. However, exiting is costly as capital loses some of its value in the process. These investment irreversibilities, as modeled by Caballero and Engel (1999), combined with idiosyncratic uncertainty, generate an equilibrium solution where plant owners rationally delay their exit decisions.

We allow for exogenously imposed rigidities. In particular, we study the effect of regulatory distortions that alter firms’ decisions to leave or stay in the market. Governments may be willing to impose such policies to reduce the volatility and short-run social and political costs associated to the entry – exit process or simply to collect revenues. The larger these are, the lower the rate of technology adoption that developing economies engage in, and the larger their income gap with rich economies. Our simulation results are consistent with this fact: as the leading edge technology expands, distortions to the extensive margins dampen the reallocation process reducing short-run output losses at the cost of lowering adoption, productivity gains, and output trend.

To relate our model to the existing micro dynamics literature, we refer to production units as "plants." However, we do not provide a theory of the firm or the plant. In our model the size of the firm as a collection of production units is indeterminate; thus, the modeled entry-exit dynamics can occur either within or across *actual* firms or plants. Nevertheless, to the extent that a firm or plant activities tend to consist of interrelated production units (or investment projects), we expect that there is a considerable correlation between production dynamics in the model and actual plant dynamics.

The gap between the definition of production units in the model and in the data implies that our model abstracts from reality in other dimensions that are also relevant for the specification of parameters as well as for the interpretation of our results. First, in the model only new plants invest, while in the data investment is carried out by both new and old plants. Second, in the model technological adoption requires firms to close down, while in the data incumbent plants may also adopt new technologies. Thus, we conjecture that the magnitude of entry and exit implicit in the model is an upper bound of those in reality. In what follows we describe our model in detail.

The model economy. The economy is populated by a continuum of heterogeneous plants. A plant needs labor (*n*) and capital (*k*) for production of the unique good, which can be used for consumption or investment. This production good is the numeraire.

Each plant's production function is given by,

$$y_t = A n_t^{\alpha} \left(e^{\theta_t} k_t\right)^{1-\alpha} \tag{1}$$

where A is aggregate productivity common to all the establishments (a scale factor), and θ_t is the idiosyncratic productivity in period *t*. Since technologies are characterized by constant returns to scale, we can restrict the size of all the plants to be equal to one unit of capital. Thus, capital goods are identified with plants so that investing one unit of the aggregate good yields a unit mass of plants. Slightly abusing notation, from now on $k_t(\theta_t)$ will represent the density of plants with embodied technology θ_t.

The aggregate production function of this model economy is,

$$Y_t = AN_t^{\alpha}\left[\int_{-\infty}^{\infty} e^{\theta_t} k_t(\theta_t) d\theta_t\right]^{1-\alpha} = AN_t^{\alpha}\overline{K}_t^{1-\alpha} \tag{2}$$

where $\overline{K}_t = \int_{-\infty}^{\infty} e^{\theta_t} k_t(\theta_t) d\theta_t$ is the aggregate effective capital stock and where $N_t = \int_{-\infty}^{\infty} n_t(\theta_t) k_t(\theta_t) d\theta_t$ is aggregate labor.

Capital embodying relatively low level of technology is scrapped as its productivity lags behind that of the leading edge technology. When a plant is retired, a unit of capital that is scrapped has salvage value $s < 1$. The total amount of salvaged capital in period *t* is then

$$S_t = (1-\delta)s \int_{-\infty}^{\overline{\theta}_t} k_t(\theta_t) d\theta_t \tag{3}$$

where $\overline{\theta_t}$ is the endogenous cut-off level of productivity that determines the exit decision of plants and δ is the capital's depreciation rate.

Units of the production goods not consumed -- which are made up of investment and part of last period's scrapped capital -- are transformed into new units of capital embodied with the leading edge technology. That is, the initial productivity level of a plant born in period *t* is a random variable with a normal distribution $\theta_{t+1} \sim \mathrm{N}(z_t, \sigma_z^2)$, where z_t represents the level of leading edge technology. This stochastic variable follows a random walk with a positive drift μ_z according to

$$z_{t+1} = \mu_z + z_t + \varepsilon_{t+1}^z, \quad \varepsilon_{t+1}^z \sim \mathrm{N}(0, \sigma^2). \tag{4}$$

This drift is the only source of long-run aggregate growth in our economy.

Capital that is not scrapped receives an idiosyncratic shock to its productivity level before next period production process starts, according to

$$\theta_{t+1} = \theta_t + \varepsilon_{t+1}^{\theta}, \quad \varepsilon_{t+1}^{\theta} \sim \mathrm{N}(0, \sigma_{\theta}^2) \tag{5}$$

This idiosyncratic shock has zero mean and, thus, it does not affect the economy's long-run growth rate. The random walk property of the stochastic process ensures that the differences in average productivity across units of capital persist over time. Thus, at any *t*, the units of capital with more advanced technology have a lower probability of shutting down.

Summarizing, there are two sources of uncertainty. First, an idiosyncratic productivity shock, ε_t^{θ} , that determines the plant level decisions of incumbents. This shock does not alter the aggregate equilibrium allocation. Second, a leading edge idiosyncratic productivity shock, ε_t^{z} , that governs the economy's aggregate growth. Notice that plants, as they decide to stay or leave, choose between the following distributions,

$$\theta_{t+1} \sim \mathrm{N}\left(\theta_{\mathrm{t}}, \sigma_{\theta}^{2}\right) \tag{6}$$

$$\theta_{t+1} \sim \mathrm{N}\left(\mathrm{z}_{\mathrm{t}}, \sigma_{z}^{2}\right) \tag{7}$$

Plants last only one period. At the beginning of the period, firms decide production and hiring. The wage rate in period *t* is ω_t , and the beginning and end of period prices of a plant with productivity θ_t are $q_t^0(\theta_{\mathrm{t}})$ and $q_t^1(\theta_{\mathrm{t}})$, respectively. Within this setting, given the number of units of capital with productivity θ_t, $k_t\,(\theta_{\mathrm{t}})$, in equilibrium employment in each plant is given by,

$$n_t(\theta_t) = N_t e^{\theta_t} / \overline{K}_t \tag{8}$$

After production, firms decide which plants should be scrapped and which ones should be maintained in business. Firms sell their production units and salvaged capital to the consumer and to a construction firm that produces capital embodying the leading edge technology. The construction firm, which buys I_t^c units of the aggregate good from the producer, incorporates the leading edge technology at zero cost, and then sells it to consumers at the end of the period at a price per unit q_t^{1i} . In addition, for each project that the consumer buys from the construction firm, she must pay π units of the consumption good to the government. In what follows, this would be our definition of entry cost. Profit maximization requires the price of the construction project *i* to be equal to the cost of inputs. That is,

$$q_t^{1i} = 1 + \pi_{\mathrm{t}}. \tag{9}$$

This is the ex-ante price of capital, that is, before the realization of the productivity shock.

The distribution of capital evolves according to the law of motion

$$k_{t+1}^{0}(\theta_{t+1}) = \int_{-\infty}^{\infty} \frac{1}{\sigma_\theta} \phi\left(\frac{\theta_{t+1} - \theta_t}{\sigma_\theta}\right) k_t^1(\theta_t) d\theta_t + \phi\left(\frac{\theta_{t+1} - z_t}{\sigma_z}\right) I_t^c, \quad \textit{for all } \theta_{t+1} \tag{10}$$

Since asset prices equal discounted expected dividend streams, increases in the level of productivity raise these prices; and since the scrap value of a plant is independent of its productivity, only plants with productivity level below the threshold $\overline{\theta_t}$ exit the market. Thus, the marginal plant, that is, the one with productivity level $\overline{\theta_t}$, must have a market value given by the scrap value. The following equation states this condition.

$$s = q_t^1(\overline{\theta_t}) \tag{11}$$

Finally, the purchasing price of a unit of capital is determined not only by its marginal productivity, less any operating costs, but also by the price at which capital, after depreciation, may be sold at the end of the period. Thus, for each θ_t, the purchase and sale decisions of capital units must be characterized by the zero profit condition,

$$q_t^0(\theta_t) = (1-\alpha)\left(\frac{\overline{K}_t}{N_t}\right)^{-\alpha} e^{\theta_t}{}_t + (1-\delta)\left[1\{\theta_t < \overline{\theta_t}\}s + 1\{\theta_t \geq \overline{\theta_t}\}q_t^1(\theta_t)\right] \tag{12}$$

where $1\{\cdot\}$ is an indicator function that equals one if its argument is true and zero otherwise. This condition restricts the beginning of period price to be the return from using the capital plus the price at which it can be sold at the end of the period.

The parameter π is a fee per plant that the firm has to pay to be able to operate. Notice that π is independent of the productivity of the particular plant. With this we try to capture the impact of policy regulatory restrictions such as legal fees, government permits, and bureaucratic process, whose cost firms must suffer regardless their size or productivity. The government´s budget constraint is satisfied by paying a lump-sum transfer to consumers using fee collections.

The remainder of the model is standard. There is a continuum of identical infinitely lived consumers who own labor and equity. Their preferences are given by

$$E_0\left[\sum_{t=0}^{\infty} \beta^t \left(\log(c_t) + \kappa(1-n_t)\right)\right] \tag{13}$$

where c_t and $1-n_t$ are consumption and leisure, respectively, and β and κ ∈ (0,1) are, respectively, the subjective time discount factor and the marginal utility of leisure. Every period, consumers have a time endowment equal to 1. Notice that we assume that the utility function is linear in leisure.[6] Following Hansen (1985) and Rogerson (1988), this can be interpreted as an environment in which consumers, with standard utility functions, can work only a fixed number of hours or none at all, and they can trade employment lotteries. Thus, n_t is interpreted as the fraction of the population that works.

Definition of the equilibrium: A *Competitive Equilibrium* in this economy is a set of decision rules $\{c_t, I_t, \{k_t^1(\theta), k_t^0(\theta), n_t(\theta), y_t(\theta)\}_{\forall\theta}\}_{t=0}^{\infty}$, stochastic aggregate allocations, $\{c_t, I_t, I_t^i, Y_t, N_t, S_t, \overline{K}_t\}_{t=0}^{\infty}$, contingent prices, $\{\omega_t, q_t^{1i}, \{q_t^1(\theta), q_t^0(\theta)\}_{\forall\theta}\}_{t=0}^{\infty}$ and threshold process $\{\overline{\theta}_t\}_{t=0}^{\infty}$ such that, given fiscal policy $\{T_t, \pi_t\}_{t=0}^{\infty}$ and technology stochastic process $\{z_t, \theta_t\}_{t=0}^{\infty}$ at each period *t*,

1) Given the initial holding of capital, the representative consumer maximizes utility subject to a budget constraint and the law of capital accumulation,

$$\textit{Maximize } E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\log(c_t)+\kappa(1-n_t)\right)\right]$$

Subject to,

$$c_t + I_t^c(q_t^{1i}-\pi_t) + \int_{-\infty}^{\infty} q_t^1(\theta_t)k_t^1(\theta_t)d\theta_t = \omega_t n_t + \int_{-\infty}^{\infty} q_t^0(\theta_t)k_t^0(\theta_t)d\theta_t + T_t$$

$$k_{t+1}^0(\theta_{t+1}) = \int_{-\infty}^{\infty}\frac{1}{\sigma_\theta}\phi\left(\frac{\theta_{t+1}-\theta_t}{\sigma_\theta}\right)k_t^1(\theta_t)d\theta_t + \phi\left(\frac{\theta_{t+1}-z_t}{\sigma_z}\right)I_t^c$$

$k_0^0(\theta_0)$>0 given

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[6] If we run the numerical simulations using a standard log utility function for leisure, the main results remain qualitatively unchanged.

2) The producer of the consumption good satisfies (firm's first order conditions),

$$n_t(\theta_t) = N_t^{\alpha} e^{\theta_t} / \overline{K}_t$$

$$\omega_t = \alpha A \left(\frac{\overline{K}_t}{N_t} \right)^{1-\alpha}$$

$$q_t^1(\overline{\theta}_t) = s$$

$$q_t^0(\theta_t) = (1-\alpha)\left(\frac{\overline{K}_t}{N_t} \right)^{-\alpha} e^{\theta_t} + (1-\delta)\left[1\{\theta_t < \overline{\theta}_t\}s + 1\{\theta_t > \overline{\theta}_t\}q_t^1(\theta_t)\right]$$

3) The intermediary satisfies,

$$I_t^i = q_t^{1i} I_t^c$$

4) The government budget constraint satisfies,

$$\pi_t I_t^c = T_t$$

5) Markets clear,

$$c_t + I_t = Y_t + S_t \qquad (14)$$

3. Numerical evaluation

We analyze steady states under alternative distortions at the entry and exit margins and, for each distortion, the transitional path following a positive leading-edge technology shock. To approximate actual experiences and to assess the robustness of the results we simulate equilibria for a wide range of policy values.

Numerical equilibria are solved using a three-step strategy. First, we compute the non-stochastic steady state equilibrium variables. Second, we log-linearize the system of equations that characterize the solution around the long-run values of the equilibrium elements. Third, we apply the method of undetermined coefficients described in Christiano (2002) in order to recover the coefficients of the individual policy functions. Because the economy exhibits unbounded growth most of the variables are not stationary. Thus, when solving the equilibrium we scale the non-stationary variables by the long-run (gross) growth rate. Then, a mapping takes the solution from the scaled objects solved for in the computations to the unscaled objects of interest.

We can separate the parameters into three types: aggregate parameters $\{\beta, \delta, \kappa, \mu_z, \alpha\}$, plant specific parameters $\{\sigma_z, \sigma_\theta\}$, and distortions $\{\pi, s\}$. The aggregate parameters are calibrated as in a representative firm economy. Since time is measured in years, we use a discount factor of $\beta = 0.96$, consistent with an annual net real interest rate of 4%. The share of labor incomes to output is set at $\alpha = 0.7$, following Gollin (2002). Long-run growth is given by $\mu_z(1-\alpha)/\alpha$, which, since population is stationary, also represents the growth rate of income per capita. Thus, to have a trend growth rate of 2% per year, we set μ_z equal to 4.5%. The marginal utility of leisure, κ, determines the fraction of available time allocated to labor. We choose κ consistently with N equal to 0.33 in the steady state.

The previous parameters have a straightforward interpretation as their mapping to the parameters in the standard macro literature is direct. The calibration of the depreciation rate δ deserves more discussion, however. In a representative firm model, without entry, exit and idiosyncratic innovation, this parameter is typically set around 6% per year. Under its usual interpretation, it represents the loss of capital goods over time. This loss occurs for two reasons: the use of the capital and technological obsolescence. In a standard growth model, with a unique good, δ is chosen as the average of these two components. In our environment, however, this approach is no longer valid. We are explicitly including a rate of technological obsolescence, which is determined by both s and the exit rate. Then, in our economy δ represents only the deterioration of the components of capital goods due to usage, not the speed at which they become technologically obsolete. Consequently, we choose δ so that, given s and the exit rate, the capital output ratio is 2.6. This value is 2% per year. Even though this is a low value when compared to the standard 6%, notice that it is similar to the depreciation rate reported for housing, where technological obsolescence is a matter of minor importance.

Since we focus on aggregate variables, plant specific parameters are chosen to mimic aggregate entry and exit rates in the U.S. There are two reasons to do so. First, we use the U.S. as our undistorted long-run developed benchmark, and economies in our model are equal in all respects but their entry and exit cost. Second, long series of plant level data are not available for a large sample of countries.

The average entry and exit rates in the U.S. are around 11% and 10% respectively (see Bartelsman, Haltiwanger and Scarpetta, 2004).[7] In our economy, the entry rate is defined as investment (new units of capital, since their unit price is one) over the total measure of units of capital. Similarly, the exit rate is defined as S_t/s (S_t is the total value of exiting firms while s is their unit price) over the total measure of units of capital in the economy. We choose $\sigma_\theta = 0.09$ and $\sigma_z = 0.25$ to match these figures. Even though we generate an 11% entry rate, our exit rate is close to 9%, below the 10% observed in the U.S. Given our parametric specification, our model cannot generate net entry rates lower than 2%. Alternatively, we could choose to match the exit rate, but then we would over estimate the entry rate, which in turn would over emphasize our main economic mechanism.

Finally, we calibrate the entry and exit distortions, π and s, to match data from the World Bank Doing Business database.[8] We use data for 2007, the most recent year of widely available information. Two specific indexes are of interest for the purpose of our paper: the cost of starting a business and the percentage of the initial investment that is preserved (or recovered) when a firm exits the market. The mapping between these indexes and the model's parameters, π and s, is not exact. We acknowledge that the indicators from *Doing Business* are neither complete nor exclusive proxies of the model parameters.[9] However, for the purpose of the application and interpretation of the model, they are the best in terms of representing distortions to the entry and exit margins of firm dynamics for a large sample of countries.

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[7] The entry rate is defined as the number of new firms divided by the total number of incumbents and entrants firms producing in a given year; the exit rate is defined as the number of firms exiting the market in a given year divided by the population of origin, *i.e.* the incumbents in the previous year.

[8] Doing Business considers government regulations that affect business activity. It does not measure all aspects important to business, however. For example, it does not study directly security, macroeconomic stability, corruption or the strength of institutions. On entry costs, this is the same source used by the Fraser Institute to construct their index of regulatory freedom. It includes time, cost, procedures and paid-in minimum capital. The exit cost is solely based on the recovery rate.

[9] There is an ongoing debate over the quality of the Doing Business database. Most critiques, however, focus on the employment indexes. See Lee, McCann, and Torm (2008).

Table 1 presents selective statistics on entry barriers and recovery rates for the 183 countries included in the *Doing Business* database. It also presents the values corresponding to the U.S. (our benchmark efficient economy), the median LDC according to income per capita, which in 2007 is Egypt, and the median Latin American and Caribbean (LAC) country, which in 2007 is Brazil. Differences across countries are large.

Table 1. Selected Statistics, *Doing Business*

	Entry		Exit
	Fees (% of GDP pc)	Time (days)	Recovery rate (cents per 1$)
Average	106.3	46.2	30.8
Median	24.3	34.6	27.3
Minimum	0.0	2	0.0
Maximum	6,375.5	694	92.7
St. deviation	491.3	59.6	24.9
P90	203.9	87.5	75.3
P10	3.21	11.7	0.0
U.S.	0.8	6	77.0*
Median LDC (Egypt)	68.8	19	16.6*
Median LAC (Brazil)	9.9	152	12.1*

Source: World Bank, *Doing Business*, 2007

*In the simulations, the recovery rates of the U.S., Egypt, and Brazil are rounded to the nearest number used in the simulation grid. As shown in Table 2, they are, respectively, 77.5, 17.5, and 12.5.

The most entry-regulated economies (90th percentile) have a direct cost to start a business of about 200% of GDP per capita. That is around 60 times larger than the cost of the least entry-regulated ones (10th percentile). Recovery rates after exiting are 0% and 75% for the worst (10th percentile) and best (90th percentile) countries, respectively.

Table 2. Parametric specification

Aggregate parameters	***Parameter***	***Value***
Discount factor	β	0.95
Fraction of steady state hours worked	N	0.33
Labor share	α	0.7
Depreciation rate	δ	0.02
Leading edge technology drift	μ_ζ	0.045
Plant level parameters		
St. deviation of shock to incumbents	σ_θ	0.09
St. deviation of shock to startups	σ_z	0.25
Simulation parameters		
Leading edge technology shock	ε_ζ	0.045
Efficient economy – US		
Recovery rate	s	0.775
Entry barrier	π	0
Developing economies		
Median LDC – Egypt		
Recovery rate	s	0.175
Entry barrier	π	0.325 (0.74 GDP pc)
Median LAC – Brazil		
Recovery rate	s	0.125
Entry barrier	π	0.225 (0.52 GDP pc)

The link between the recovery rates from *Doing Business* and the parameter *s* in the model is direct. Both represent the fraction of initial investment that is not lost when the firm closes. On the other hand, the connection between the entry barrier data from *Doing Business* and the parameter π in the model is more involved. First, we need to convert the two measures (fees and time) into the same unit. As an approximation, we do it by assuming that the fraction of days in a year that takes to open a business corresponds to the fraction of GDP per capita lost in the process. Then, we add this measure to the fees, already expressed as ratio to GDP per capita. The second step is to transform this cost from units of GDP per capita to units of capital (see equation 12). The transformation is not linear and depends, among other things, on the prevailing recovery rate s. For instance, an economy with a recovery rate of 0.175 and an entry barrier of 0.74 of GDP per capita (corresponding to the median LDC) would have a parameter π equal to 0.2. The U.S., having about 0.02 of GDP as entry barrier and 0.775 of recovery rate, would have $\pi = 0$.[10] Table 2 presents the chosen parametric specification.

4. Dynamics: A mechanism based on firm renewal

In this section, we simulate the dynamics of the model for the efficient economy (the U.S.) and for two developing countries, the median LDC (Egypt) and the median LAC (Brazil), according to income per capita. Our purpose is to clarify the mechanism through which distortions to firm dynamics affect growth and output per capita. As emphasized in the paper, this mechanism consists of technological adoption through firm renewal.

Figure 2 shows the impulse response of firm entry, firm exit, aggregate capital, aggregate labor, TFP, and output to a positive shock of 4.5% to the leading technology (a shock of a one-drift size, equivalent to a permanent increase in long-run growth rate of about 2 percentage points). The impulse responses are presented for the U.S. and the two developing economies, Egypt and Brazil. Firm entry and exit are calculated, respectively, as the ratios of entry and exit of net capital over GDP, and their impulse responses correspond to the after-shock percentage point deviations with respect to the initial ratio. For the remaining variables, the impulse response is presented as the after-shock deviation with respect to the original steady-state growth rate.

Firm entry jumps more rapidly and remains at a significantly higher level in the efficient economy than in the typical developing economies for the first 10 periods, slowly converging to the initial ratio with respect to GDP. Firm exit shows a similar pattern, but in this case the differences between the U.S. and the developing economies are much more pronounced. Firm exit in the U.S. is much larger than in the typical developing economies and for a longer period

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[10] The full mapping is not provided here to save space but is available upon request.

of time, reflecting the larger difference on recovery rates than on entry barriers between the two types of countries.

The result of the more active firm dynamics in the efficient economy can be seen in the remaining panels. Capital grows substantially more in the efficient economy than in the developing ones but only in the first few periods. Since at the end both types of economies fully adopt the new technology, more adoption through capital accumulation occurs later on in the developing economies.[11] Interestingly, labor response is more intense in the developing than the efficient economy during the first few periods. This reverses after approximately 5 periods, gradually converging towards the new steady state. The stronger labor response in developing economies is partly to compensate for their weaker capital and productivity responses.

The effect of the more active firm renewal is strikingly seen in the impulse response associated to TFP. In fact, TFP grows substantially higher in the efficient than in the developing economies for the first periods. Later on, the latter economies have somewhat higher TFP growth, as they catch up on the adoption of the new technology. The impulse response of GDP reflects the responses of the components of the production function, with some predominance of the TFP response. GDP grows much more rapidly in the efficient than developing economies during the first periods, with a reversal of smaller magnitude in the following years. The difference in GDP growth rates in favor of the efficient economy is less pronounced than the corresponding difference in TFP growth rates. This is due to the stronger initial response of labor in developing countries, as well as their stronger response of capital in subsequent periods.

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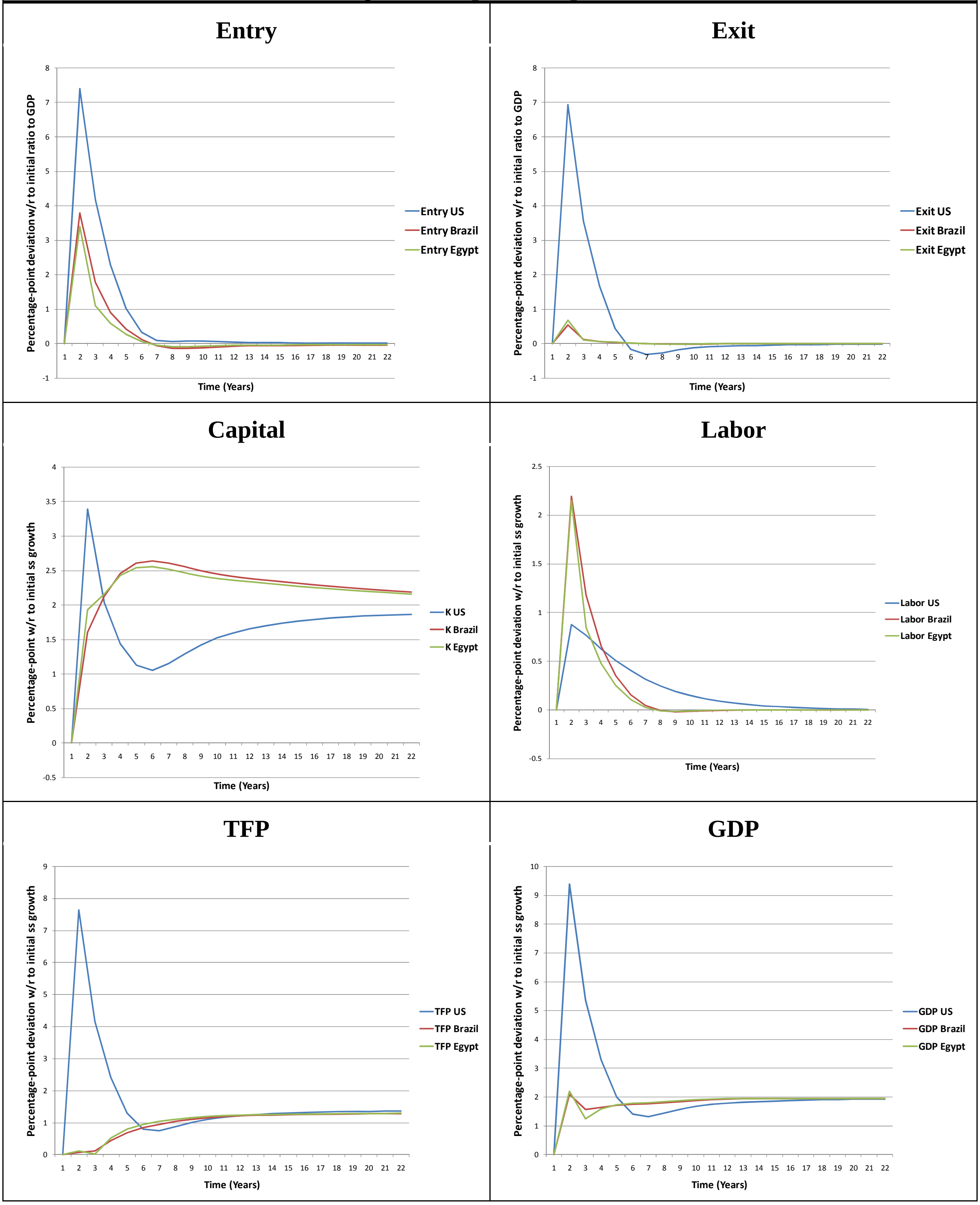
[11] The "inevitable" full adoption of new technologies is implicit in the assumption that long run growth (μ_z) is exogenous and equal in both economies. We think that this assumption reflects accurately the sources of growth, since, sooner or later, all technological innovations are worldwide adopted.

Figure 2: Impulse Responses



5. Steady-State: Explaining long-run per capita output gaps

Our model proposes a partial explanation for the observed differences in output (income) per capita across countries –some countries are poorer than others because their economies suffer from barriers to the adoption of new technologies.[12] In the theory, any microeconomic distortion that affects current and expected productivity by interfering with the natural process of birth, growth, and death of firms, will have a detrimental effect on aggregate growth. Our goal is to take this theory to the data to quantify its empirical relevance.

As the cost of entering and exiting the economy increases, the distribution of firms is altered such that too many inefficient firms remain in the market and too few potentially more efficient firms enter the market. As a result, both the reshuffling of resources from less to more efficient firms and the adoption of the leading-edge technology are impeded. The mechanism does not require new technologies to be fully blocked since slowing down this adoption process is enough to render significant income differences across countries. New technologies are eventually fully adopted by all countries, but what matters to account for income disparities at a moment in time is the difference in the speed at which they are adopted.

In order to illustrate the potential impact that the barriers to technological adoption can have on long-run output differences across countries, we simulate the steady-state output of a set of economies with given entry and exit barriers relative to the output of the U.S., our benchmark efficient economy. These economies are alike in all respects but their entry and exit costs. Thus, what we are measuring is the change in efficient output due to changes in the costs of starting and closing a firm. The results are illustrated in Figure 3, where we plot the effect of entry barriers (upper panel) and the effect of recovery rates (bottom panel) for four different values of each other parameter.

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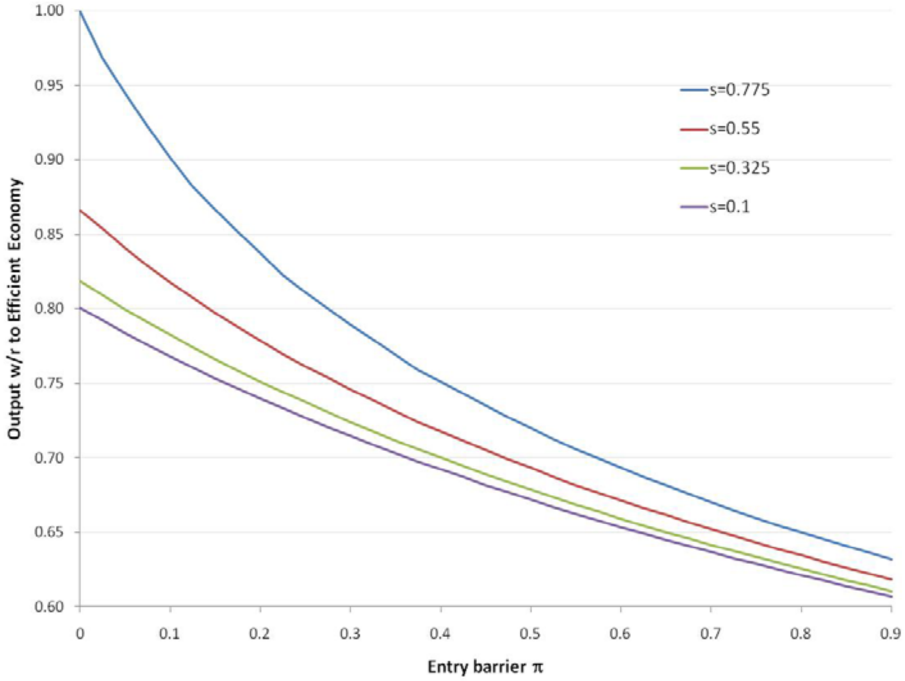
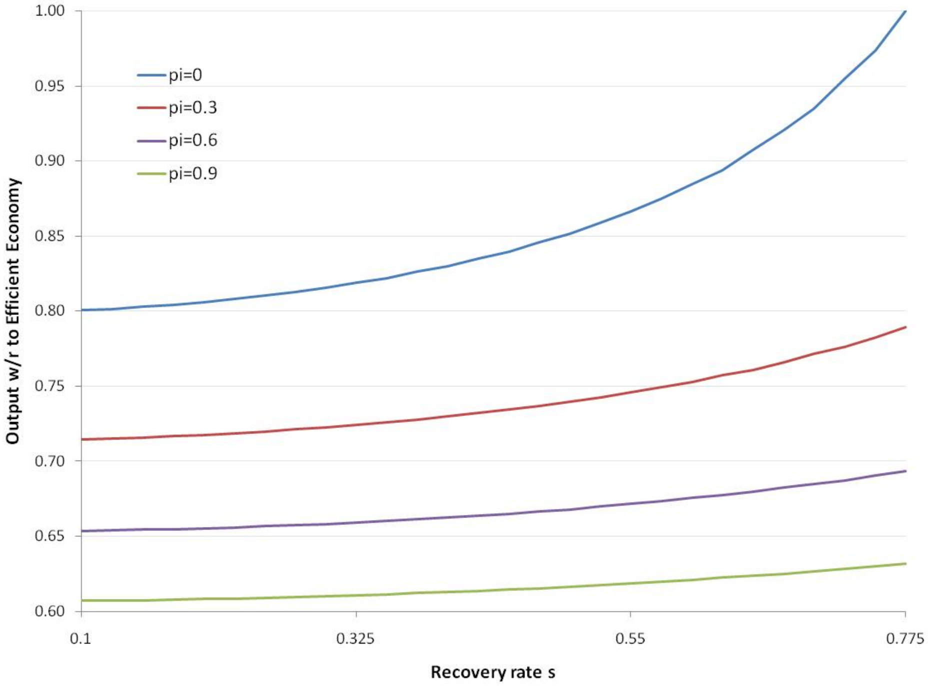
[12] We indistinctly refer to income and output as GDP. And, unless otherwise noted, GDP is presented in per capita terms. As it is evident from the feasibility condition in equation (15), the analogous to GDP per capita in our model economy is $Y+S$, not Y by itself. That is, the "transformation" of plants back into the *numeraire* is a production process itself, which entails the loss of $1-s$ parts of the original components of the plant. Thus, GDP per capita is Y+S in the model economy.

Figure 3: Output Relative to Efficient Economy (U.S.)

For given recovery rate (s)



For given entry barrier (π)

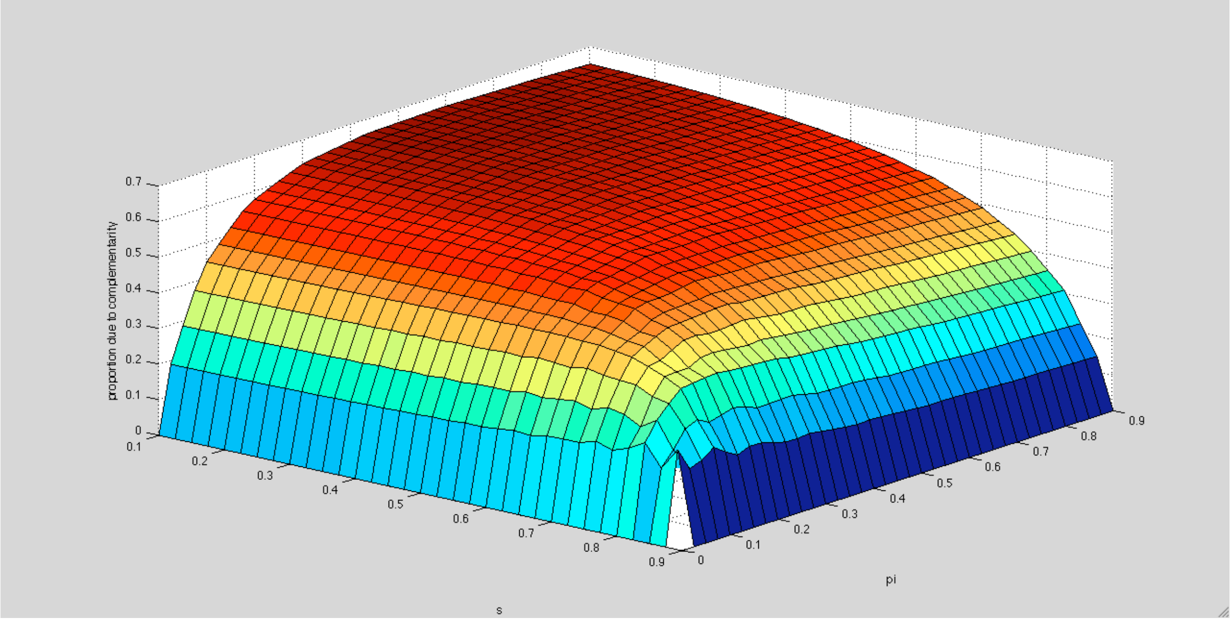


Three conclusions deserve to be highlighted. First, worsening entry barriers (higher π) or poorer recovery rates (lower s) decreases monotonically steady-state output. Overall, notice that given the direct effect of each distortion and their positive interaction, the model generates substantial income heterogeneity. With respect to the efficient economy ($\pi = 0$ and $s = 0.775$), worsening the entry barrier or the recovery rate can lead to output being as low as 60% of the benchmark, efficient economy. Second, the negative impact on output of higher barriers to entry or exit is increasing in the corresponding barrier. That is, the negative marginal effect on output of a higher π (or lower s) is larger, the larger is π (or the lower is s). Third, there is a complementarity between entry and exit distortions in their effect on firm renewal. Improving an economy's recovery rate (increasing s) when its entry barriers (π) are kept at a high level has almost no impact on GDP per capita. Likewise, reducing entry barriers when the economy exhibits high exit costs has a small impact on GDP per capita.

The output effect of the interaction between improvements in the entry and exit margins is true everywhere: the better one margin, the larger the value of the theoretical derivative of output with respect to the other margin. The positive interaction between distortions is reflected in each panel in Figure 3 by the increasing distance between the curves as the other distortion is reduced. For instance, in the upper panel of Figure 3, when s increases from 0.55 to 0.775, output as a fraction of the benchmark value jumps from 86% to 100% if $\pi = 0$, but only increases from 62% to 63% if $\pi = 0.9$. This complementarity is consistent with the empirical findings presented in Bergoeing, Loayza and Piguillem (2010). A policy implication follows: the benefits from reforms can be considerably reduced if they are not uniformly addressed. And thus, small but ubiquitous reform programs may generate much larger immediate output gains than deep, but narrow ones.

Figure 4 illustrates in more detail the features and quantitative relevance of the positive interaction between distortions in our model. The vertical axis shows the fraction of the steady state output gap –measured as the proportional difference in GDP with respect to the benchmark- accounted for by the complementarity of distortions (that is, the fraction of output loss not explained by each distortion individually). We display this measure of complementarity for a wide range of values for the entry and exit costs. If a distortion does not exist, there is no interaction; but the complementarity rapidly explains around 20% of the output gap when both distortions are present, with most combinations of positive π and s accounting for 30% to 60% of the output gap. For each combination of distortions, the fraction of the output gap explained by the complementarity is maximized when π and 1-s coincide.

Figure 4: The importance of the complementarity



Having analyzed the theoretical effect of entry and exit distortions on potential output, we can next quantify their effect on explaining the observed output gaps between the benchmark efficient economy (the U.S.) and developing countries around the world. First, using the model and each country's observed entry cost and recovery rate, we simulate the predicted output gap with respect to the U.S. of an economy similar to the U.S., except for π and s. That is, we measure the output the U.S. would lose if it had the higher entry and exit costs of developing countries in our sample. Second, we compare the simulated and actual output gaps per country - that is, per duple (π, s) - in order to assess the model's ability to account for observed income differences. Finally, we analyze the contribution of entry and exit distortions and their complementarity in explaining the simulated output gap between each developing country and the benchmark economy.

For the interested reader, Appendix I presents the country-specific results on long-run output gaps corresponding to 107 developing countries. Here, for brevity, we discuss only the results related to the median LDC (Egypt) and median LAC (Brazil). They are summarized in Table 3.

Table 3. Explaining Long-Run Output Gaps

	Median LDC (Egypt)	Median LAC (Brazil)
Simulated GDP gap with respect to U.S.*	0.29	0.27
Simulated / Actual GDP gap with respect to U.S.	33%	34%
Contribution to simulated output gap:		
Individual effects		
Recovery rate	24%	34%
Entry barrier	32%	25%
Complementarity	44%	41%

* Proportional output gap with respect to the U.S. $\left(\frac{Output_{US} - Output_{i}}{Output_{US}}\right)$ obtained from the model.

Two results deserve special attention. First, despite the model's narrow emphasis on growth through technological adoption and firm renewal, its mechanism can generate a substantial fraction of the GDP gap of developing countries with respect to the U.S. In fact for the typical less-developed country, the model explains around one-third of the actual GDP gap with respect to the leading developed economy. Considering the full sample of developing countries, the median explanation performance of the model is nearly 31%.

A second finding is no less interesting. About 40% of the simulated gap is accounted for by the complementarity of entry and exit distortions. This is the case for the typical LDC and typical LAC. It is also very similar to the median contribution from the interaction of both distortions obtained from the full sample of developing countries, as shown in Figure 4. The remaining 60% is, of course, explained by each distortion separately. [13] Their proportional

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[13] Our findings are robust to the parametric specification chosen. For instance, if we use a much smaller standard deviation for the shock to incumbents, say $\sigma_{\theta} = 0.03$, as in Campbel (1998), the model accounts for a third of the income gap, with the complementarity explaining close to 35% of it. In this case, to

contribution varies from country to country, depending on the relative importance of entry barriers and recovery rates. For the median LDC, entry barriers are somewhat more important than recovery rates, accounting for 32% and 24%, respectively. This is approximately the same as the median values obtained from the full sample of developing countries.

Our results suggest that distortions to the extensive margin of firm dynamics are quantitatively relevant for development. These findings may be magnified by our economic mechanism, which restricts innovation to new plants. Acemoglu and Cao (2010) have recently extended the Schumpeterian growth model by allowing incumbents to improve their production processes. However, as these authors acknowledge, their model cannot be carefully calibrated given available data and the current knowledge of the technology of innovation. Our broad interpretation of entry and exit as associated with economic projects, rather than firms, provides a sensible representation of the Schumpeterian mechanism of creative destruction.

6. Concluding comments

This paper links microeconomic rigidities and technological innovation in order to provide a theory, albeit partial, of aggregate economic development. Since world knowledge expands continuously, economies that keep obstacles to innovation permanently lag the leading-edge technology, and thus, the leaders' income per capita. In particular, when distortions deter the ongoing process of resource reallocation, through limiting firm creation and destruction, technological adoption becomes sluggish and the economy fails to generate enough growth to close the developed-developing gap. Even though all economies end up fully adopting the new technologies, poor economies are always behind. These distortions not only exert an independent effect on firm dynamics but also interact with each other, compounding their negative effect on firm renewal and, therefore, technological adoption.

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approximate the distribution of firms for the U.S. economy we must use $\sigma_z = 0.05$, instead of Campbell's $\sigma_z = 0.25$.

In spite of its single focus on technological adoption and firm renewal, our model explains a substantial fraction of the per capita GDP gap between leading and less developed countries. For instance, it explains over one-third of the income per capita gap between the U.S. and the typical LDC, with 60% of this simulated gap being explained by entry and exit distortions individually and 40% by their complementarity.

These results suggest further research on other policy issues, such as the timing of the reforms. Economic reforms have been extensively undertaken by developing economies during the last two decades. However, most reforms are implemented sequentially, so when one reform is in place other obstacles to reallocation remain. Our theory suggests that the benefits from these market reforms have been substantially reduced when distortions have not been uniformly eliminated. A corollary follows –since resource reallocation implies costly adjustment, sequentially implemented reforms may end up being reverted in developing economies.

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Appendix I: Explaining Output Differences between the U.S. and Developing Countries

Country	Recovery Rate (s)	Entry Barrier (π)	Simulated Output Gap*	Percentage Simulated Over Actual Output Gap	Percentage Contribution To Simulated Output Gap		
					s	π	complementarity
Algeria	0.425	0.100	0.21	25%	52%	20%	28%
Angola	0.100	0.900	0.39	44%	6%	49%	44%
Argentina	0.350	0.100	0.21	30%	54%	17%	29%
Armenia	0.425	0.050	0.19	21%	70%	11%	18%
Azerbaijan	0.325	0.100	0.22	26%	55%	17%	29%
Bangladesh	0.250	0.300	0.28	29%	25%	32%	43%
Belarus	0.325	0.200	0.25	33%	35%	27%	38%
Belize	0.625	0.325	0.25	29%	12%	58%	30%
Benin	0.225	0.825	0.38	39%	7%	50%	44%
Bolivia	0.375	0.650	0.35	38%	8%	50%	42%
Bosnia and Herzegovina	0.350	0.225	0.25	30%	30%	30%	40%
Botswana	0.600	0.200	0.21	30%	23%	46%	31%
Brazil	0.125	0.225	0.27	34%	33%	25%	41%
Bulgaria	0.350	0.075	0.21	27%	63%	14%	24%
Burkina Faso	0.275	0.525	0.33	34%	12%	43%	45%
Cameroon	0.250	0.600	0.34	36%	11%	45%	45%
Chile	0.225	0.075	0.22	31%	65%	12%	24%
China	0.325	0.100	0.22	25%	55%	17%	29%
Colombia	0.575	0.150	0.20	24%	33%	37%	31%
Congo, Dem. Rep.	0.100	0.900	0.39	40%	6%	49%	44%
Congo, Rep.	0.200	0.600	0.34	38%	11%	44%	45%
Costa Rica	0.175	0.200	0.26	34%	37%	24%	39%
Cote d'Ivoire	0.350	0.600	0.34	35%	10%	48%	43%
Djibouti	0.150	0.850	0.39	40%	7%	49%	44%
Dominican Republic	0.100	0.225	0.27	32%	34%	25%	41%
Ecuador	0.175	0.225	0.26	32%	33%	26%	41%
Egypt, Arab Rep.	0.175	0.325	0.29	33%	24%	32%	44%
El Salvador	0.300	0.350	0.29	34%	20%	36%	43%
Ethiopia	0.325	0.225	0.26	26%	31%	29%	40%
Fiji	0.200	0.175	0.25	28%	41%	22%	37%
Gabon	0.150	0.175	0.25	37%	41%	22%	37%
Gambia, The	0.175	0.900	0.39	40%	6%	50%	44%
Georgia	0.275	0.075	0.21	24%	64%	12%	24%
Ghana	0.250	0.300	0.28	29%	25%	32%	43%
Guatemala	0.275	0.275	0.27	30%	27%	31%	42%
Guinea	0.175	0.750	0.37	38%	8%	47%	45%
Guyana	0.175	0.475	0.32	34%	15%	39%	46%
Haiti	0.100	0.900	0.39	40%	6%	49%	44%
Honduras	0.200	0.325	0.29	31%	23%	33%	44%
India	0.125	0.375	0.30	32%	20%	34%	46%
Indonesia	0.125	0.475	0.32	35%	16%	39%	46%

Country	Recovery Rate (s)	Entry Barrier (π)	Simulated Output Gap*	Percentage Simulated Over Actual Output Gap	Percentage Contribution To Simulated Output Gap		
					s	π	complementarity
Iran, Islamic Rep.	0.200	0.050	0.211	28%	74%	8%	18%
Jamaica	0.650	0.050	0.127	15%	57%	27%	16%
Jordan	0.275	0.325	0.285	32%	22%	34%	43%
Kazakhstan	0.400	0.050	0.190	25%	71%	10%	19%
Kenya	0.325	0.275	0.269	28%	26%	33%	42%
Kyrgyz Republic	0.150	0.075	0.222	23%	65%	11%	23%
Latvia	0.350	0.050	0.197	30%	72%	10%	18%
Lebanon	0.200	0.425	0.311	41%	17%	38%	45%
Lesotho	0.375	0.275	0.266	27%	25%	35%	41%
Liberia	0.100	0.900	0.393	40%	6%	49%	44%
Lithuania	0.500	0.050	0.171	27%	68%	13%	19%
Macedonia, FYR	0.150	0.050	0.214	26%	74%	8%	18%
Malawi	0.125	0.850	0.386	39%	7%	49%	45%
Malaysia	0.375	0.125	0.220	31%	46%	21%	33%
Maldives	0.175	0.075	0.221	25%	65%	11%	23%
Mali	0.225	0.800	0.377	39%	7%	49%	44%
Mauritania	0.100	0.575	0.342	36%	12%	42%	46%
Mauritius	0.350	0.100	0.215	29%	54%	17%	29%
Mexico	0.650	0.100	0.154	22%	36%	40%	24%
Micronesia, Fed. Sts.	0.100	0.550	0.337	36%	13%	41%	46%
Moldova	0.300	0.100	0.220	23%	55%	16%	29%
Mongolia	0.175	0.050	0.213	23%	74%	8%	18%
Montenegro	0.425	0.075	0.196	26%	61%	16%	23%
Morocco	0.350	0.075	0.206	23%	63%	14%	24%
Mozambique	0.150	0.475	0.322	33%	15%	39%	46%
Namibia	0.425	0.200	0.239	28%	32%	31%	37%
Nepal	0.250	0.375	0.298	30%	19%	36%	45%
Nicaragua	0.350	0.575	0.335	36%	10%	47%	43%
Niger	0.150	0.900	0.393	40%	6%	50%	44%
Nigeria	0.275	0.300	0.279	29%	24%	33%	43%
Pakistan	0.400	0.125	0.218	23%	46%	22%	32%
Panama	0.325	0.125	0.226	30%	48%	20%	33%
Papua New Guinea	0.225	0.200	0.255	27%	36%	25%	39%
Paraguay	0.150	0.625	0.350	39%	11%	44%	46%
Peru	0.250	0.225	0.261	31%	32%	27%	41%
Philippines	0.100	0.175	0.253	27%	41%	21%	37%
Poland	0.275	0.150	0.238	37%	44%	21%	35%
Romania	0.200	0.025	0.203	27%	84%	4%	12%
Russian Federation	0.275	0.075	0.214	32%	64%	12%	24%
Samoa	0.150	0.250	0.272	30%	30%	27%	42%
Senegal	0.325	0.525	0.326	34%	12%	45%	44%
Serbia	0.225	0.075	0.218	27%	65%	12%	24%
Sierra Leone	0.100	0.900	0.393	40%	6%	49%	44%

Country	Recovery Rate (s)	Entry Barrier (π)	Simulated Output Gap*	Percentage Simulated Over Actual Output Gap	Percentage Contribution To Simulated Output Gap		
					s	π	complementarity
Solomon Islands	0.225	0.400	0.304	32%	18%	37%	45%
South Africa	0.350	0.075	0.206	26%	63%	14%	24%
Sri Lanka	0.500	0.100	0.193	21%	49%	23%	28%
St. Lucia	0.425	0.150	0.223	28%	40%	26%	34%
Suriname	0.100	0.900	0.393	46%	6%	49%	44%
Swaziland	0.375	0.250	0.259	29%	27%	33%	40%
Syrian Arab Republic	0.300	0.150	0.236	26%	43%	22%	35%
Tajikistan	0.225	0.400	0.304	32%	18%	37%	45%
Tanzania	0.225	0.425	0.310	32%	17%	38%	45%
Thailand	0.425	0.075	0.196	24%	61%	16%	23%
Togo	0.275	0.900	0.390	40%	6%	52%	42%
Tonga	0.250	0.100	0.224	24%	56%	15%	29%
Tunisia	0.500	0.050	0.171	21%	68%	13%	19%
Turkey	0.175	0.125	0.236	33%	50%	17%	33%
Uganda	0.400	0.425	0.301	31%	15%	44%	42%
Ukraine	0.100	0.075	0.224	26%	66%	11%	23%
Uruguay	0.425	0.250	0.254	34%	25%	35%	39%
Uzbekistan	0.175	0.100	0.229	24%	57%	14%	29%
Vanuatu	0.400	0.325	0.277	30%	20%	39%	41%
Venezuela, RB	0.100	0.275	0.279	38%	28%	29%	43%
Vietnam	0.175	0.175	0.251	27%	41%	22%	37%
Yemen, Rep.	0.275	0.900	0.390	41%	6%	52%	42%
Zambia	0.250	0.175	0.247	25%	40%	23%	37%
Sample Median	0.250	0.225	0.258	30%	31%	30%	40%
Typical LDC (Egypt)	0.175	0.325	0.289	33%	24%	32%	44%
Typical LAC (Brazil)	0.125	0.225	0.266	34%	33%	25%	41%

* Proportional output gap with respect to the U.S. $\left(\frac{Output_{US} - Output_i}{Output_{US}}\right)$ obtained from the model.