

Penn Institute for Economic Research
Department of Economics
University of Pennsylvania
3718 Locust Walk
Philadelphia, PA 19104-6297
pier@econ.upenn.edu
<http://economics.sas.upenn.edu/pier>

PIER Working Paper 13-011

“Project Heterogeneity and Growth
The Impact of Selection”

by

Sînâ T. Ateş and Felipe E. Saffie

<http://ssrn.com/abstract=2215027>

Project Heterogeneity and Growth:

The Impact of Selection *

Sinâ T. Ateş[†] and Felipe E. Saffie[†]

February 5, 2013

[PRELIMINARY]

Abstract

In the classical literature of innovation-based endogenous growth, the main engine of long run economic growth is firm entry. Nevertheless, when projects are heterogeneous, and good ideas are scarce, a *mass-composition* trade off is introduced into this link: larger cohorts are characterized by a lower average quality. As one of the roles of the financial system is to screen the quality of projects, the ability of financial intermediaries to detect promising projects shapes the strength of this trade-off. In order to study this relationship, we build a general equilibrium endogenous growth model with project heterogeneity and financial screening. To illustrate the relevance of the mass and composition margins we apply this framework to two important debates in the growth literature. First, we show that corporate taxation has only a weak effect on growth, but a strong effect on firm entry, both well known empirical regularities. A second illustration studies the effects of financial development in growth. A word of caution arises: for economies that are characterized by high rates of firm creation, domestic credit should not be used as a proxy of financial development, in contrast to most of the empirical literature.

Keywords: Growth, Firm Entry, Project Heterogeneity, Financial Selection, Entrepreneurship, Financial Development

*The authors wish to thank Ufuk Akcigit, Harold Cole, Dirk Krueger, Jeremy Greenwood, and seminar participants at the Macro Club at Upenn, Pontificia Universidad Catolica de Chile, and Banco Central de Chile for useful comments and suggestions. The authors are responsible for all the remaining imperfections.

[†]University of Pennsylvania, Department of Economics, 3718 Locust Walk, Philadelphia, PA 19104. Ateş: sinaates@sas.upenn.edu. Saffie: fesaffie@sas.upenn.edu.

1 Introduction

There is a growing empirical and theoretical literature that examines the relationship between financial development and long-run growth.¹ The macroeconomic workhorse, the Ramsey-Cass-Koopmans model, shows that the only reliable source of long-run growth is increases in productivity; hence, a study of the impact of financial development on growth needs to focus on the mechanisms that link the financial system with the productivity process of the economy. Thus, any model with an exogenous productivity process is not well suited for this task.

Early models of innovation such as Grossman and Helpman (1991) and Aghion and Howitt (1992) provide a framework to find tractable micro-foundations for the productivity process at the core of macroeconomic models. The main mechanism that creates productivity growth is Schumpeterian creative destruction: entrepreneurs with a new invention (creative) have lower production costs; when they enter the market, they replace the former leader (destruction) of a product line. Hence, entry plays a central role in the determination of long run growth. In fact, Bartelsman et al. (2009) use firm level data for 24 countries to study firm dynamics and the sources of productivity growth. They document that between 20% and 50% of the overall productivity growth is explained by net entry. Moreover, a sizeable fraction of new entrants use external finance in order to access the market. For instance, Nofsinger and Wang (2011) document that 45% of the start up in their 27 country panel was using external funding. In combination, a first link between finance and growth can be seen: more developed financial systems are able to pool more funds to finance more start-ups, and the higher entry rate materializes into more creative destruction and hence more growth. This is the underlying assumption in most of the empirical literature that uses size measures, such as the fraction of domestic credit over GDP, as proxies for financial development.

Nevertheless, not all ideas are good, and good ideas are scarce. In fact, Silverberg and Verspagen (2007) document that both patent citation and returns to patenting are highly skewed toward relatively few patents. Hence, selecting the most promising projects is not a trivial task. If the financial system has access to a screening device then it creates value not only by pooling funds, but also by using them more efficiently. Benfratello et al. (2008) use Italian firm level data to show that the development of banking affected the probability of firm innovation. Another recent study by Fracassi et al. (2012), using start up application data for a major venture capital in United States, documents a loan approval rate of only 18.2%. Moreover, credit allocation is far from being random; in fact, funded start-ups in their sample survive longer and are more profitable than rejected ones. This implies that financial intermediation is not only about the *mass* of the entrant cohort, but also about its *composition*. Thus, a model that studies the link between the financial system and long run economic growth needs to include not only the mass but also the composition dimension.

In order to understand how mass and composition effects shape long run productivity growth, we modify the quality-ladder framework of Grossman and Helpman (1991) along two dimensions. First, we introduce *ex ante* project heterogeneity that is translated into *ex post* firm heterogeneity in the intermediate good sector. Second, we introduce a non trivial

¹The seminal contribution by Levine (2005) provides a thorough review.

financial system, with access to a screening technology, which accurately represents the level of financial development. The analytical characterization of the unique interior balanced growth path shows how the creative destruction in this economy is shaped by the interaction between mass and composition of the entrant cohorts. Then, two quantitative experiments illustrate both the strength and the relevance of the composition effect introduced in this article.

The first experiment relates the model to the empirical literature on corporate taxation, firm entry, and growth. The model is able to generate mild responses in growth for a wide range of corporate taxes, and at the same time match the much stronger effect on entry rates. The main underlying intuition comes from the strength of financial selection. When taxes increase, a large set of projects are not enacted. Nevertheless, when the screening technology is accurate enough, the marginal contribution of those entrants to economic growth is almost negligible. Moreover, since the composition of an entrant cohort is decreasing in its size, the tradeoff between mass and composition is highly non linear, being dominated by mass for low entry rates and by composition for high ones.

The second quantitative illustration revisits the classical link between financial development and growth. In line with the empirical literature, the model suggests that improvements in the accuracy of the screening technology generate higher marginal gains in terms of economic growth per entrant for financially more developed economies. This experiment also shows that for countries characterized by high entry rates, mass related measures are extremely misleading when proxying for financial development.

This paper is structured as follows. Section 2 reviews some of the related contributions in the endogenous growth literature, then Section 3 presents the model and the analytical results, which are illustrated by two quantitative experiments in section 4, and section 5 concludes.

2 Related Literature

The existence of a financial structure that evaluates investment projects has been in the growth literature for a long time.² Greenwood and Jovanovic (1990) introduced this idea into an externality driven endogenous growth model inspired by Romer (1986) to study the interdependence between financial development and economic growth. One study in that strand to which the current work particularly relates is Bose and Cothren (1996). They study how improvements in the screening technology of the financial system affect the economic growth rate of the economy. In a nutshell, they build a two type (borrowers and lenders) overlapping generation model where young borrowers seek resources to start heterogeneous projects. Financial intermediation uses screening and rationing to allocate the resources of the lenders. Projects differ only in their success probability (low or high), and the economy growth rate is driven by the externality generated by the average capital stock in the economy. They show that cost reducing improvements in the screening technology can decrease economic growth. Notice that heterogeneity and financial selection influence growth

²We can trace this idea back to Bagehot (1878) and Schumpeter (1934), but a more formal exposition can be found on Boyd and Prescott (1986).

only through the mass of successfully enacted projects. Moreover, one of the main limitations of this class of endogenous growth models is their inability to provide micro-foundations for output growth which emerges only through the accumulation of physical capital.

An early innovation based endogenous growth model with heterogeneity and financial selection is proposed by King and Levine (1993a). They introduce heterogeneity to the original Aghion and Howitt (1992) model dividing the population between agents that are capable to manage an innovative project and individuals that are not. The role of the financial system is to pool resources and try to identify capable individuals in order to put them in charge of project enactment. Hence, the better the screening device the larger the mass of innovation generated in the economy. A recent contribution by Jaimovich and Rebelo (2012) builds on the non-Schumpeterian innovation tradition of Romer (1990), including heterogeneous agents as in Lucas (1978) to study the non linear relationship between taxation and long run growth. In their model every successfully enacted project enlarges the measure of intermediate good varieties by the same amount. Nevertheless, entrepreneurs are heterogeneous in their ability to enact projects. As the ability distribution is skewed, only few of them account for most of the generation of new varieties and, thus, output growth. Hence, as taxation discourages relatively unproductive entrepreneurs, both the mass of firms created and the growth rate of the economy decrease very mildly for a wide range of tax rates.

None of the endogenous growth models discussed above attempt to link the *ex-ante* heterogeneity with *ex-post* differences on the production side. Hence, the impact of financial selection is only driven by the mass effect.³ In particular, these models imply a monotonic relationship between firm entry and growth: the larger the mass of an entrant cohort, the higher the growth rate of the economy. In contrast, instead of using heterogeneity on the success rate, our model includes *ex ante* project heterogeneity that is also translated into *ex post* firm heterogeneity, generating a non monotonic and non linear relationship between entry and growth rates.

3 Model

This model builds on the classical endogenous growth literature of quality-ladder models. In line with the seminal contributions of Grossman and Helpman (1991) and Aghion and Howitt (1992), a continuum of intermediate good varieties, indexed by $j \in [0, 1]$, are used for final good production and the producer with the lower marginal cost monopolizes the production of its variety.⁴ The engine of economic growth is the creative destruction generated by successfully enacted projects where the former leader is surpassed by a newcomer with a lower marginal cost. In order to disentangle the mass and composition effect of financial intermediation, we modify this framework to allow for project heterogeneity and financial selection. A representative financial intermediary owns a unit mass of projects, indexed by $e \in [0, 1]$, and borrows resources from the representative household to enact a portion of them. First, we introduce heterogeneity in both projects and cost advantages. In particular, after enactment,

³We can say that projects are heterogeneous only in their success rate, just as in the non innovation based tradition.

⁴For a recent review of the relevance and scope of this framework see Aghion et al. (2013).

a successful project can generate either a drastic or an incremental cost reduction innovation in a product line. This implies that leaders have heterogeneous cost advantages over their followers. Moreover, since projects are characterized by their idiosyncratic probability of generating a drastic innovation, there is also heterogeneity before enactment. Second, we introduce financial selection by allowing the financial intermediary to access a costless yet imperfect screening device. In this section, we introduce the components of the model, define a competitive equilibrium and a balanced growth, and derive the analytical characterization of the model.

3.1 The Representative Household

The representative household lends assets (a_{t+1}) to the financial intermediary at the interest rate r_{t+1} and receives the profits of the financial intermediary (π_t) as well as the revenue generated by corporate taxation (T_t), which the government levies on intermediate firms. The household supplies L units of labor inelastically, and future utility is discounted at rate β . We assume constant relative risk aversion utility to allow for a balanced growth path equilibrium, and intertemporal elasticity of substitution of $\frac{1}{\gamma} \leq 1$. In particular, given the sequences of wages, interest rates, profits, lump sum transfers of tax revenue $\{w_t, r_{t+1}, \Pi_t, T_t\}_{t=0}^{\infty}$, and initial asset a_0 , the representative household chooses consumption, assets $\{c_t, a_{t+1}\}_{t=0}^{\infty}$ to solve: ⁵

$$\max_{\{c_t, a_{t+1}\}_{t=0}^{\infty}} \left\{ \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\gamma}}{1-\gamma} \right\} \quad (1)$$

sbj. to

$$c_t + a_{t+1} \leq w_t L + a_t(1 + r_t) + \Pi_t + T_t \quad (2)$$

$$a_{t+1} \geq 0 \quad (3)$$

As shown in equation (2), the price of consumption is set to unity since we use final good as the numeraire. The interior first order condition that characterizes this program is

$$\left(\frac{c_{t+1}}{c_t} \right)^{\gamma} = \beta (1 + r_{t+1}). \quad (4)$$

3.2 Final Good Sector

Using a constant returns to scale technology, the representative final good producer combines intermediate inputs to produce the final good

$$\ln Y_t = \int_0^1 \ln x_{j,t}^D dj,$$

which in turn provides resources for consumption.⁶ In particular, given input prices and wages $\{w_t, p_{j,t}\}$, the final good producer demands intermediate varieties $\left\{ \{x_{j,t}^D\}_{j \in [0,1]} \right\}$ every

⁵Subject to the standard transversality condition.

⁶Since this is a long run model, adding capital to the final good production does not affect the main features of the model. For a stochastic quantitative version of this model that includes capital accumulation see Ates and Saffie (2013)

period in order to solve

$$\max_{\left\{ \{x_{j,t}^D\}_{j \in [0,1]} \right\}_{\geq 0}} \left\{ \exp \left(\int_0^1 \ln x_{j,t}^D dj \right) - \int_0^1 x_{j,t}^D p_{j,t} dj \right\}, \quad (5)$$

This problem is fully characterized by the following interior set of first order conditions:

$$x_{j,t}^D = \frac{Y_t}{p_{j,t}}. \quad (6)$$

3.3 Intermediate Good Sector

In line with the endogenous growth literature, we assume that the amount of the intermediate good j produced, $x_{j,t}$, is linear in labor $l_{j,t}$, with constant marginal productivity $q_{j,t}$.⁷ Thus,

$$x_{j,t} = l_{j,t} q_{j,t}. \quad (7)$$

The efficiency of labor in the intermediate good production evolves with each technological improvement generated by successful innovation. Innovations are heterogeneous in their capacity to improve the existing technology. In particular, the evolution of technology follows

$$q_{j,t} = I_{j,t} q_{j,t-1} (1 + \sigma^d) + (1 - I_{j,t}) q_{j,t-1}; \quad d \in \{L, H\} \quad (8)$$

where $I_{j,t}$ is an indicator function that equals to 1 if the product line j receives an innovation in period t , and 0 otherwise, implying that this period, the level of productivity is the same as in the last period. Moreover, σ^d is the heterogeneous step size of the innovation, with $\sigma^H > \sigma^L > 0$.⁸ This implies that *high* type projects (H) improve the productivity of labor more drastically than *low* type projects (L). Therefore, the leaders are heterogeneous in their absolute distance to the closest follower.⁹

In line with the literature, we assume Bertrand monopolistic competition. This set-up implies that the competitor with the lower marginal cost dominates the market by following a limit pricing rule, i.e. she sets her price, $p_{j,t}$ equal to the marginal cost of the closest follower. Denote the efficiency of the closest follower, by $\tilde{q}_{j,t}$, then:¹⁰

$$p_{j,t} = \frac{w_t}{\tilde{q}_{j,t}}. \quad (9)$$

⁷The constant elasticity aggregation on the final good production and this linear production function for intermediate varieties is the standard procedure in the literature to generate constant markups and hence avoid history dependence in each product line.

⁸Incumbent heterogeneity has been introduced in step by step models even with rich incumbent dynamics, for example in Akcigit and Kerr (2010). That literature usually follows a quantitative approach and do not include financial selection.

⁹We allow only two types in order to summarize the composition of the product line with only one variable, the fraction of leaders with σ^H advantage.

¹⁰Note that, as there is no efficiency improvement by incumbents, hence $q_{j,t} = (1 + \sigma^d) \tilde{q}_{j,t}$. This framework can be easily extended to allow for undirected incumbent innovations.

In any product line j , the owner of the latest successful project of type d reaps profits $\pi_{j,t}^d$ at time t . Profits are subject to tax rate τ . A firm owner collects after-tax profits in the current period. In the next period, this firm will continue to produce if it is not replaced by a new leader. If a mass M_{t+1} of projects is enacted at time $t+1$, and each of them is successful with fixed probability λ , the existing firm will continue to produce with probability $1 - \lambda M_{t+1}$. Then, given interest rate r_{t+1} , the value $V_{j,t}^d$ of owning the product line j at time t for a type d leader is given by

$$V_{j,t}^d = (1 - \tau)\pi_{j,t}^d + \frac{1 - \lambda M_{t+1}}{1 + r_{t+1}} V_{j,t+1}^d. \quad (10)$$

In this framework, incumbents are randomly replaced by more efficient entrants. This is the engine of economic growth in the model, the Schumpeterian creative destruction. Bartelsman et al. (2009) use firm level data for 24 countries to study firm dynamics and the sources of productivity growth. They document that between 20% and 50% of the overall productivity growth is explained by net entry. Then, focusing this model on firm entry allow us to disentangle one of the main sources of productivity growth.

3.4 Projects

Projects are indexed by $e \in [0, 1]$. The fixed cost of enacting a project is κ units of labor. An enacted project is successful with probability λ and it generates an undirected cost reduction. In Aghion and Howitt (1992) potential entrants are homogeneous, and of infinite mass. One of the key novelties this model presents is the way heterogeneity and scarcity are introduced into this framework, and how this *ex ante* heterogeneity is related to the *ex post* heterogeneity of incumbents. In this economy, projects are heterogeneous in their expected cost reduction, and promising ones are scarce.¹¹ In particular, every project has an unobservable idiosyncratic probability $\theta(e) = e^\nu$ of generating a drastic improvement on productivity characterized by σ^H . As shown in Figure 1, the higher the index e is, the more likely it is for project e to generate a drastic (type- H) innovation, and hence, the higher the expected cost reduction. In this sense, e is more than an index, it is a ranking among projects based on their idiosyncratic $\theta(e)$, which is unobservable ex-ante.

In this setting, ν governs the underlying scarcity of good projects in the economy. Figure 1 shows that for any $\bar{\theta} \in [0, 1]$, the higher the value of ν the less projects with a probability $\theta(e) > \bar{\theta}$ of generating a type H innovation. For example, when $\bar{\theta} = 0.6$, if $\nu = 0.2$ there is a mass 0.9 of projects that deliver a drastic innovation with probability higher than 0.6, whereas when $\nu = 5$ only a mass 0.1 is above that level. Hence, the parameter ν governs the scarcity of projects that are likely to generate drastic innovations. Proposition 1 translates the ranking of projects into a probability distribution for θ , the proof is provided in Appendix A.

¹¹A similar strategy in a different framework is followed by Palazzo and Clementi (2010). They introduce *ex ante* heterogeneity linked with *ex post* firm productivity in the framework of Hopenhayn (1992) to study firm dynamics over the business cycle in a quantitative partial equilibrium model.

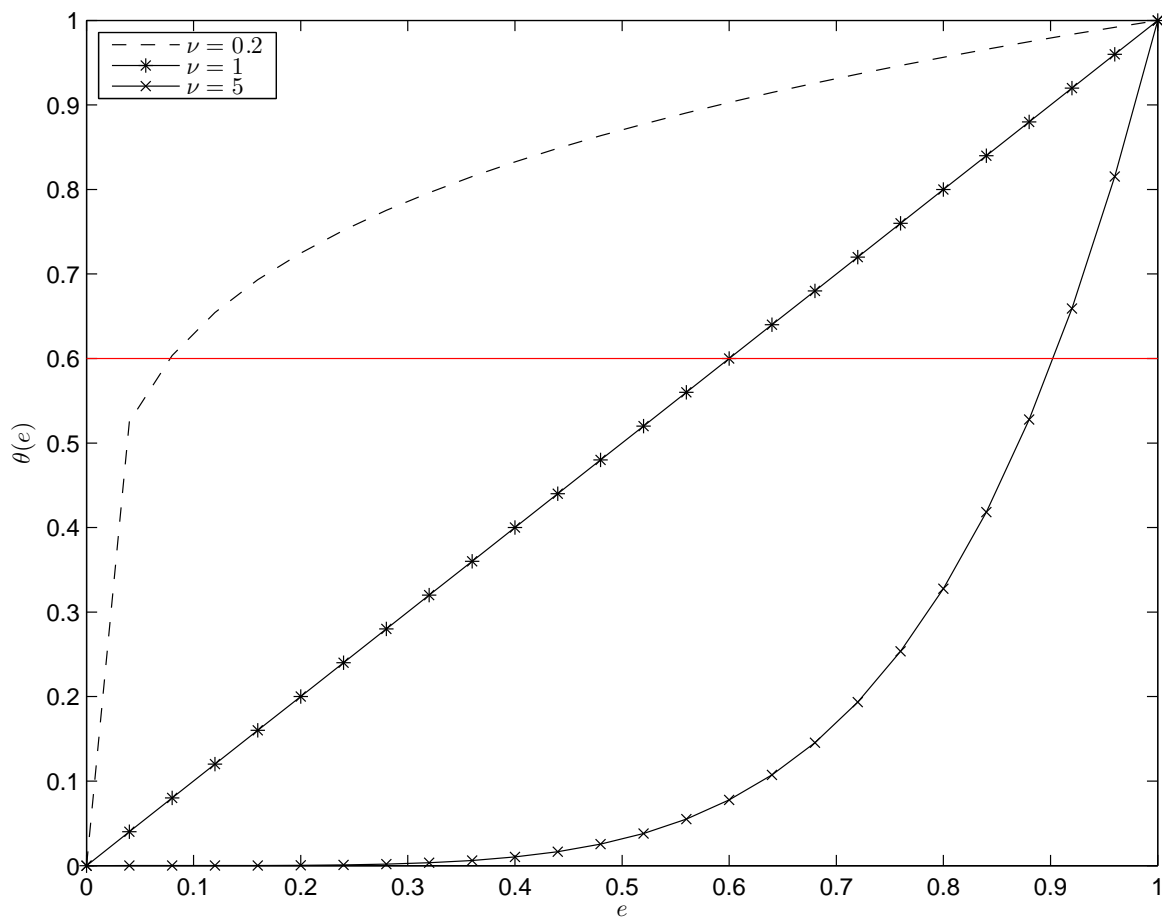


Figure 1: Project Heterogeneity

Proposition 1 We can characterize the probability distribution $f(\theta)$ by

$$f(\theta) = \frac{1}{\nu} \left(\frac{1}{\theta} \right)^{1-\frac{1}{\nu}}$$

the mean of this distribution is given by $E[\theta] = \frac{1}{\nu+1}$. Moreover, the skewness $S(\nu)$ of $f(\theta)$ is given by

$$S(\nu) = \frac{2(\nu-1)\sqrt{1+2\nu}}{1+3\nu}$$

and it is positive and increasing for $\nu \geq 1$.

We assume that good projects are scarce, this means $\nu > 1$. This right-skewness of the probability distribution of generating drastic innovations implies that relatively few projects are likely to result in a high type innovation, as suggested by the empirical research in this area. For instance, Silverberg and Verspagen (2007) use patent data to study the

skewness of the patent quality distribution proxied by citations. They find that both the distribution of citations and the return to patent are highly skewed, and that the tail index is roughly constant over time.¹² The fraction of high-type improvements when enacting a mass $M \in (0, 1]$ of projects is given by

$$\tilde{\mu}^H = \frac{1}{M} \int_0^1 \text{prob}(e \in M) \times \theta(e) de$$

Random selection implies that for all e , $\text{prob}(e \in M) = M$. We denote by $\underline{\tilde{\mu}}^H$ the proportion of high type project on the entering cohort under random selection. Then $\underline{\tilde{\mu}}^H$ equals to the unconditional probability of observing a drastic innovation:

$$\underline{\tilde{\mu}}^H = \int_0^1 e^\nu de = \int_0^1 \theta f(\theta) d\theta = \frac{1}{\nu + 1}$$

Finally, the higher ν is, the lower the proportion of high type innovations among the randomly enacted cohort. This is capturing one of the main intuitions of the model, that projects are heterogeneous and good ideas are scarce.

3.5 The Representative Financial Intermediary

The second key novelty of this model is the introduction of a non trivial financial system that screen and select the most promising projects.¹³ The representative financial intermediary has access to a unit mass of projects every period. It borrows from households, selects in which project to invest according to their expected value, and pays back to the household the profits generated by these projects.¹⁴ This set up implicitly assumes that all the entrants are in need of external financing as the enactment of any project requires the investment by the intermediary. Even though this assumption is highly stylized it is not extremely inaccurate. Nofsinger and Wang (2011) use data from 27 countries, to document that 45% of start-ups use funds from financial institutions and government programs.¹⁵ Note that, if $\forall j V_{j,t}^H > V_{j,t}^L$, the financial intermediary strictly prefers to enact projects with higher e . In particular, if e were observable, a financial intermediary willing to finance M projects, would enact only the projects with $e \in [1 - M, 1]$. However, e is unobservable. Nevertheless, the financial

¹²Other firm related variables with *fat tails* are widely documented in the literature. For instance, Moskowitz and Vissing-Jorgensen (2002) find large skewness on entrepreneurial returns. Axtell (2001) shows that the size distribution of US firms closely mimics Zipf distribution, where the probability of a firm having more than n employees is inversely proportional to n . Scherer (1998) uses German patent data to show the skewness of the distribution of profits and technological innovation.

¹³The closest reference of a financial intermediary performing this function in an endogenous growth model is King and Levine (1993b). Nevertheless, the lack of a link between *ex ante* and *ex post* heterogeneity, focus their model only in the effect of the mass of entrants.

¹⁴Alternatively, we can assume that the representative household owns the projects but does not have access to any screening technology. Hence it sells the projects to the representative financial intermediary at the expected profits net of financing costs, and the financial intermediary earns no profits.

¹⁵Categories for 2003: self saving and income (39.97%), close family members (12.79%), work colleague (7.7%), employer (14.18%), banks and financial institutions (33.92%), and government programs (11.02%).

intermediary has access to a costless, yet imperfect, screening technology that delivers a stochastic signal \tilde{e} defined by:

$$\tilde{e}_t = \begin{cases} \tilde{e}_t = e_t & \text{with probability } \rho \\ \tilde{e}_t \sim U[0, 1] & \text{with probability } 1 - \rho \end{cases}$$

Note that $\rho \in [0, 1]$ characterizes the accuracy of the screening with $\rho = 1$ implying the perfect screening case. Levine (2005) suggests that one characteristic of financial development is the *improvement in the production of ex ante information about possible investments*. In this sense, the accuracy of the financial selection technology ρ is a reflect of the financial development of an economy. There is also empirical evidence of financial selection, for instance, Gonzalez and James (2007) document that firms with previous banking relationships perform significantly better after going public than firms without such relationships.¹⁶ Define $V_t^d = E_j[V_{j,t}^d]$ to be the expected value of successfully enacting a project with step size d . Proposition 2 shows that when the expected return of a drastic innovation is higher than the one of generating an incremental innovation, the optimal strategy is to set a cut-off for the signal. The proof is provided in Appendix B.

Proposition 2 *If $V_t^H > V_t^L$, the optimal strategy for a financial intermediary financing M_t projects at time t is to set a cut-off $\bar{e}_t = 1 - M_t$, and to enact projects only with signal $\tilde{e}_t \geq \bar{e}_t$.*

When the financial intermediary optimally uses this technology to select a mass $M_t = 1 - \bar{e}_t$ of projects, the proportion $\tilde{\mu}_t^H(\bar{e}_t)$ of high type projects in the successfully enacted λM_t mass is given by

$$\begin{aligned} \tilde{\mu}_t^H(\bar{e}_t) &= \frac{1}{\lambda M_t} \int_0^1 \lambda \times \text{prob}(\tilde{e}_t \geq \bar{e}_t | e_t) \times \theta(e_t) de_t \\ \tilde{\mu}_t^H(\bar{e}_t) &= \int_0^{\bar{e}_t} (1 - \rho)(1 - \bar{e}_t) e_t^\nu de_t + \int_{\bar{e}_t}^1 \{(1 - \rho)(1 - \bar{e}_t) + \rho\} e_t^\nu de_t \\ \tilde{\mu}_t^H(\bar{e}_t) &= \frac{1}{\nu + 1} \left[1 - \rho + \frac{\rho}{1 - \bar{e}_t} (1 - \bar{e}_t^{\nu+1}) \right]. \end{aligned} \quad (11)$$

Note that for any cut-off \bar{e} , the composition increases with the level of financial technology ρ and decreases with the scarcity of high type projects ν . Moreover, in terms of the resulting composition, financial selection performs at least as well as the random selection of projects. We summarize these properties in Proposition 3.¹⁷

Proposition 3 *The proportion of high type entrants $\tilde{\mu}^H$ exhibits the following features:*

1. $\tilde{\mu}^H(\bar{e}_t)$ is increasing in \bar{e}_t . Moreover, $\tilde{\mu}^H(\bar{e}_t)$ is increasing in ρ and decreasing in ν for every \bar{e}_t .
2. $\tilde{\mu}^H(\bar{e}_t) \geq \underline{\mu}^H$ with $\tilde{\mu}^H(\bar{e}_t) = \underline{\mu}^H$ if $\rho = 0$ or $\bar{e}_t = 0$.

¹⁶Keys et al. (2010) document that the lower screening intensity in the sub prime crisis generated between 10% and 25% more defaults.

¹⁷Proof is trivial and therefore omitted.

$$3. \tilde{\mu}^H(\bar{e}_t) = \frac{1 - \bar{e}_t^{\nu+1}}{(\nu+1)(1 - \bar{e}_t)} \quad \text{if } \rho = 1 \text{ and } \lim_{\bar{e}_t \rightarrow 1} \tilde{\mu}^H(\bar{e}_t) = \frac{1 + \nu\rho}{\nu+1} \leq 1$$

In this set up, the financial intermediary collects deposits D_t from the representative household in order to enact a mass $M_t = \frac{D_t}{w_t\kappa}$ of projects every period. Proposition 3 implies that the financial intermediary will always use its screening device.¹⁸ Then, given $\{V_t^H, V_t^L, r_t, w_t\}$ the financial intermediary chooses $\{\bar{e}_t, D_t\}$ in order to solve

$$\max_{\{D_t, \bar{e}_t\}} \left\{ \frac{\lambda D_t}{w_t\kappa} [\tilde{\mu}^H(\bar{e}_t)V_t^H + (1 - \tilde{\mu}^H(\bar{e}_t))V_t^L] - D_t(1 + r_t) - \xi_1 \left(1 - \bar{e}_t - \frac{D_t}{w_t\kappa}\right) - \xi_2 \left(\frac{D_t}{w_t\kappa} - 1\right) + \frac{\xi_3}{w_t\kappa} D_t \right\} \quad (12)$$

where $\{\xi_1, \xi_2, \xi_3\}$ are the corresponding Lagrange multipliers. Note that the term that multiplies the brackets in the first line is the mass of projects that are enacted and turn out to be successful. The bracketed term is the expected return of the portfolio with composition $\tilde{\mu}^H(\bar{e})$. The intermediary needs to pay back D_t plus the interest. The rest are constraints specifying the range of the variables. As the objective function is strictly concave, the first order conditions are sufficient for optimality. As Proposition 3 states, a financial intermediary with $\rho > 0$ faces a trade-off between mass and composition of the enacted pool. Now, we examine the optimal decisions of the intermediary. First order conditions regarding $\{D_t, \bar{e}_t\}$, respectively, yield

$$\begin{aligned} \frac{\lambda}{w_t\kappa} [\tilde{\mu}^H(\bar{e}_t)V_t^H + (1 - \tilde{\mu}^H(\bar{e}_t))V_t^L] - (1 + r_t) + \xi_1 - \frac{\xi_2}{w_t\kappa} + \frac{\xi_3}{w_t\kappa} &= 0 \\ \frac{\lambda D_t}{w_t\kappa} \left(\frac{V_t^H - V_t^L}{\nu + 1}\right) \left[\frac{\rho}{1 - \bar{e}_t} \left(\frac{1 - \bar{e}_t^{\nu+1}}{1 - \bar{e}_t} - (\nu + 1)\bar{e}_t^\nu\right)\right] + \xi_1 &= 0. \end{aligned}$$

Note that if $\rho > 0 \rightarrow \xi_1 < 0$ which in turn implies a positive wedge between the marginal revenue the intermediary generates and the marginal payment it needs to make to households. Therefore, the screening technology allows the intermediary to make positive profits. Furthermore, the unique interior solution ($\xi_2 = \xi_3 = 0$) is characterized by

$$\rho \bar{e}_t^\nu = \frac{\frac{w_t\kappa}{\lambda}(1 + r_t) - V_t^L}{(V_t^H - V_t^L)} - \frac{1 - \rho}{(\nu + 1)} \quad (13)$$

The uniqueness crucially depends on ρ being larger than zero. Otherwise, there are no profits and the intermediary is indifferent when enacting any mass of projects. This partial equilibrium result is quite intuitive. In fact, the cut-off is increasing in the enacting cost κ , the interest rate, the wages, and the scarcity of good projects ν . The cut-off is decreasing in the precision of screening technology ρ and in the value of the projects which means that, in these cases, the intermediary is willing to enact more projects.

¹⁸When a fixed cost is included the partial solution exhibits a kink. In general equilibrium there is a region where the equilibrium implies not screening, another region where it always implies screening, and a third region characterized by non existence. A well behaved variable cost does not alter the results significantly.

3.6 Equilibrium

Having introduced the basic components of the model, we can examine its equilibrium and balanced growth path (BGP). First, we characterize the analytical relationships posed by the equilibrium conditions, then we narrow down our analysis further to state the existence and uniqueness of a BGP, and characterize it analytically.

Definition 1 (Equilibrium) *A competitive equilibrium for this economy consists of quantities $\left\{ D_t, \{x_{t,j}^S\}_{j \in [0,1]}, \{x_{t,j}^D\}_{j \in [0,1]}, c_t, y_t, a_{t+1}, \{l_{j,t}^d\}_{j \in [0,1]}, \bar{e}_t \right\}_{t=0}^{\infty}$, policy parameters $\{\tau, T_t\}_{t=0}^{\infty}$, values $\left\{ \{V_{j,t}^H\}_{j \in [0,1]}, \{V_{j,t}^L\}_{j \in [0,1]} \right\}_{t=0}^{\infty}$, prices $\left\{ w_t, r_{t+1}, \{p_{j,t}\}_{j \in [0,1]} \right\}_{t=0}^{\infty}$, financial intermediary profits $\{\Pi_t\}_{t=0}^{\infty}$, intermediate good producer's profits $\{\pi_{t,j}^d\}_{j \in [0,1], t=0}^{\infty}$, entrants and incumbents compositions $\{\tilde{\mu}_t, \mu_t\}_{t=0}^{\infty}$ and initial conditions $\left\{ a_0, \{q_{0,j}\}_{j \in [0,1]}, \mu_0^H \right\}$ such that:*

1. Given $\{w_t, r_{t+1}, T_t, \Pi_t\}_{t=0}^{\infty}$, household chooses $\{c_t, a_{t+1}\}$ to solve (1) subject to (2) and (3).
2. Given $\{p_{j,t}\}$, final good producer chooses $\left\{ \{x_{t,j}^D\}_{j \in [0,1]} \right\}$ to solve (5) every t .
3. Given $\{w_t\}$, and $\{q_{j,t-1}\}$ intermediate producer of good j with type d sets $p_{j,t}$ according to (9), and earns profits $\pi_{t,j}^d$, for every t that she remains the leader in product line j .
4. Given $\{V_t^H, V_t^L, r_t, w_t\}$, financial intermediary chooses $\{D_t, \bar{e}_t\}$ to solve (12) every t .
5. Labor, asset, final and intermediate good markets clear:

$$\int_0^1 l_{j,t}^d dj + (1 - \bar{e}_t)\kappa = L \quad (14)$$

$$a_t = D_t = (1 - \bar{e}_t)w_t\kappa \quad (15)$$

$$x_{j,t}^S = x_{j,t}^D \Rightarrow l_{j,t}q_{j,t} = \frac{y_t}{p_{j,t}} \quad (16)$$

$$c_t = y_t = e^{\int_0^1 \ln x_{j,t} dj} \quad (17)$$

6. $V_{j,t}^d$ evolves accordingly to (10), $q_{j,t}$ evolves accordingly to (8), and government budget is balanced every period.
7. The entrant's composition $\tilde{\mu}_t$ is determined by (11) and the composition of the product line μ_t evolves according to:

$$\mu_{t+1}^H = \mu_t^H + \lambda(1 - \bar{e}_t)(\tilde{\mu}_{t+1}^H - \mu_t^H). \quad (18)$$

An important feature of this class of models is that profits, values, and labor across intermediate goods are independent of the efficiency level accumulated in product line j up to time t . This is summarized in Proposition 4, the derivation is in Appendix C.

Proposition 4 *Equilibrium:*

1. $\forall j \in [0, 1]$ and $\forall D \in \{L, H\}$ we have:

$$\pi_{j,t}^d = \pi_t^d \quad ; \quad l_{j,t}^d = l_t^d \quad ; \quad V_{j,t}^d = V_t^d$$

2. If $\sigma^H > \sigma^L$:

$$\pi_t^H > \pi_t^L \quad ; \quad l_t^H < l_t^L \quad ; \quad V_t^H > V_t^L$$

Proposition 4 shows that in equilibrium we have $V_t^H > V_t^L$ and hence the financial intermediary is using a cut-off strategy when selecting projects. Note that more efficient leaders needs less labor to serve the demand of their variety. For concreteness, imagine a type H leader with a follower characterized by \tilde{q} , he will charge the same price than a type L leader followed by someone with the same efficiency \tilde{q} . This implies that both are selling the same quantity, nevertheless, the more efficient leader needs less labor to produce that quantity, and hence earns more profits. The system of equations that characterizes the equilibrium is in Appendix D.

Definition 2 (BGP) *The economy is in a Balanced Growth Path at time T if it is in such an equilibrium that, $\forall t > T$, the endogenous aggregate variables $\{C_t, Q_t, Y_t, a_{t+1}\}$, where $Q_t = \exp \left\{ \int_0^1 \ln q_{j,t} \right\} dj$ is the efficiency level of the economy, grow at a constant rate, and the threshold \bar{e}_t is constant.*

Theorem 1 states the existence and uniqueness of a BGP for this economy. The proof is provided in Appendix E.

Theorem 1 *Existence and Uniqueness:*

$\frac{\kappa}{L} \in [a, b]$, where $\{a, b\}$ are constants that depend on the model parameters, is a sufficient condition for the existence and uniqueness of an interior BGP for this economy.

3.7 Mass and Composition Effect

As derived in Appendix E, the long run growth of this economy is characterized by the following expression:

$$1 + g(\bar{e}) = \left[(1 + \sigma^H)^{\mu^H(\bar{e})} (1 + \sigma^L)^{1 - \mu^H(\bar{e})} \right]^{\lambda(1 - \bar{e})} \quad (19)$$

The economic intuition of equation (19) is clear: the long run growth of this economy is the geometric mean of the efficiency improvement weighted by the composition of the entrants and scaled by the mass of entrants. The trade-off between mass and composition is manifested in this term. A lower standard (\bar{e}) implies a larger pool of entrants that increases the exponent of this term, but also decreases the base through the indirect effect on composition ($\mu(\bar{e})$). The interaction of these two margins determines the long run growth ($g(\bar{e})$). Nevertheless, \bar{e} is an endogenous variable, so we should also clarify the optimization problem that determines this variable.

To understand the source of the trade-off it is useful to think about two alternative cases: An economy with no accuracy ($\rho = 0$) where project initialization is random, and a model with no heterogeneity ($\sigma^H = \sigma^L$) where selection is useless. These two alternatives have in common that the expected step size of the marginal enacted project is constant with respect to the total enacted mass, destroying the trade-off between the enacted mass and its composition.¹⁹ But, the full model is characterized by the decreasing expected step size of the marginal entrants with respect to the total entry, this tension introduces a trade off between mass and composition into the model. Since this is a general equilibrium model, the economic impact of this trade-off should be assessed by studying the long run comparative statics of the model. Proposition 5 shows the general equilibrium comparative statics to changes in the enacting cost κ , the patience coefficient β , and the corporate tax rate τ .²⁰

Proposition 5 *General Equilibrium Comparative Statics:*

1. *An economy with higher enacting cost κ has higher lending standards, less entry but better composition. Long run growth decreases with κ :*

$$\frac{\partial \bar{e}}{\partial \kappa} \geq 0 \quad ; \quad \frac{\partial g(\bar{e})}{\partial \kappa} \leq 0 \quad ; \quad \frac{\partial \mu^H(\bar{e})}{\partial \kappa} \geq 0$$

2. *An economy with lower patience coefficient β has higher lending standards, less entry but better composition. Long run growth increases with β :*

$$\frac{\partial \bar{e}}{\partial \beta} \leq 0 \quad ; \quad \frac{\partial g(\bar{e})}{\partial \beta} \geq 0 \quad ; \quad \frac{\partial \mu^H(\bar{e})}{\partial \beta} \leq 0$$

3. *An economy with higher corporate tax rate τ has higher lending standards, less entry but better composition. Long run growth increases with τ :*

$$\frac{\partial \bar{e}}{\partial \tau} \geq 0 \quad ; \quad \frac{\partial g(\bar{e})}{\partial \tau} \leq 0 \quad ; \quad \frac{\partial \mu^H(\bar{e})}{\partial \tau} \geq 0$$

Proposition 5 shows first that economies with higher enacting cost (κ) enact in equilibrium less projects and hence, exert a tighter selection. Note that those economies are characterized by a lower rate of long run growth but a higher composition on their product line.²¹ Second, economies with a higher patience coefficient (β) save more they are able to enact more projects. Although those economies grow more on the long run, their average composition is lower.²² Finally, economies with higher corporate taxes (τ) have lower entry rates and lower long run growth, but higher composition. In all these cases the mass effect generated

¹⁹In both cases, the financial intermediary has no profits. Nevertheless this is not the source of the composition effect, if we impose a zero expected profit condition, as long as $\rho > 0$ and $\sigma^H > \sigma^L$, all the results carry on.

²⁰We select these parameters for the intuitive relationship to the main mechanism of the model, other results are available upon request. The proof is provided in Appendix F.

²¹Appendix G presents empirical evidence about cross country correlations that points to this direction.

²²Note that Figure 5 in Appendix H is consistent with this feature.

by the underlying parametric change dominates the composition effect. Nevertheless, the composition effect introduces non linearities on the relationship between credit availability and growth. In fact, in the alternative models that lack either selection or heterogeneity every marginal resource allocated to project enaction has a constant contribution to growth, hence, the relationship between entry (or total credit) and growth is linear. The model presented here breaks that linearity introducing a non trivial relationship between entry and growth shaped by the interaction between heterogeneity, scarcity, and financial selection that characterizes the economy. In fact, the strength of the selection margin that determines the magnitude of the trade off between mass and composition rest on the accuracy of the screening technology of the financial intermediary. Hence, before concluding this section, we would like to point that the effect of a better screening technology (higher ρ) is relatively more complex.

A better selection technology can be used to avoid enacting bad projects or to aim for more high-type projects. On the one hand, we can expect economies characterized by a high entry rates to increase their lending standards (higher \bar{e}) in response to an increase in the accuracy of their financial system. In fact, for those economies the marginal project enacted is more likely to be of low type, so the marginal benefit of improving the overall quality of the pool by reducing its size outweighs the potential benefit of increasing its mass. On the other hand, economies that are currently enacting less projects, should be willing to relax the selection standards and aim for a larger entry, since the marginal entrant has a high probability of becoming a type H leader. Proposition 6 gives analytical support to this intuition.²³

Proposition 6 *Financial Development:*

1. Let $\bar{s} > \underline{s}$ be two constants that are determined by the model parameters. For any economy with an equilibrium level of selection $\bar{e} \geq \bar{s}$ a marginal increase on the accuracy of the screening technology ρ will result in a less selective equilibrium.

$$\bar{e} \geq \bar{s} \Rightarrow \frac{\partial \bar{e}}{\partial \rho} < 0.$$

2. For any economy with an equilibrium level of selection $\bar{e} \leq \underline{s}$ a marginal increase on the accuracy of the screening technology ρ will result in a more selective equilibrium.

$$\bar{e} \leq \underline{s} \Rightarrow \frac{\partial \bar{e}}{\partial \rho} > 0.$$

Proposition 6 suggests that the effects of financial development are highly non linear, in particular, the level of domestic savings shapes the marginal response to changes in the accuracy of the financial system.²⁴ The non monotonic relationship between domestic savings and financial development challenges the most widely used variable to proxy economic development in the empirical literature. In fact, as can be seen in the masterful survey of

²³The proof is provided in Appendix F.

²⁴Recall that equation 15 imply a one to one mapping between entry and savings in equilibrium.

Levine (2005), practically all the cross country empirical research that relates financial development and economic growth proxies the first by the amount of domestic savings. If we emphasize the screening role of the financial system, this strategy is only valid for economies with low entry rates.²⁵ Moreover, the ambiguous relationship between financial development and firm entry carries on to the effect in growth. For example, if an increase in ρ triggers a reduction in the entry, the final effect on growth will depend on the relative strength of the two margins: a smaller cohort but a higher proportion of drastic improvements.

This section introduced a long run endogenous growth model that features project heterogeneity and financial selection. In this economy good ideas are scarce and the ability of the financial intermediary to select the most promising ones is limited. This induces a trade off between mass and composition as the larger the entrant cohort is, the lower the fraction of drastic innovations in the economy. The growth rate of this economy is endogenously determined and results from the interaction between mass and composition effect described above. In the next section we parametrize the model to perform two numerical experiments that allow us to illustrate both, the strength of the mechanism presented in this paper, and the potential of this framework to deal with two classical development issues in the empirical literature. The first experiment shows how the composition effect allows the model to generate non linear effects of corporate taxation in long run growth. Moreover, in line with the empirical literature, the model generates strong effects on firm entry with negligible effects on long run growth for the empirically relevant range of taxes. The second experiment revisits one of the most recurrent question in the recent empirical growth literature: the effects on financial development in economic growth. In line with this literature, the model predicts non linear effects on growth that depends on the actual level of financial development. In particular, for low level of financial development, the marginal benefit in terms of growth of an increase in financial development is considerable smaller than for a more financially developed economy.

4 Mass and Composition: Two Quantitative Illustrations

In this section we perform a quantitative exploration of the model to illustrate the relevance of the composition effect introduced in this paper. After proposing a reasonable parametrization of the model, we revisit two classical development problems.

First, we study the effects of corporate taxation on firm entry and economic growth. The empirical research points to an almost insignificant negative effect on growth but a strong and significant negative effect on entry. As the trade off between mass and composition effect implies that the marginal entrant's contribution to growth is decreasing in entry, the model can successfully account for both facts.

Second, we study the impact of financial development in economic growth. In the baseline parametrization, financial development reduces entry but increases growth due to a better

²⁵In section 4 we illustrate this critique comparing a high κ parametrization in Appendix J where domestic credit and financial development are positively related, with another in the main text with lower entry costs and higher entry where the former relationship is reversed.

allocation of resources. In particular, more financially developed economies increase their lending standards, experiencing gains from the composition margin that outweigh the losses on the mass margin. Interestingly, the marginal gain from reallocation is increasing in the level of financial development.

4.1 Parametrization of the Model

Table 1 shows the baseline parametrization for the quantitative experiments of this section. Given the normalization of the labor force to 1 the value of κ implies that 12% of the labor

Table 1: Parameter Values

κ	λ	σ^L	σ^H	β	ν	ρ	γ	τ	L
0.12	0.25	0.095	0.45	0.95	5	0.9	2	0.3	1

force is enough to enact all the projects in the economy. The value of λ implies that one out of every four projects are able to generate a successful innovation in some product line. When the innovation is drastic the increase in the productivity of labor is 45% while an incremental innovation just generates a 9.5% increase in productivity. Given the scarcity parameter ν , the underlying heterogeneity of the projects is such that one out of every six projects generate is expected to generate a drastic innovation, this implies a highly skewed distribution for the probability of generating a drastic innovation.²⁶ The value of ρ suggests that 90% of the projects are successfully screened by the financial intermediary. In line with the average of statutory corporate tax for high income economies in Djankov et al. (2010), we set τ to 30%. Finally, the intertemporal elasticity of substitution is set to 0.5 and the discount factor β to 0.95.

Table 2 presents a summary of the long run implications of the model under the baseline parametrization. The resulting cut-off value implies that 40% of the projects are enacted,

Table 2: Output of the Model

\bar{e}	μ^H	$\lambda(1 - \bar{e})$	g	r	$\frac{\kappa w}{Y}$	$\kappa(1 - \bar{e})$	$Av.(\sigma)$	$Sd.(\sigma)$	$Sk.(\pi)$
0.5987	0.3732	0.1003	0.0198	0.0948	0.1046	0.0482	0.2275	0.1717	0.5242

given the level of financial development the resulting composition on the intermediate good sector is more than two times higher than the one under random selection. The entry rate of 10% is in line with the international firm level evidence for developed countries.²⁷ The growth rate is also consistent with the average labor productivity growth of the European Union and the United States reported by Ark et al. (2008).²⁸ Fracassi et al. (2012) report

²⁶The implied skewness using Proposition 1 is 1.66, in general, any value larger than one is considered high.

²⁷According to the International Finance Corporation's micro small and medium-size enterprises database the Euro area has an average entry rate of 8.9% between 2000–2007 while United States has a 12.9% average entry rate between 2003–2005.

²⁸They report an average of 1.5% for the European Union between 1995–2005 and 2.3% for United States over the same period.

an average interest rate for start up loans in the United States 11.5% higher than the one generated by this set of parameters.²⁹ According to the *Doing Business* project, the average entry cost in 2012 resulting from fees and legal procedures among the OECD countries was 4.5% of the average per capita income. Moreover, the average minimum capital requirement to start a business was 13.3% for those countries, also in 2012, so the entry cost generated by the model of 10.5% of the average income seems very reasonable. Fairlie (2012) states that in 2011, according to the Kauffman index of Entrepreneurial Activity, 0.32% of adults in the United States were engaged in business creation every month. This implies that almost 4% of the adult population was engaged in entrepreneurship every year which is comparable to the 5% generated by the parametrized model. The average markup generated by the model is also consistent with the estimates of Christopoulou and Vermeulen (2008). They document an average markup of 28% for the manufacturing and construction sector in the United States between 1981 – 2004 and a corresponding value of 18% for the Euro area. The standard deviation of the markup is roughly half of the one estimated by Dobbelaere and Mairesse (2005) for the French economy between 1978 – 2001.³⁰ Finally, the resulting skewness of the profit distribution is roughly consistent with the values reported by Scherer et al. (2000).³¹ We focus the baseline parametrization in high income economies and then in each experiment we study deviations from this setup. We proceed this way due to the availability of empirical literature on mark-up and manufacturing productivity for more developed economies.³² The first quantitative experiment studies the effects of corporate taxation in both entry and growth rates.

4.2 Corporate Taxation, Firm entry and Growth

The empirical literature points to a very fragile relationship, if any, between corporate taxes and long run growth rates, whereas the effect on firm entry is found to be negative and sizeable. On the one hand, a cross sectional study with 85 countries performed by Djankov et al. (2010) suggests that decreasing the average tax rate from 29% to 19% would increase the average entry rate from 8% to 9.4%. Another study by Rin et al. (2011) based on firm level panel data estimation for 17 European countries finds a non linear relationship between corporate taxes and entry rates with high responses in the relevant corporate tax range. On the other hand, the empirical growth literature finds only a slightly negative effect of corporate taxation on growth. Easterly and Rebelo (1993) study this relationship using a panel of 125 countries spanning over 1970 – 1988 and find that there is no robust effect of taxes on growth. Widmalm (2001), and Angelopoulos et al. (2007) establish a similar result for the OECD countries. Moreover, Levine and Renelt (1992) argue that the negative

²⁹They use the complete set of start-up loan applications received by Accion Texas between 2006 – 2011. This number is consistent with the 11.3% reported by Petersen and Rajan (1994) from the National Survey of Small Business Finance also in the US for the years 1988 and 1989.

³⁰Their weighted markup average estimation (33%) more than doubles the one estimated for France by Christopoulou and Vermeulen (2008).

³¹Note that financial selection implies that not all the underlying skewness is passed to the composition of the intermediate producers.

³²For a firm level calibration of a slightly more complete model to a developing economy, see Ates and Saffie (2013).

relationship documented in the literature is not robust to slight changes on the specifications of the econometric model. To compare the magnitude of this relationship to the former stated regularity on entry rates we can take the estimation of Gemmell et al. (2011), where a 10 basis point corporate tax reduction could increase long run growth by at most 0.3 percentage points. In summary, the research in corporate taxation suggests a fragile negative effect on growth and an economically significant negative effect on entry.³³

Figure 2 shows the long run responses of entry, composition, and growth in the model to changes in corporate taxation for the baseline parametrization ($\rho = 0.9$) and three other values. Figure 2(d) displays the entry-growth Pass-Trough defined as the ratio between the percentage change in growth generated by a one basis point increase in taxation and the percentage change in entry generated by the same increase in corporate taxation. In particular, a Pass-Trough smaller than one in absolute value implies that marginal increases in taxation have larger absolute marginal effects on entry than in growth, in other words, growth responds less to taxation than entry. In line with Proposition 5, increases in marginal taxation reduce both entry and growth, but improve the composition of the economy.³⁴ We first focus the analysis on the responses of the model when ρ is at its benchmark level. As Figures 2(a) and 2(c) show, the responses of long run entry and growth to changes in taxation are both highly non linear, yet the growth rate exhibits the strongest non linearity. Moreover, the responses of both, entry and growth are in line with the magnitudes suggested by the empirical literature discussed above. In fact, a tax cut from the baseline parametrization of 30% of ten basis points increases growth from 1.98% to 2.11% while the change increase in entry is more sizeable, from 10% to 12.5%. This asymmetry in the response to taxation is summarized in Figure 2(d) where, for a wide range of tax rates, the marginal percentage reduction of the growth rate caused by a one basis point increase in taxation is only 60% of the corresponding marginal percentage reduction in the entry rate. The reason behind this difference is the strength of the composition effect. As seen in Figure 2(b) the decrease in entry induced by higher corporate taxation implies tighter lending standards and hence a higher composition. In fact, financial selection implies that the contribution of the marginal entrant to growth is decreasing in entry, hence, the initial reductions in entry triggered by higher corporate taxation do not impose an important cost in terms of growth to a financially developed economy. Only when the level of taxation reaches extremely high levels, with low entry rates, the sacrificed entrants pose a sizeable challenge to the long run growth of the economy. In a related article, Jaimovich and Rebelo (2012) use a similar mechanism to generate extremely non linear responses of long run growth to taxation. Their model combines the product line expansion framework of Romer (1990) with the heterogeneous ability framework of Lucas (1978). In a nutshell, entrepreneurs are heterogeneous in their ability to create firms, and more skilled entrepreneurs have a higher rate of success when enacting a project.³⁵ As the

³³For concreteness, Appendix I uses cross country data to show that higher taxes are significantly and strongly correlated with lower entry, but the negative correlation with growth rate is extremely weak.

³⁴Recall that this result holds only for interior solutions. In fact, after a corner solution is met, entry and growth are both zero and do not react to extra taxation.

³⁵In the context of our model, the heterogeneity is not in σ but in λ . Nevertheless, as the frameworks are completely different, this comparison need to be taken cautiously. In fact, Romer (1990) engine of growth is not the Schumpeterian creative destruction of Aghion and Howitt (1992), but an expansion in the number of intermediate varieties without replacement.

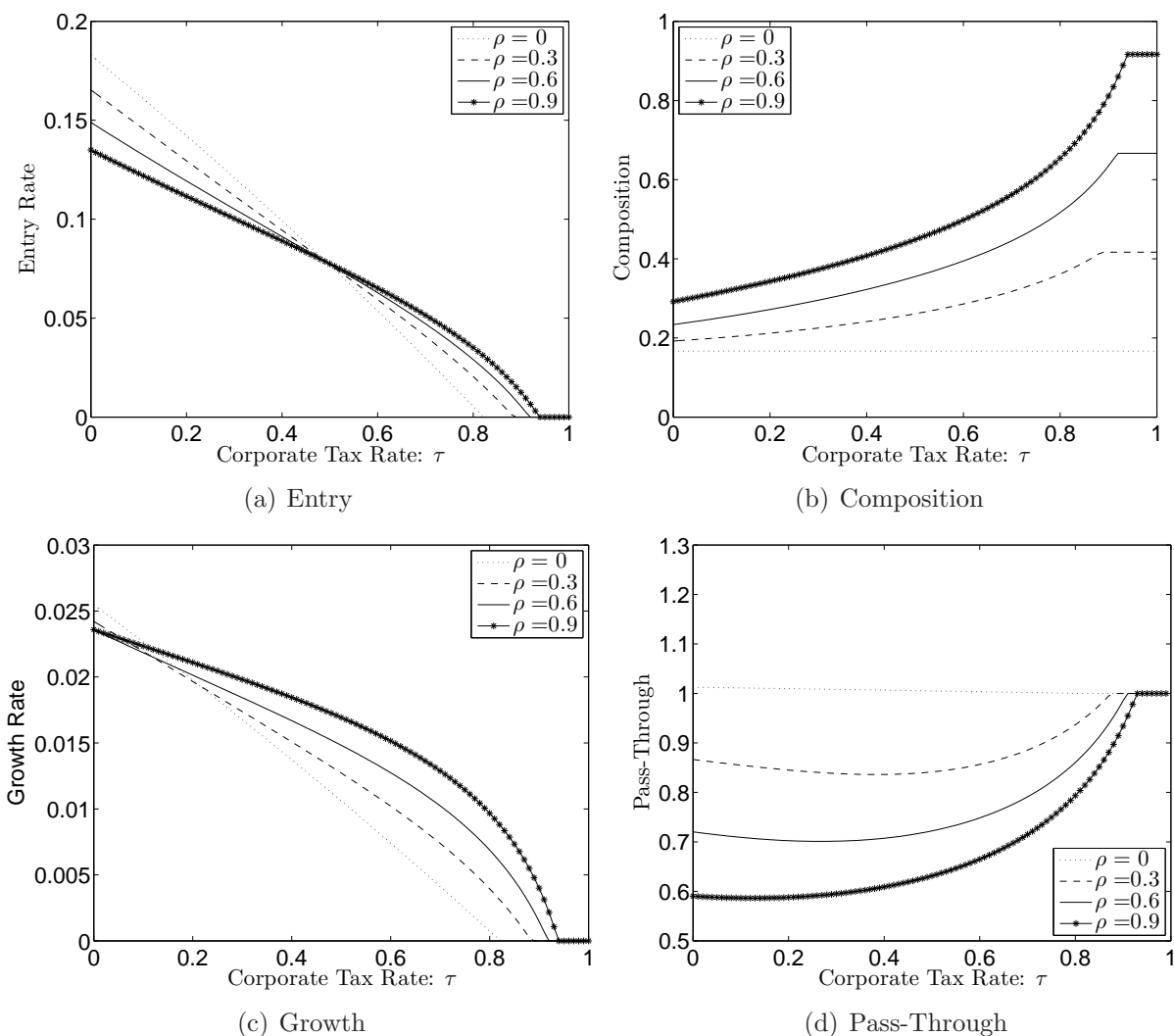


Figure 2: The Effect of Corporate Taxation on Growth and Entry

distribution of ability is highly skewed, relatively few entrepreneurs explain most of the entry rate of the economy. Hence, increases in taxation discourages only marginal entrepreneurs, and both the entry and the growth rates respond mildly for a wide range of taxes. In their model there is no *ex post* heterogeneity, all the active incumbents are identical, and hence the average *per firm* contribution to growth is the same for every cohort, regardless of its size.³⁶ In other words, even though their model features selection, the only engine of growth is the volume of the entrant cohort: the mass effect. The absence of a composition channel implies that their model exhibits, by construction, a Pass-Through equal to one for any level of taxation, so it cannot generate any asymmetry between the responses of entry and growth.³⁷ Hence, the composition margin is fundamental when modelling this asymmetry.

³⁶They focus on self selection instead of financial selection, we believe that both mechanism are present in the data and reinforce each other.

³⁷Jaimovich and Rebelo (2012) do not study the effects on entry. When interpreting the results we use the

Returning to Figure 2, as financial selection plays a key role determining the strength of the composition effect, we also compare the baseline parametrization with three alternatives that only differ in the value of ρ . The dotted line represents a model with no financial selection ($\rho = 0$) where project enaction is random and, in line with Proposition 3, composition is constant. As expected by the previous analysis, the absence of composition effect implies linear responses of growth and entry to taxation, moreover, as shown in Figure 2(d), there is no asymmetry between the two responses. The other two parameterizations exhibit intermediate levels of financial development. Figure 2(a) shows that for a wide range of corporate tax rates the models with less financial development exhibit higher entry rates, but, as seen in Figure 2(c), these economies are not able to capitalize that entry in a higher rate of economic growth.³⁸ This is a consequence of the potential strength of the composition effect, where economies with less entry can grow at a faster pace only due to a higher proportion of drastic innovation. In fact, as shown in Figure 2(b), the higher the corporate tax rate, the bigger the compositional advantage of the more developed economies. Moreover, for extremely high tax rates, a more developed economy can have larger and better cohorts than a less developed one, dominating the later not only in composition but also in mass. Finally, note that more financially developed economies exhibit extremely convex responses in growth, accentuating the asymmetry between the sensitivity of growth and entry to corporate taxation. This is clear in Figure 2(d), where more financially developed economies have systematically lower entry-growth Pass-Trough. Given the relevance of the financial development parameter ρ , we explore quantitatively its influence in entry and growth in the next experiment.

4.3 Financial Development and Resource Allocation

Finally, we perform a quantitative experiment to illustrate the relevance of Proposition 6 when studying the empirical relationship between financial development and economic growth. Figure 3 shows the long run responses of entry, growth, composition, and entry-growth Pass-Through to changes in the accuracy of the screening technology, under the baseline parametrization. In line with Proposition 6, the high levels of entry associated with the baseline parametrization imply that, in Figure 3(a), entry rate decreases with financial development at a decreasing rate. Under the alternative parametrization of Appendix J entry rate increases in ρ at a decreasing rate. As shown in equation 15, the entry rate $\lambda(1 - \bar{e})$ and the level of domestic savings $(1 - \bar{e})\kappa w$ are always positively related. Hence, the relationship between domestic savings and financial development is not monotonic; it is in fact shaped by the level of domestic savings.³⁹ As Figure 3(b) shows, the proportion of

same definition as in Romer (1990) for an entrant. Nevertheless, if an entrant is defined as one entrepreneur regardless of the number of product lines that she owns, then that model also generates this asymmetry between entry and growth. In this case, the composition should refer to the average size of an entrant in terms of the number of product line per entrepreneur. Yet, still the only engine of growth is the increase in the number of product lines, and hence, a mass perspective.

³⁸For extremely high taxes this parametrization implies that economies with less financial development can grow more than more developed ones. This is due to the extremely high entry rate at $\tau = 0$, and alternative parametrization in Appendix J with a slight increase in κ eliminates this feature.

³⁹The only parametric change in Appendix J is a higher entry cost κ in order to reduce entry rate and study the behavior on the other region of Proposition 6. An intermediate value for κ can generate a U-shaped

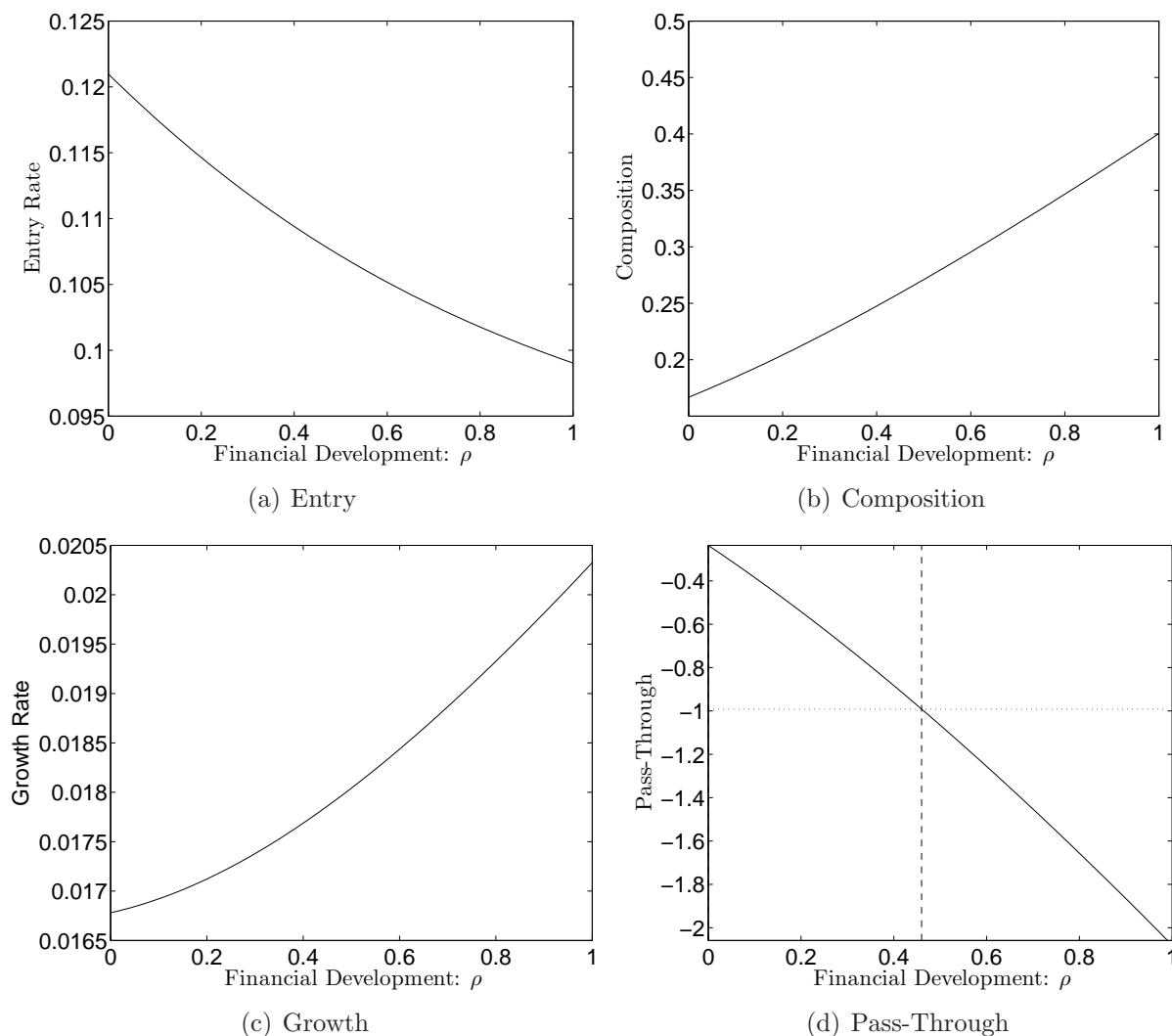


Figure 3: The Effect of Financial Development on Growth and Entry

high type leaders increases with the accuracy of the financial screening. Hence, under the baseline parametrization, mass and composition effect go in opposite directions: a higher level of financial development reduces mass but increases composition. Two forces explain the increase in composition: a direct one due to the increase in ρ , and an indirect one due to the reduction in entry. Note that the composition effect dominates the mass effect for this parametrization as in Figure 3(c); growth is increasing in ρ . This suggests that, under the baseline parametrization, the main source of growth is a reallocation of resources, and not an increase in the volume of resources allocated. Moreover, as the composition effect gets stronger at lower entry rates, the response of growth to financial development is non linear: for less financially developed countries, an increase in ρ generates less extra growth

relationship between entry and financial development since both regions could be on the entry domain.

than for more financially developed countries.⁴⁰ Figure 3(d) plots the ratio between the percentage increase in the growth rate and the percentage decrease in the entry rate due to a one basis point change in the selection technology. An entry-growth Pass-Through larger than one in absolute value implies that the percentage increase in growth is larger than the percentage decrease in entry. The trade off between entry and growth is clearly increasing in ρ , this means that more financially developed economies generate more growth when reducing entry than less developed economies. This increasing Pass-Through in absolute value results from the decreasing rate of change in entry noted before, and hence, it is also observed in Figure 8(d) in Appendix J. This implies that for high levels of ρ , more financially developed economies differ more in terms of resource allocation and long run economic growth than in domestic credit and firm entry.

On the empirical side, there are at least two issues when assessing the impact of financial development on economic growth. The first problem relates to the identification of a causal relationship from finance to growth and not the inverse. The second challenge is finding a convincing way to measure or proxy for the financial development of a country. The seminal contribution of Rajan and Zingales (1998) is one the most successful and widely used ways to deal with the first issue. In a nutshell, they build an industry based financial dependency measure using data from United States and assume that financial dependence is a characteristic of an industry, and hence is not affected by a particular location. Then they examine a cross country cross industry sample and find that industries with higher financial dependency grow faster in countries with more developed financial markets. Note that, in the context of the model presented in this paper, industries more in need of the financial system should be subject to screening more often, and hence, grow more in more financially developed countries. Nevertheless, this analogy is accurate only if the empirical proxy for financial development is a good measure of the screening accuracy ρ , which relates with the second empirical challenge in this literature. Rajan and Zingales (1998), as most of the literature, use a size measure in order to proxy for financial development, in particular, they use the total size of the stock market and the measure of domestic credit. But, as seen in Proposition 6, the amount of resources available in the credit market is not always positively related with the accuracy of the financial system.

Figure 3(a) illustrates the fact that for the baseline parametrization this is clearly not a good proxy, but under the alternative parametrization of Appendix J, as seen in Figure 8(a), this would be a good measure for ρ . Rioja and Valev (2004) explicitly mention this issue when using a 74 countries panel data to study if the effect of financial development in growth is constant across levels of financial development. In fact, they use three proxies for financial development, two of them centered on the size dimension (private credit and liquid liabilities) and a third measure that tries to proxy the ability of an economy to perform a more accurate selection. In particular, they use the ratio of commercial bank assets

⁴⁰Under the alternative parametrization of Appendix J, mass and composition effect reinforce each other, so the increase in growth due to higher levels of financial development in Figure 8(c) exhibits less non linearities. As can be seen in Figure 2(c), if we set $\tau = 0.1$ under the baseline parametrization, we see a hump shaped response to growth. This means, that the mass effect might dominate the composition effect for some parameterizations, and hence economic growth could decrease with financial development. Bose and Cothren (1996) find a similar result in the context of optimal contracting in an externality growth driven model.

over central bank assets.⁴¹ For the two size measure they find that the effects of financial development are stronger for countries with an intermediate level of financial development than for countries with high levels. Moreover, the effect on countries with very low levels of financial development is insignificant. Nevertheless, when using the third measure, they also find a significant economic effect for lower levels of financial development. All their specifications point to strong non linearities in both the relationship between volume of credit and economic growth, and the relationship between screening intensity and economic growth. These observations are in line with the non linearities displayed in Figures (3) and (8).

In another related empirical study, Wurgler (2000) studies the efficiency of the allocation of resources for different economies. His main contribution is the development of an elasticity based index that measures the ability of an economy to increase its investment in growing industries, and decrease it in the ones that are shrinking. In a first set of regressions he uses the same size based proxy as Rajan and Zingales (1998), and finds that more financially developed countries have a better allocation of resources; nevertheless, he finds no significant relationship between the volume of capital allocated in manufacturing and his proxy for financial development. In accordance with Figures 3(d) and 8(d), he argues that financially more developed economies grow more mainly because of a better allocation of resources. He also finds that his measure of efficient capital allocation is strongly and positively related with the idiosyncratic firm information available in the stock prices.⁴² These findings relate directly to Figures 3(b) and 8(b) where the proportion of high type firms always increases in ρ . Moreover, Galindo et al. (2007) use a different approach that does not rely on a size proxy to study the relationship between finance and the allocation of resources.⁴³ They use firm level panel data for 12 developing countries to build a measure of the efficiency in the allocation of resources, and then they use the chronology of financial reforms in Laeven (2003) for those countries. They find that episodes of financial liberalization are linked to better allocation of resources, but not necessarily to a larger mobilization of resources.

In this section we performed a quantitative exploration to assess the strength and relevance of the composition effect introduced in this paper. The first experiment showed that the composition effect can overturn the mass effect and allow an economy to grow faster even when enacting less projects. We also explained how the composition effect can rationalize the empirical relationship between corporate taxation, firm entry, and economic growth. The quantitative illustration showed the empirically observed non linear relationship between financial development, allocation and reallocation of resources. That last experiment also exemplifies the risk of using only volume based proxies for financial development.

⁴¹The empirical work of King and Levine (1993b) and King and Levine (1993a) states these and other proxies for financial development. They suggest that the higher this ratio is, the stronger the screening in the economy, since commercial bank tend to exert a more thorough selection. For each of their measures they find a strong relationship between economic growth and financial development, moreover, they use case studies of financial reforms to validate them.

⁴²The lower price *synchronicity* on the stock market, measured as in Morck et al. (2000), the higher the idiosyncratic information contained on the stock. He also finds that reallocation is more efficient when state ownership declines, and minority stockholder rights are strong

⁴³They also review the cross country and firm level literature on the relationship between financial liberalization and growth. They argue that the positive effect on growth is well established, while a clear effect on the amount of resources allocated has not been found.

5 Conclusion

In this paper we introduced project heterogeneity and financial selection in an analytically tractable way to the classical endogenous growth framework of Aghion and Howitt (1992). A financial intermediary, with access to an imperfect screening device, selects *ex ante* heterogeneous projects characterized by an idiosyncratic probability of generating a drastic innovation. Following implementation of the projects, the model also delivers an *ex post* heterogeneity, where two types of incumbents have different cost advantages over their followers, and hence, earn more profits. The model has a unique interior balanced growth path shaped by the Schumpeterian creative destruction generated by new firms. The impact of creative destruction in this economy results from the interaction between the mass and the composition of the entrant cohort. The relative strength of each margin crucially depends on the underlying scarcity of drastic ideas relatively to the accuracy of the selection technology in the economy.

Two quantitative experiments illustrate the importance of including heterogeneity and financial selection into the endogenous growth framework. First, since the marginal entrant has a decreasing contribution to economic growth, changes in the entry rate are not linearly mapped into the economic growth rate of the economy. Hence, this framework can accommodate the strong negative relationship between entry rates and corporate taxation without delivering a counter factually strong negative effect of corporate taxation on economic growth.

The second experiment addresses the widely-debated link between financial development and economic growth. Two main lessons arise from this experiment. First, when countries are characterized by high entry rates, size measures should not be used to proxy for financial development. Second, the effect of financial development in economic growth is extremely non linear; in particular, for a country with a high degree of financial development, a marginal increase in that financial development leads to a greater increase in growth, relative to the change in firm entry.

In a companion paper we extend this framework to study the growth effect of a credit crunch.⁴⁴ A stochastic version of this model that also includes capital accumulation is well suited for economic analysis even outside the balanced growth path. Moreover, when using firm level data from Chile and the Asian crisis as a natural experiment to test the model, we observe a strong compositional component; in fact, cohorts born under tighter credit conditions perform significantly better than cohorts arising under laxer credit standards. We believe that this framework can be enriched and brought quantitatively to data in order to perform policy analysis. For instance, changes in corporate taxation, entry barriers or financial liberalization can be evaluated, even accounting for the economic transition between the two balanced growth paths. Moreover, this framework can be modified to include rich incumbent dynamics introducing competition for credit between entrants and established firms. In fact, entrants and incumbents are very different borrowers; incumbents can collateralize their short term profits, while entrants might promise a higher return. A stochastic quantitative model with these dimensions might be used to study the effects of discretionary credit subsidies.

⁴⁴Ates and Saffie (2013).

References

- Aghion, P., U. Akcigit, and P. Howitt (2013). “What Do We Learn From Schumpeterian Growth Theory?”. *mimeo*. Harvard University.
- Aghion, P. and P. Howitt (1992, March). “A Model of Growth through Creative Destruction”. *Econometrica* 60(2), 323–51.
- Akcigit, U. and W. R. Kerr (2010, November). “Growth Through Heterogeneous Innovations”. NBER Working Papers 16443, National Bureau of Economic Research, Inc.
- Angelopoulos, K., G. Economides, and P. Kammass (2007). “Tax-spending policies and economic growth: Theoretical predictions and evidence from the OECD”. *European Journal of Political Economy* 23(4), 885–902.
- Ark, B. v., M. O’Mahony, and M. P. Timmer (2008). “The Productivity Gap between Europe and the United States: Trends and Causes”. *The Journal of Economic Perspectives* 22(1), pp. 25–44.
- Ates, S. T. and F. Saffie (2013). “Fewer But Better Entrants: Growth Effects of a Credit Crunch”. *mimeo*. University of Pennsylvania.
- Axtell, R. L. (2001). “Zipf Distribution of U.S. Firm Sizes”. *Science* 293, 1818–1820.
- Bagehot, W. (1878). “*Lombard Street: a description of the money market*”. Paul.
- Bartelsman, E., J. Haltiwanger, and S. Scarpetta (2009, January). “Measuring and Analyzing Cross-country Differences in Firm Dynamics”. In *Producer Dynamics: New Evidence from Micro Data*, NBER Chapters, pp. 15–76. National Bureau of Economic Research, Inc.
- Benfratello, L., F. Schiantarelli, and A. Sembenelli (2008, November). “Banks and innovation: Microeconomic evidence on Italian firms”. *Journal of Financial Economics* 90(2), 197–217.
- Bose, N. and R. Cothren (1996, October). “Equilibrium loan contracts and endogenous growth in the presence of asymmetric information”. *Journal of Monetary Economics* 38(2), 363–376.
- Boyd, J. H. and E. C. Prescott (1986, April). “Financial intermediary-coalitions”. *Journal of Economic Theory* 38(2), 211–232.
- Christopoulou, R. and P. Vermeulen (2008, January). “Markups in the euro area and the US over the period 1981–2004 - a comparison of 50 sectors”. Working Paper Series 856, European Central Bank.
- Djankov, S., T. Ganser, C. McLiesh, R. Ramalho, and A. Shleifer (2010). “The Effect of Corporate Taxes on Investment and Entrepreneurship”. *American Economic Journal: Macroeconomics* 2(3), 31–64.

- Dobbelaere, S. and J. Mairesse (2005, December). “Cross-Sectional Heterogeneity in Price-Cost Margins and the Extent of Rent Sharing at the Sector and Firm Level in France”. IZA Discussion Papers 1898, Institute for the Study of Labor (IZA).
- Easterly, W. and S. Rebelo (1993, December). “Fiscal policy and economic growth: An empirical investigation”. *Journal of Monetary Economics* 32(3), 417–458.
- Fairlie, R. (2012). “Kauffman Index of Entrepreneurial Activity, 1996-2011”. Available at SSRN 2027008.
- Fracassi, C., M. Garmaise, S. Kogan, and G. Natividad (2012). “How Much Does Credit Matter for Entrepreneurial Success in the United States?”. Available at SSRN 2157707.
- Galindo, A., F. Schiantarelli, and A. Weiss (2007, July). “Does financial liberalization improve the allocation of investment?: Micro-evidence from developing countries”. *Journal of Development Economics* 83(2), 562–587.
- Gemmell, N., R. Kneller, and I. Sanz (2011). “The Timing and Persistence of Fiscal Policy Impacts on Growth: Evidence from OECD Countries”. *The Economic Journal* 121(550), F33–F58.
- Gonzalez, L. and C. James (2007, October). “Banks and bubbles: How good are bankers at spotting winners?”. *Journal of Financial Economics* 86(1), 40–70.
- Greenwood, J. and B. Jovanovic (1990). “Financial Development, Growth, and the Distribution of Income”. *Journal of Political Economy* 98(5), pp. 1076–1107.
- Grossman, G. M. and E. Helpman (1991, January). “Quality Ladders in the Theory of Growth”. *Review of Economic Studies* 58(1), 43–61.
- Hopenhayn, H. A. (1992, September). “Entry, Exit, and Firm Dynamics in Long Run Equilibrium”. *Econometrica* 60(5), 1127–50.
- Jaimovich, N. and S. Rebelo (2012, October). “Non-linear Effects of Taxation on Growth”. Working Paper 18473, National Bureau of Economic Research.
- Keys, B. J., T. Mukherjee, A. Seru, and V. Vig (2010). “Did Securitization Lead to Lax Screening? Evidence from Subprime Loans”. *The Quarterly Journal of Economics* 125(1), 307–362.
- King, R. G. and R. Levine (1993a, August). “Finance and Growth: Schumpeter Might Be Right”. *The Quarterly Journal of Economics* 108(3), 717–37.
- King, R. G. and R. Levine (1993b, December). “Finance, entrepreneurship and growth: Theory and evidence”. *Journal of Monetary Economics* 32(3), 513–542.
- Laeven, L. (2003). “Does Financial Liberalization Reduce Financing Constraints?”. *Financial Management* 32(1), pp. 5–34.

- Levine, R. (2005, 00). “Finance and Growth: Theory and Evidence”. In P. Aghion and S. Durlauf (Eds.), *Handbook of Economic Growth*, Volume 1 of *Handbook of Economic Growth*, Chapter 12, pp. 865–934. Elsevier.
- Levine, R. and D. Renelt (1992, September). “A Sensitivity Analysis of Cross-Country Growth Regressions”. *American Economic Review* 82(4), 942–63.
- Lucas, R. E. (1978, Autumn). “On the Size Distribution of Business Firms”. *Bell Journal of Economics* 9(2), 508–523.
- Morck, R., B. Yeung, and W. Yu (2000). “The information content of stock markets: why do emerging markets have synchronous stock price movements?”. *Journal of financial economics* 58(1), 215–260.
- Moskowitz, T. J. and A. Vissing-Jorgensen (2002, April). “The Returns to Entrepreneurial Investment: A Private Equity Premium Puzzle?”. NBER Working Papers 8876, National Bureau of Economic Research, Inc.
- Nofsinger, J. R. and W. Wang (2011). “Determinants of start-up firm external financing worldwide”. *Journal of Banking & Finance* 35(9), 2282 – 2294.
- Palazzo, D. and G. L. Clementi (2010). “Entry, Exit, Firm Dynamics, and Aggregate Fluctuations”. 2010 Meeting Papers 1188, Society for Economic Dynamics.
- Petersen, M. A. and R. G. Rajan (1994, March). “The Benefits of Lending Relationships: Evidence from Small Business Data”. *Journal of Finance* 49(1), 3–37.
- Rajan, R. G. and L. Zingales (1998, June). “Financial Dependence and Growth”. *American Economic Review* 88(3), 559–86.
- Rin, M. D., M. D. Giacomo, and A. Sembenelli (2011). “Entrepreneurship, firm entry, and the taxation of corporate income: Evidence from Europe”. *Journal of Public Economics* 95(910), 1048 – 1066. Special Issue: The Role of Firms in Tax Systems.
- Rioja, F. and N. Valev (2004, January). “Finance and the Sources of Growth at Various Stages of Economic Development”. *Economic Inquiry* 42(1), 127–140.
- Romer, P. M. (1986, October). “Increasing Returns and Long-run Growth”. *Journal of Political Economy* 94(5), 1002–37.
- Romer, P. M. (1990, October). “Endogenous Technological Change”. *Journal of Political Economy* 98(5), S71–102.
- Scherer, F. M. (1998). “The Size Distribution of Profits from Innovation”. *Annals of Economics and Statistics / Annales d’économie et de Statistique* (49/50), pp. 495–516.
- Scherer, F. M., D. Harhoff, and r. K. J (2000). “Uncertainty and the size distribution of rewards from innovation”. *Journal of Evolutionary Economics* 10(1), 175–200.

Schumpeter, J. (1934). *“The Theory of Economic Development”*. Harvard University Press.

Silverberg, G. and B. Verspagen (2007). “The size distribution of innovations revisited: An application of extreme value statistics to citation and value measures of patent significance”. *Journal of Econometrics* 139(2), 318–339.

Widmalm, F. (2001, June). “Tax Structure and Growth: Are Some Taxes Better Than Others?”. *Public Choice* 107(3-4), 199–219.

Wurgler, J. (2000). “Financial markets and the allocation of capital”. *Journal of Financial Economics* 58(12), 187 – 214. Special Issue on International Corporate Governance.

Appendices

A Proposition 1

Proof. First note that, for any $\bar{\theta} \in [0, 1]$, the probability of a randomly drawn project $e \in [0, 1]$ having a probability $\theta(e) \leq \bar{\theta}$ is given by:

$$F(\bar{\theta}) = (\bar{\theta})^{\frac{1}{\nu}}$$

Then, $F(\theta)$ is the cumulative density function of θ , and we can use it to find its probability density function:

$$f(\theta) = \frac{\partial F(\theta)}{\partial \theta} = \frac{1}{\nu} (\theta)^{\frac{1}{\nu}-1}$$

More algebra delivers:

$$\begin{aligned} E[\theta] &= \int_0^1 \frac{\theta}{\nu} (\theta)^{\frac{1}{\nu}-1} d\theta = \frac{1}{\nu+1} \\ V[\theta] &= E[(\theta - E[\theta])^2] = \frac{\nu^2}{(\nu+1)^2(2\nu+1)} \\ S[\theta] &= \frac{E[(\theta - E[\theta])^3]}{(E[(\theta - E[\theta])^2])^{\frac{3}{2}}} = \frac{2(\nu-1)\sqrt{1+2\nu}}{1+3\nu} \end{aligned}$$

■ Note that $\nu = 1$ corresponds to a uniform distribution. For $\nu \geq 1$ this distribution resembles a Truncated Pareto distribution, but it behaves better on the neighborhood of 0.

B Proposition 2

Proof. Denote by $P(H|\tilde{e})$ the expected probability of a project generating a drastic innovation conditional on delivering a signal \tilde{e} . Then:

$$P(H|\tilde{e}) = \rho \tilde{e}^{\nu} + (1 - \rho) \frac{1}{\nu + 1}$$

$P(H|\tilde{e})$ is increasing in the signal \tilde{e} . Then if $V_t^H > V_t^L$, the expected benefits of enacting a project is also increasing in \tilde{e} . As the cost of enacting a project is independent of the signal, the optimal strategy is to pick the desired mass M of projects with the highest signal. Finally, in order to get a mass M , the cut-off \bar{e} must satisfy:

$$\int_0^{\bar{e}} (1 - \rho) (1 - \bar{e}) de + \int_{\bar{e}}^1 \{(1 - \rho) (1 - \bar{e}) + \rho\} de = M \Leftrightarrow \bar{e} = 1 - M$$

■

C Proposition 4

Proof. We start solving for the profits of the intermediate good sector. Given (7), (9), and (16) the profits of a type d firm are given by

$$\pi_{j,t}^d = l_{j,t}^d q_{j,t} \left(\frac{w_t}{\tilde{q}_{j,t}} - \frac{w_t}{q_{j,t}} \right) = \frac{\sigma^d}{(1 + \sigma^d)} Y_t. \quad (20)$$

Thus, $\forall j \in [0, 1]$, $\pi_{j,t}^d = \pi_t^d$. Then, by (10), we have $\forall j \in [0, 1]$, $V_{j,t}^d = V_t^d$. Also, as $\sigma^H > \sigma^L$, we have $\pi_t^H > \pi_t^L$, and then $V_t^H > V_t^L$. This rationalizes the equilibrium cut-off strategy of the financial intermediary. Moreover, σ^d determines the constant markup of type d leader in any product line. Using (20) and (14) we can find an expression for the labor demand that only depends on the type d of the leader:

$$l_{j,t}^L = \frac{(1 + \sigma^H) [L - (1 - \bar{e}_t) \kappa]}{1 + \sigma^H - \mu_t^H (\sigma^H - \sigma^L)} = l_t^L; \quad l_{j,t}^H = \frac{(1 + \sigma^L) [L - (1 - \bar{e}_t) \kappa]}{1 + \sigma^H - \mu_t^H (\sigma^H - \sigma^L)} = l_t^H \quad (21)$$

Note that $l_t^L > l_t^H$. ■

D Dynamic System

From (20) and (21) we get the following expression for wages:

$$w_t = \frac{[1 + \sigma^H - \mu_t^H (\sigma^H - \sigma^L)]}{(1 + \sigma^L)(1 + \sigma^H) [L - (1 - \bar{e}_t) \kappa]} Y_t. \quad (22)$$

Now, we are able to characterize the output growth in the model:

$$(1 + g_t) = \frac{Y_{t+1}}{Y_t} = e^{\left(\int_0^1 \left\{ \ln \frac{l_{j,t+1}^1}{l_{j,t}^1} \right\} dj + \int_0^1 \left\{ \ln \frac{q_{j,t+1}^1}{q_{j,t}^1} \right\} dj \right)}. \quad (23)$$

Recall that $Q_t \equiv \exp(\int_0^1 \ln q_{j,t} dj)$. Then:

$$\begin{aligned} \ln(Q_{t+1}) &= \lambda M_t \left\{ \tilde{\mu}_t^H \int \ln[q_{jt}(1 + \sigma^H)] dj + (1 - \tilde{\mu}_t^H) \int \ln[q_{jt}(1 + \sigma^L)] dj \right\} + (1 - \lambda M_t) \int \ln q_{jt} dj \\ \Rightarrow \ln \left(\frac{Q_{t+1}}{Q_t} \right) &= \lambda M_t \left\{ \tilde{\mu}_t^H \ln(1 + \sigma^H) + (1 - \tilde{\mu}_t^H) \ln(1 + \sigma^L) \right\} \end{aligned} \quad (24)$$

We also have:

$$\int_0^1 \ln(l_{j,t}) dj = \mu_t^H \ln(l_t^H) + (1 - \mu_t^H) \ln(l_t^L) \quad (25)$$

Using (24) and (25) on (23) we get:

$$(1 + g_t) = \left(\frac{(l_{t+1}^H)^{\mu_{t+1}^H} (l_{t+1}^L)^{1 - \mu_{t+1}^H}}{(l_t^H)^{\mu_t^H} (l_t^L)^{1 - \mu_t^H}} \right) \left(\left[(1 + \sigma^H)^{\tilde{\mu}_t^H} (1 + \sigma^L)^{1 - \tilde{\mu}_t^H} \right]^{\lambda(1 - \bar{e}_t)} \right). \quad (26)$$

Finally, combining equations (4) and 17 we get the following equilibrium relationship between output growth and interest rate:

$$\frac{(1 + g_{t+1})^\gamma}{\beta} = 1 + r_{t+1} \quad (27)$$

The following nine equation dynamic system fully characterizes the equilibrium of this economy. The system is written in its stationary form.

$$1 + r_{t+1} = \frac{(1 + g_{t+1})^\gamma}{\beta} \quad (28)$$

$$\mu_t^H = \mu_{t-1}^H + \lambda(1 - \bar{e}_t) \left[\frac{1}{\nu + 1} \left(1 - \rho + \frac{\rho}{1 - \bar{e}_t} (1 - \bar{e}_t^{\nu+1}) \right) - \mu_{t-1}^H \right] \quad (29)$$

$$l_t^H = \frac{(1 + \sigma^L)(L - (1 - \bar{e}_t)\kappa)}{1 + \sigma^H - \mu_t^H(\sigma^H - \sigma^L)} \quad (30)$$

$$l_t^L = \frac{(1 + \sigma^H)(L - (1 - \bar{e}_t)\kappa)}{1 + \sigma^H - \mu_t^H(\sigma^H - \sigma^L)} \quad (31)$$

$$1 + g_{t+1} = \left[(1 + \sigma^H)^{\mu_{t+1}^H - \mu_t^H(1 - \lambda(1 - \bar{e}_{t+1}))} (1 + \sigma^L)^{\lambda(1 - \bar{e}_{t+1}) - (\mu_{t+1}^H - \mu_t^H(1 - \lambda(1 - \bar{e}_{t+1})))} \right] \left[\frac{(l_{t+1}^H)^{\mu_{t+1}^H} (l_{t+1}^L)^{1 - \mu_{t+1}^H}}{(l_t^H)^{\mu_t^H} (l_t^L)^{1 - \mu_t^H}} \right] \quad (32)$$

$$\frac{w_t}{Y_t} = \frac{(1 + \sigma^H - \mu_t^H(\sigma^H - \sigma^L))}{(1 + \sigma^L)(1 + \sigma^H)(L - (1 - \bar{e}_t)\kappa)} \quad (33)$$

$$\frac{V_t^H}{Y_t} = \frac{(1 - \tau)\sigma^H}{1 + \sigma^H} + \frac{1 - \lambda(1 - \bar{e}_{t+1})}{1 + r_{t+1}} (1 + g_{t+1}) \left(\frac{V_{t+1}^H}{Y_{t+1}} \right) \quad (34)$$

$$\frac{V_t^L}{Y_t} = \frac{(1 - \tau)\sigma^L}{1 + \sigma^L} + \frac{1 - \lambda(1 - \bar{e}_{t+1})}{1 + r_{t+1}} (1 + g_{t+1}) \left(\frac{V_{t+1}^L}{Y_{t+1}} \right) \quad (35)$$

$$\bar{e}_t = \left[\frac{\frac{\kappa}{\lambda} \frac{w_t}{Y_t} (1 + r_t) - \frac{V_t^L}{Y_t}}{\rho \left(\frac{V_t^H}{Y_t} - \frac{V_t^L}{Y_t} \right)} - \frac{1 - \rho}{\rho(\nu + 1)} \right]^{\frac{1}{\nu}} \quad (36)$$

Note that, since the model has no capital, the composition μ_t^H drives all the dynamics.

E Theorem 1

Proof. First we characterize the system of two equations that defines an interior BGP.

E.1 The System on BGP

Note that, (27) implies that the interest rate is constant along the BGP. Then, as $\gamma \geq 1$, we can collapse (10) using (20) and (27):

$$V_t^d = \frac{(1 - \tau)\sigma^d}{\beta \left[(\lambda(1 - \bar{e}_t) - 1)(1 + g)^{1-\gamma} + \frac{1}{\beta} \right]} Y_t. \quad (37)$$

In an interior BGP (13) must hold, so, using (22) and (37), we obtain the following relationship:

$$\rho \bar{e}_t^\nu = \frac{1}{\Gamma_0} \left(\frac{(1 + g)^\gamma [1 + \sigma^H - \Delta \tilde{\mu}^H] \left[(1 - \bar{e} - \frac{1}{\lambda})(1 + g)^{1-\gamma} + \frac{1}{\lambda\beta} \right]}{\left[\frac{L}{\kappa} - (1 - \bar{e}) \right]} - (1 + \sigma^H)(1 - \tau)\sigma^L \right) - \frac{1 - \rho}{(\nu + 1)} \quad (38)$$

where $\Gamma_0 = (1 - \tau)\Delta$ and $\Delta = \sigma^H - \sigma^L$. The last formula proves that indeed, \bar{e}_t is constant on BGP, and so is $\tilde{\mu}_t^H$, hence, $\tilde{\mu}^H = \mu^H$. Then, from (21), it follows that l_t^d is also constant. Hence, (26) becomes

$$1 + g = \left[(1 + \sigma^H)^{\mu^H} (1 + \sigma^L)^{1-\mu^H} \right]^{\lambda(1-\bar{e})}. \quad (39)$$

Then, the system is characterized by:

$$\begin{aligned} \Gamma_0 \left(\rho \bar{e}^\nu + \frac{1 - \rho}{(\nu + 1)} \right) &= \left(\frac{(1 + g)^\gamma [1 + \sigma^H - \Delta \mu^H] \left[(1 - \bar{e} - \frac{1}{\lambda})(1 + g)^{1-\gamma} + \frac{1}{\lambda\beta} \right]}{\left[\frac{L}{\kappa} - (1 - \bar{e}) \right]} - (1 + \sigma^H)(1 - \tau)\sigma^L \right) \\ 1 + g &= \left[(1 + \sigma^H)^{\mu^H} (1 + \sigma^L)^{1-\mu^H} \right]^{\lambda(1-\bar{e})} \\ \mu^H(\bar{e}) &= \frac{1}{\nu + 1} \left[1 - \rho + \frac{\rho}{1 - \bar{e}} (1 - \bar{e}^{\nu+1}) \right]. \end{aligned}$$

Now we find sufficient conditions for existence and uniqueness of a solution to that system.

E.2 Existence and Uniqueness

E.2.1 Preliminary Derivations

$$\begin{aligned} \frac{\partial[1 + g(\bar{e})]}{\partial \bar{e}} &= \lambda[1 + g(\bar{e})] \left[\left[\ln(1 + \sigma^H) - \ln(1 + \sigma^L) \right] \left[(1 - \bar{e}) \frac{\partial \mu^H(\bar{e})}{\partial \bar{e}} - \mu^H(\bar{e}) \right] - \ln(1 + \sigma^L) \right] \\ \frac{\partial \mu^H(\bar{e})}{\partial \bar{e}} &= \frac{\rho}{\nu + 1} \left[\frac{1 - \bar{e}^{\nu+1} - (\nu + 1)(1 - \bar{e})\bar{e}^\nu}{(1 - \bar{e})^2} \right] > 0. \end{aligned}$$

This implies:

$$\frac{\partial[1 + g(\bar{e})]}{\partial \bar{e}} = -\lambda[1 + g(\bar{e})] \left[\left[\ln(1 + \sigma^H) - \ln(1 + \sigma^L) \right] \left(\rho \bar{e}^\nu + \frac{1 - \rho}{\nu + 1} \right) + \ln(1 + \sigma^L) \right] < 0.$$

E.2.2 Uniqueness

Define the following function of \bar{e} :

$$A(\bar{e}) = \frac{(1+g)^\gamma [1 + \sigma^H - \Delta\mu^H] \left[(1 - \bar{e} - \frac{1}{\lambda})(1+g)^{1-\gamma} + \frac{1}{\lambda\beta} \right]}{\left[\frac{L}{\kappa} - (1 - \bar{e}) \right]}$$

Then we can rewrite (38) as:

$$\rho\bar{e}^\nu = \frac{1}{\Gamma_0} (A(\bar{e}) - (1 + \sigma^H)(1 - \tau)\sigma^L) - \frac{1 - \rho}{(\nu + 1)} \quad (40)$$

Note that, the left hand side of (40) is increasing in \bar{e} . Then, if the right hand side of (40) is decreasing in \bar{e} any interior solution must be unique. The right hand side of (40) is decreasing if and only if $A(\bar{e})$ is decreasing.

Note that, as $\gamma \geq 1$ and as equation (27), we have $\forall e \in [0, 1]$ all the multiplicative terms are positive. So, we can study the derivative of $\ln(A(\bar{e}))$:

$$\ln(A(\bar{e})) = \gamma \ln[1 + g(\bar{e})] + \ln[1 + \sigma^H - \Delta\mu^H(\bar{e})] + \ln \left[(1 - \bar{e} - \frac{1}{\lambda})(1+g)^{1-\gamma} + \frac{1}{\lambda\beta} \right] - \ln [L - (1 - \bar{e})\kappa]$$

Differentiating we get:

$$\begin{aligned} \frac{\partial \ln(A(\bar{e}))}{\partial \bar{e}} &= \gamma \frac{\partial \ln[1 + g(\bar{e})]}{\partial \bar{e}} - \frac{\frac{\partial \mu^H(\bar{e})}{\partial \bar{e}} \Delta}{1 + \sigma^H - \mu^H(\bar{e})(\sigma^H - \sigma^L)} \\ &\quad - \frac{(1+g)^{1-\gamma} - (1 - \bar{e} - \frac{1}{\lambda})(1 - \gamma)(1+g)^{-\gamma} \frac{\partial(1+g(\bar{e}))}{\partial \bar{e}}}{(1 - \bar{e} - \frac{1}{\lambda})(1+g) + \frac{1}{\lambda\beta}} - \frac{\kappa}{L - (1 - \bar{e})\kappa} \end{aligned}$$

As $0 \leq \lambda \leq 1$ and $\gamma \geq 1$ we have $\frac{\partial \ln(A(\bar{e}))}{\partial \bar{e}} < 0$. Then if the system composed by (38) and (39) has an interior solution, it is unique.

E.2.3 Existence

Now we need to find sufficient conditions for the existence of $\bar{e} \in [0, 1]$ that solves (40). Note that (40) is continuous in \bar{e} , then if the right hand side of (38) is smaller than ρ when $\bar{e} \rightarrow 1$, and positive at $\bar{e} = 0$, the existence of an interior solution is guaranteed.

The first condition will hold if:

$$\rho > -\frac{1 - \rho}{(\nu + 1)} + \frac{1}{\Gamma_0} [A(1) - (1 + \sigma^H)(1 - \tau)\sigma^L]$$

Note that, $\lim_{\bar{e} \rightarrow 1} \mu^H(\bar{e}) = \bar{\mu}^H = \frac{1 + \nu\rho}{\nu + 1}$, and $g(1) = 0$. Then:

$$A(1) = \left[1 + \sigma^H - \frac{1 + \nu\rho}{\nu + 1} \Delta \right] \left[\frac{1 - \beta}{\lambda\beta} \right] \frac{\kappa}{L}$$

We can then find the following condition on $\frac{\kappa}{L}$, the percentage of the labor force needed to enact all the projects of the economy:

$$b = \frac{\lambda\beta}{1-\beta} \left[\frac{\Gamma_0 \left(\rho + \frac{1-\rho}{\nu+1} \right) + (1+\sigma^H)(1-\tau)\sigma^L}{1+\sigma^H - \frac{(1+\nu\rho)\Delta}{\nu+1}} \right] > \frac{\kappa}{L}$$

Let's study now the case where $\bar{e} = 0$. We need:

$$\frac{1-\rho}{(\nu+1)}\Gamma_0 < A(0) - (1+\sigma^H)(1-\tau)\sigma^L$$

Note that, $\mu^H(0) = \underline{\mu}^H = \frac{1}{\nu+1}$, and $1+g(0) = \left[(1+\sigma^H)^{\underline{\mu}^H} (1+\sigma^L)^{1-\underline{\mu}^H} \right]^\lambda$. Then:

$$A(0) = \frac{[1+\sigma^H - \frac{\Delta}{1+\nu}] \left[(1 - \frac{1}{\lambda}) (1+g(0)) + \frac{(1+g(0))^\gamma}{\lambda\beta} \right]}{\left[\frac{L}{\kappa} - 1 \right]}$$

We can then find the following condition on $\frac{\kappa}{L}$:

$$a = \frac{\kappa}{L} > \frac{\frac{1-\rho}{(\nu+1)}\Gamma_0 + (1+\sigma^H)(1-\tau)\sigma^L}{[1+\sigma^H - \frac{\Delta}{1+\nu}] \left[(1 - \frac{1}{\lambda}) (1+g(0)) + \frac{(1+g(0))^\gamma}{\lambda\beta} \right] + \frac{1-\rho}{(\nu+1)}\Gamma_0 + (1+\sigma^H)(1-\tau)\sigma^L}$$

Then $\forall \frac{\kappa}{L} \in [a, b]$ we have existence and uniqueness of an interior solution. Finally, after solving for $\{e, g\}$ in equations (38) and (39), all the other variables can be recovered.

E.3 Recovering all Variables

$$\begin{aligned} (\mu_t^H)_{bgp} &= \mu^H = \frac{1}{\nu+1} \left[1 - \rho + \frac{\rho}{1-\bar{e}} (1 - \bar{e}^{\nu+1}) \right] \\ (r_{t+1})_{bgp} &= r = \frac{(1+g)^\gamma}{\beta} - 1 \\ (l_t^H)_{bgp} &= l^H = \frac{(1+\sigma^L) [L - (1-\bar{e})\kappa]}{1+\sigma^H - \mu_t^H(\sigma^H - \sigma^L)} \\ (l_t^L)_{bgp} &= l^L = \frac{(1+\sigma^H) [L - (1-\bar{e})\kappa]}{1+\sigma^H - \mu_t^H(\sigma^H - \sigma^L)} \\ \left(\frac{V_t^H}{Y_t} \right)_{bgp} &= v^H = \frac{(1-\tau)\sigma^H}{\beta \left[\lambda(1-\bar{e}) + \frac{1}{\beta} - 1 \right] (1+\sigma^H)} \\ \left(\frac{V_t^L}{Y_t} \right)_{bgp} &= v^L = \frac{(1-\tau)\sigma^L}{\beta \left[\lambda(1-\bar{e}) + \frac{1}{\beta} - 1 \right] (1+\sigma^L)} \\ \left(\frac{w_t}{Y_t} \right)_{bgp} &= w = \frac{[1+\sigma^H - \mu_t^H(\sigma^H - \sigma^L)]}{(1+\sigma^L)(1+\sigma^H) [L - (1-\bar{e})\kappa]} \\ \left(\frac{C_t}{Y_t} \right)_{bgp} &= c = 1 \end{aligned}$$

■

F Proposition 5 and Proposition 6

Proof.

F.1 Entry

F.1.1 Preliminaries

Define the parameter set of the model as $\Omega \equiv \{\rho, \tau, \sigma^H, \sigma^L, \gamma, \nu, \beta, \lambda, \kappa, L\}$. We can rewrite equation (40) as:

$$A(\bar{e}, \Omega) = C(\bar{e}, \Omega) \quad (41)$$

Where $A(\bar{e}, \Omega)$ is $A(\bar{e})$ from Appendix E and:

$$C(\bar{e}, \Omega) = (1 - \tau) \left[\left(\rho \bar{e}^\nu + \frac{1 - \rho}{\nu + 1} \right) \Delta + (1 + \sigma^H) \sigma^L \right]$$

Denoting the partial derivatives by sub indexes we have, for any fixed plausible set Ω satisfying the condition of Theorem 1, $\forall \bar{e} \in (0, 1)$:

$$\begin{aligned} A(\bar{e}, \Omega) &> 0 & ; & & A_{\bar{e}}(\bar{e}, \Omega) < 0 \\ C(\bar{e}, \Omega) &> 0 & ; & & C_{\bar{e}}(\bar{e}, \Omega) > 0 \end{aligned}$$

Then, using implicit derivative on equation 41 for \bar{e} and any parameter $p \in \Omega$ we get:

$$\frac{\partial \bar{e}}{\partial p} = \frac{A_p(\bar{e}, \Omega) - C_p(\bar{e}, \Omega)}{C_{\bar{e}}(\bar{e}, \Omega) - A_{\bar{e}}(\bar{e}, \Omega)} \Rightarrow \text{sign} \left(\frac{\partial \bar{e}}{\partial p} \right) = \text{sign} (A_p(\bar{e}, \Omega) - C_p(\bar{e}, \Omega))$$

F.1.2 Enacting cost κ

$$\begin{aligned} \text{sign} \left(\frac{\partial \bar{e}}{\partial \kappa} \right) &= \text{sign} (A_\kappa(\bar{e}, \Omega) - C_\kappa(\bar{e}, \Omega)) = \text{sign} (A_\kappa(\bar{e}, \Omega)) \\ &= \text{sign} \left(\frac{\partial \ln (A(\bar{e}, \Omega))}{\partial \kappa} \right) = \text{sign} \left(\frac{1 - \bar{e}}{L - (1 - \bar{e})\kappa} \right) \end{aligned}$$

We know by labor market clearing condition that $L - (1 - \bar{e})\kappa > 0$. Hence, we have $\frac{d\bar{e}}{d\kappa} > 0$, and entry decreases in the enacting cost κ .

F.1.3 Discount factor β

$$\begin{aligned} \text{sign} \left(\frac{\partial \bar{e}}{\partial \beta} \right) &= \text{sign} (A_\beta(\bar{e}, \Omega) - C_\beta(\bar{e}, \Omega)) = \text{sign} (A_\beta(\bar{e}, \Omega)) \\ &= \text{sign} \left(\frac{\partial \ln (A(\bar{e}, \Omega))}{\partial \beta} \right) = \text{sign} \left(\frac{-\frac{1}{\lambda \beta^2}}{(1 - \bar{e} - \frac{1}{\lambda})(1 + g)^{1-\gamma} + \frac{1}{\lambda \beta}} \right) \end{aligned}$$

As $\gamma \geq 1$ and given equation (27) we have: $(1 - \bar{e} - \frac{1}{\lambda})(1 + g)^{1-\gamma} + \frac{1}{\lambda\beta} > 0$. Hence, we have $\frac{d\bar{e}}{d\beta} < 0$, and entry increases in the discount factor β .

F.1.4 Corporate tax rate τ

$$\begin{aligned} \text{sign} \left(\frac{\partial \bar{e}}{\partial \tau} \right) &= \text{sign} (A_\tau(\bar{e}, \Omega) - C_\tau(\bar{e}, \Omega)) = \text{sign} (-C_\tau(\bar{e}, \Omega)) \\ &= \text{sign} \left(-\frac{\partial \ln(C(\bar{e}, \Omega))}{\partial \tau} \right) = \text{sign} \left(\frac{1}{1 - \tau} \right) > 0 \end{aligned}$$

Hence, we have $\frac{d\bar{e}}{d\tau} > 0$, and entry decreases in the corporate tax rate τ .

F.1.5 Accuracy ρ

$$\text{sign} \left(\frac{\partial \bar{e}}{\partial \rho} \right) = \text{sign} (A_\rho(\bar{e}, \Omega) - C_\rho(\bar{e}, \Omega))$$

Note first the following auxiliary results:

$$\begin{aligned} \frac{\partial \mu^H}{\partial \rho} &= \frac{1}{\nu + 1} \left[\frac{1 - \bar{e}^{\nu+1}}{1 - \bar{e}} - 1 \right] > 0 \\ \frac{\partial g}{\partial \rho} &= \frac{\partial g}{\partial \mu^H} \frac{\partial \mu^H}{\partial \rho} = (1 + g)\lambda(1 - \bar{e}) \ln \left(\frac{1 + \sigma^H}{1 + \sigma^L} \right) \frac{\partial \mu^H}{\partial \rho} > 0. \end{aligned}$$

Now, we have:

$$\begin{aligned} A_\rho(\bar{e}, \Omega) &= \frac{(1 + g) \frac{\partial \mu^H}{\partial \rho}}{\left[\frac{L}{\kappa} - (1 - \bar{e}) \right]} \left(\left(1 - \bar{e} - \frac{1}{\lambda} \right) \left(\lambda(1 - \bar{e}) \ln \left(\frac{1 + \sigma^H}{1 + \sigma^L} \right) [1 + \sigma^H - \Delta \mu^H] - \Delta \right) \right. \\ &\quad \left. + \left(\frac{(1 + g)^{\gamma-1}}{\lambda\beta} \left(\gamma\lambda(1 - \bar{e}) \ln \left(\frac{1 + \sigma^H}{1 + \sigma^L} \right) \right) [1 + \sigma^H - \Delta \mu^H] - \Delta \right) \right) = \frac{(1 + g) \frac{\partial \mu^H}{\partial \rho}}{\left[\frac{L}{\kappa} - (1 - \bar{e}) \right]} B(\bar{e}, \Omega) \end{aligned}$$

Then $\text{sign}(A(\bar{e}, \Omega)) = \text{sign}(B(\bar{e}, \Omega))$.

$$\begin{aligned} B_\rho(\bar{e}, \Omega) &= \left(1 - \bar{e} - \frac{1}{\lambda} + \frac{\gamma(1 + g)^{\gamma-1}}{\lambda\beta} \right) \lambda(1 - \bar{e}) \ln \left(\frac{1 + \sigma^H}{1 + \sigma^L} \right) [1 + \sigma^H - \Delta \mu^H] \\ &\quad - \left(1 - \bar{e} - \frac{1}{\lambda} + \frac{(1 + g)^{\gamma-1}}{\lambda\beta} \right) \Delta \end{aligned}$$

Note that $f(x) = x - \ln(1 + x)$ is increasing in x . This means that $\Delta > \ln \left(\frac{1 + \sigma^H}{1 + \sigma^L} \right)$. Hence, a sufficient condition for $A_\rho(\bar{e}, \Omega) < 0$ is:

$$\bar{e} \geq \bar{e}_A = 1 - \frac{1}{\lambda\gamma \left[1 + \frac{\sigma^L + \nu\sigma^H}{\nu+1} \right]}$$

Also note that:

$$C_\rho(\bar{e}, \Omega) = (1 - \tau)\Delta \left(\bar{e}^\nu - \frac{1}{\nu + 1} \right)$$

$C_\rho(\bar{e}, \Omega)$ is positive for $\bar{e} \geq \bar{e}_C = \left(\frac{1}{\nu+1}\right)^{\frac{1}{\nu}}$. Then we know that

$$\bar{e}(\rho) \geq \min \{ \max(\bar{e}_A, \bar{e}_C), 1 \} \equiv \bar{s} \Rightarrow \frac{\partial \bar{e}}{\partial \rho} < 0.$$

For $\bar{e} < \max(\bar{e}_A, \bar{e}_C)$, the sign of $\frac{\partial \bar{e}}{\partial \rho}$ is not clear. For example, for $\bar{e}(\rho) = 0$ we have $\frac{\partial \mu^H}{\partial \rho} = 0$, and hence $\frac{\partial \bar{e}}{\partial \rho} > 0$. This is quite intuitive, in fact, an economy performing no selection will have increasing incentives to select when they gain access to better screening technology. Nevertheless, we can also find a sufficient condition for $\frac{\partial \bar{e}}{\partial \rho} > 0$. First, a sufficient condition for $B_\rho(\bar{e}, \Omega) > 0$ is given by:

$$\bar{e} \leq \underline{e}_A = 1 - \frac{\Delta}{\lambda \gamma \ln \left(\frac{1+\sigma^H}{1+\sigma^L} \right) \left[1 + \frac{\nu \sigma^H + \sigma^L - \Delta \rho \nu}{\nu + 1} \right]}$$

Note that $\underline{e}_A < \bar{e}_A$. Then we know that

$$\bar{e}(\rho) \leq \max \{ 0, \min(\underline{e}_A, \bar{e}_C) \equiv \underline{s} \} \Rightarrow \frac{\partial \bar{e}}{\partial \rho} > 0.$$

Note that κ does not enter in \bar{s} or \underline{s} but it affects \bar{e} monotonically. So, economies with high κ , characterized by a high \bar{e} and a low entry rate, are likely to increase entry when ρ increases, but economies with low κ do just the opposite. We explore this margin on the quantitative illustration of the mechanism.

F.2 Growth

1. Given the former results and that $\frac{\partial g}{\partial \bar{e}} < 0$, we can easily show:

$$\begin{aligned} \frac{\partial g}{\partial \kappa} &= \frac{\partial g}{\partial \bar{e}} \frac{\partial \bar{e}}{\partial \kappa} < 0 \\ \frac{\partial g}{\partial \beta} &= \frac{\partial g}{\partial \bar{e}} \frac{\partial \bar{e}}{\partial \beta} > 0, \\ \frac{\partial g}{\partial \tau} &= \frac{\partial g}{\partial \bar{e}} \frac{\partial \bar{e}}{\partial \tau} < 0 \end{aligned}$$

2. We can also study:

$$\frac{\partial g}{\partial \rho} = \underbrace{\frac{\partial g}{\partial \bar{e}}}_{<0} \underbrace{\frac{\partial \bar{e}}{\partial \rho}}_{?} + \underbrace{\frac{\partial g}{\partial \mu^H} \frac{\partial \mu^H}{\partial \rho}}_{>0}.$$

Note that $\frac{\partial \bar{e}}{\partial \rho} < 0 \Rightarrow \frac{\partial g}{\partial \rho} > 0$.

F.3 Composition

1. From previous results:

$$\begin{aligned}\frac{\partial \mu^H}{\partial \kappa} &= \frac{\partial \mu^H}{\partial \bar{e}} \frac{\partial \bar{e}}{\partial \kappa} > 0 \\ \frac{\partial \mu^H}{\partial \beta} &= \frac{\partial \mu^H}{\partial \bar{e}} \frac{\partial \bar{e}}{\partial \beta} < 0, \\ \frac{\partial \mu^H}{\partial \tau} &= \frac{\partial \mu^H}{\partial \bar{e}} \frac{\partial \bar{e}}{\partial \tau} > 0\end{aligned}$$

2. We can also study:

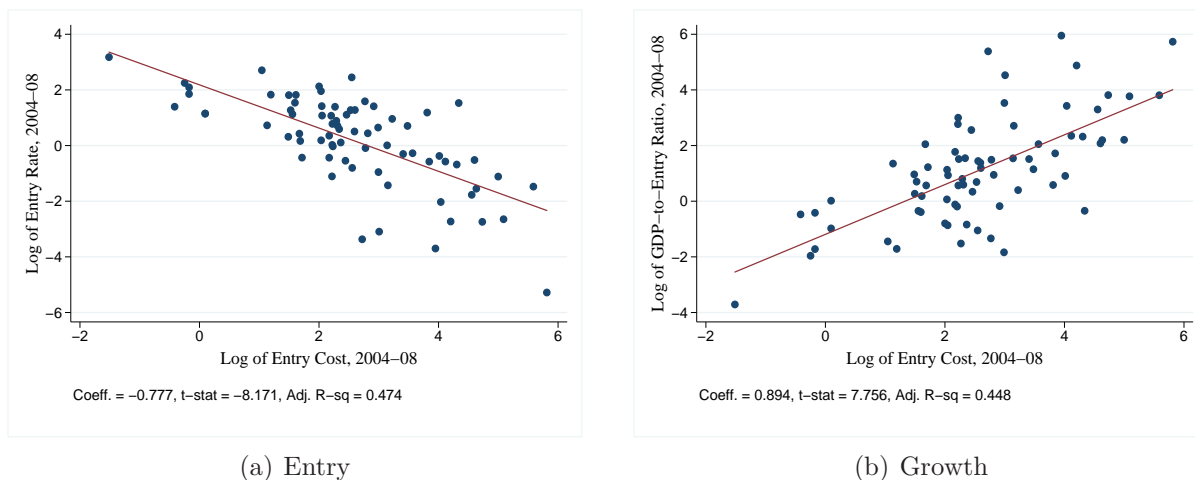
$$\frac{\partial \mu^H}{\partial \rho} = \underbrace{\frac{\partial \bar{e}}{\partial \rho}}_{?} \underbrace{\frac{\partial \mu^H}{\partial \bar{e}}}_{>0} + \underbrace{\frac{1 - \bar{e}^{\nu+1}}{1 - \bar{e}} - 1}_{>0}$$

Note that $\frac{\partial \bar{e}}{\partial \rho} > 0 \Rightarrow \frac{\partial \mu^H}{\partial \rho} > 0$

■

G Cost of Starting a Business, Entry, and Growth

Figure (4) uses World Bank data for a set of 74 countries to illustrate the effect of entry cost on both entry and composition. Left panel of Figure (4) plots the natural logarithm of entry rate against the natural logarithm of the average start-up cost as a percentage of per capita Gross National Income over the years 2004-2008. The right hand panel plots the average growth in GDP per capita divided by the entry rate of each country against the same measure of cost enacting used on the left hand side. Figure (4) clearly states that growth



(a) Entry

(b) Growth

Figure 4: Corporate Taxes, Entry and Growth

and entry costs are negatively correlated, but, the average growth contribution of entrants is positively correlated with the entry costs. In this sense, higher entry cost is correlated with lower growth but with higher composition.

H Private Credit, Entry, and Growth

Figure (5) uses World Bank data for a set of 74 countries to illustrate the effect of domestic credit on both entry and composition. The left panel plots the natural logarithm of entry rate against the natural logarithm of the credit to the private sector scaled by the entry cost over the years 2004-2008.⁴⁵ The right hand panel plots the average growth in GDP per capita divided by the entry rate of each country against the same measure of credit availability used on the left hand side.

⁴⁵The World Bank provides a measure for the average cost of the start up procedures as a fraction of the Gross National per capita Income (say C). They also provide private credit as a fraction of GDP (say S). Then we build our proxy of the availability of funds in country j as $L_j * \frac{S_j}{C_j} * P$, where P is a scalar.

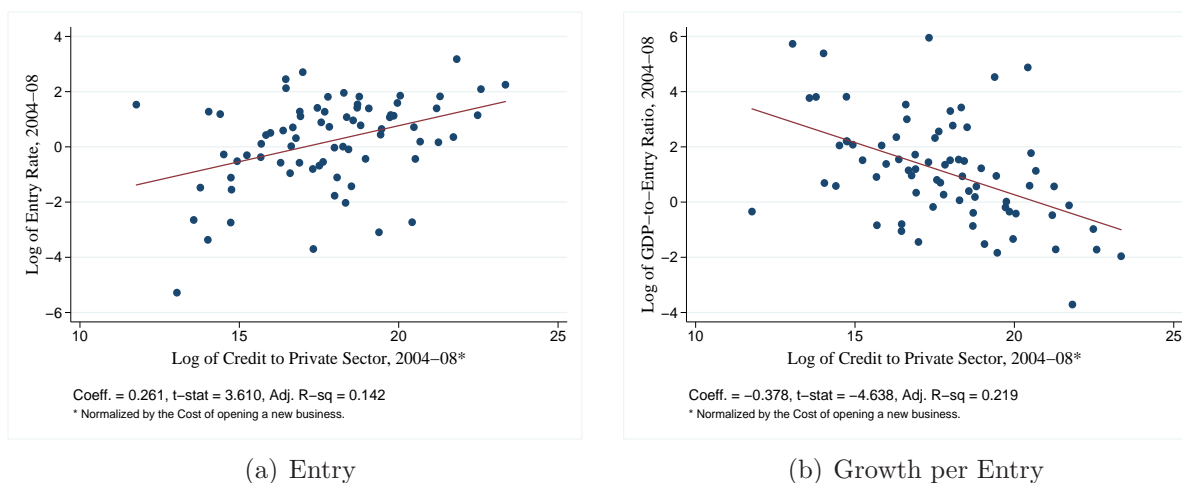


Figure 5: Credit, Entry and Growth

If we assume that domestic credit adjusted by entry cost is a good proxy for the availability of credit, both figures provide an empirical illustration for the analytical results of Proposition 5 about β . Nevertheless, a more formal econometric approach is needed, since economic growth and private credit are in general negatively related.

I Corporate Tax, Entry, and Growth

As argued on the main text, empirical research points to a strong and significant effect of taxation in firm entry, nevertheless, the effect of taxation in long run growth is practically insignificant. Figure (6) uses cross country data to illustrate this puzzle: Left panel of figure

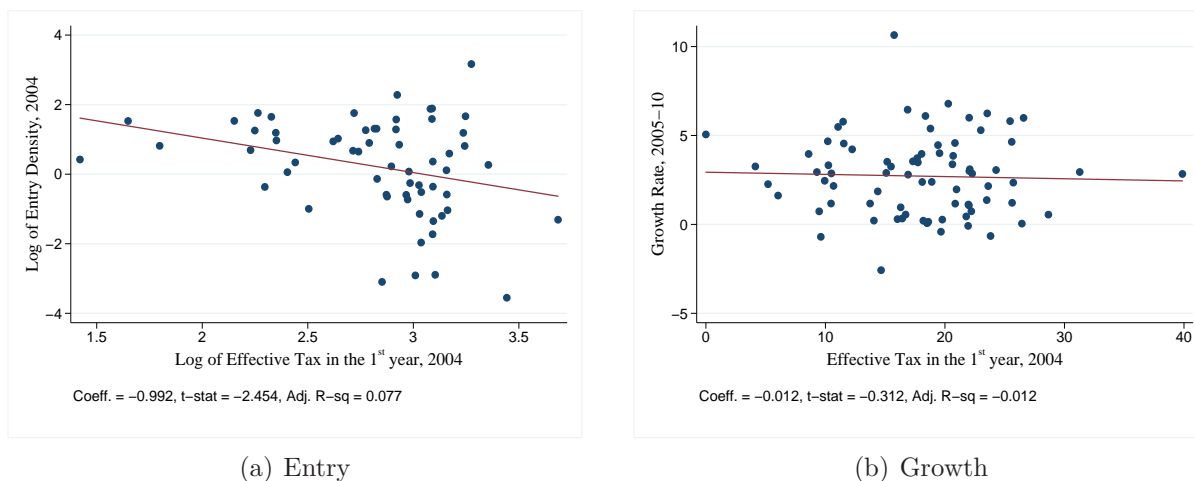


Figure 6: Corporate Taxes, Entry and Growth

(6) plots the natural logarithm of entry density against the logarithm of effective first year

corporate tax rates in 2004 for a set of 60 countries.⁴⁶ The right panel shows the relationship between the average growth rates of the next five years and effective first year corporate tax rates. It is easily discernible that higher corporate tax rates are associated with lower entry rates whereas there is no clear effect on the 5-year average of growth rates. According to our model, the explanation lies on project heterogeneity and financial selection: higher taxation induces stronger selection which reduces entry significantly decreasing the direct effect of a larger cohort, nevertheless, tighter selection also implies a better composition of the incoming cohort which might offset an important part of the negative effect on growth.

J Alternative Parametrization

Table 3 presents an alternative parametrization of the model. The only change compared to the parametrization in Table 1 is the increase in κ from 0.12 to 0.2. Table 4 presents the

Table 3: Parameter Values

κ	λ	σ^L	σ^H	β	ν	ρ	γ	τ	L
0.2	0.25	0.095	0.45	0.95	5	0.9	2	0.3	1

main long run of the model under this alternative parametrization. In line with Proposition

Table 4: Output of the Model

\bar{e}	μ^H	$\lambda(1 - \bar{e})$	g	r	$\frac{\kappa w}{Y}$	$\kappa(1 - \bar{e})$	$Av.(\sigma)$	$Sd.(\sigma)$	$Sk.(\pi)$
0.7337	0.4921	0.0666	0.0154	0.0852	0.1697	0.0533	0.2697	0.1775	0.0317

5, the higher level of κ implies more selection, hence less entry and a higher proportion of high type leaders among the incumbents, but also a lower long run growth rate. Note that all the aggregates are still in their empirical ranges for developed economies with the only exception of the skewness in the profit distribution.

⁴⁶The data for effective rates of corporate taxes in the first year of a firm is available in Djankov et al. (2010).

J.1 Corporate Taxation, Firm entry and Growth

Figure 7 shows long run responses comparable with Figure 2 on the main text. Qualitatively,

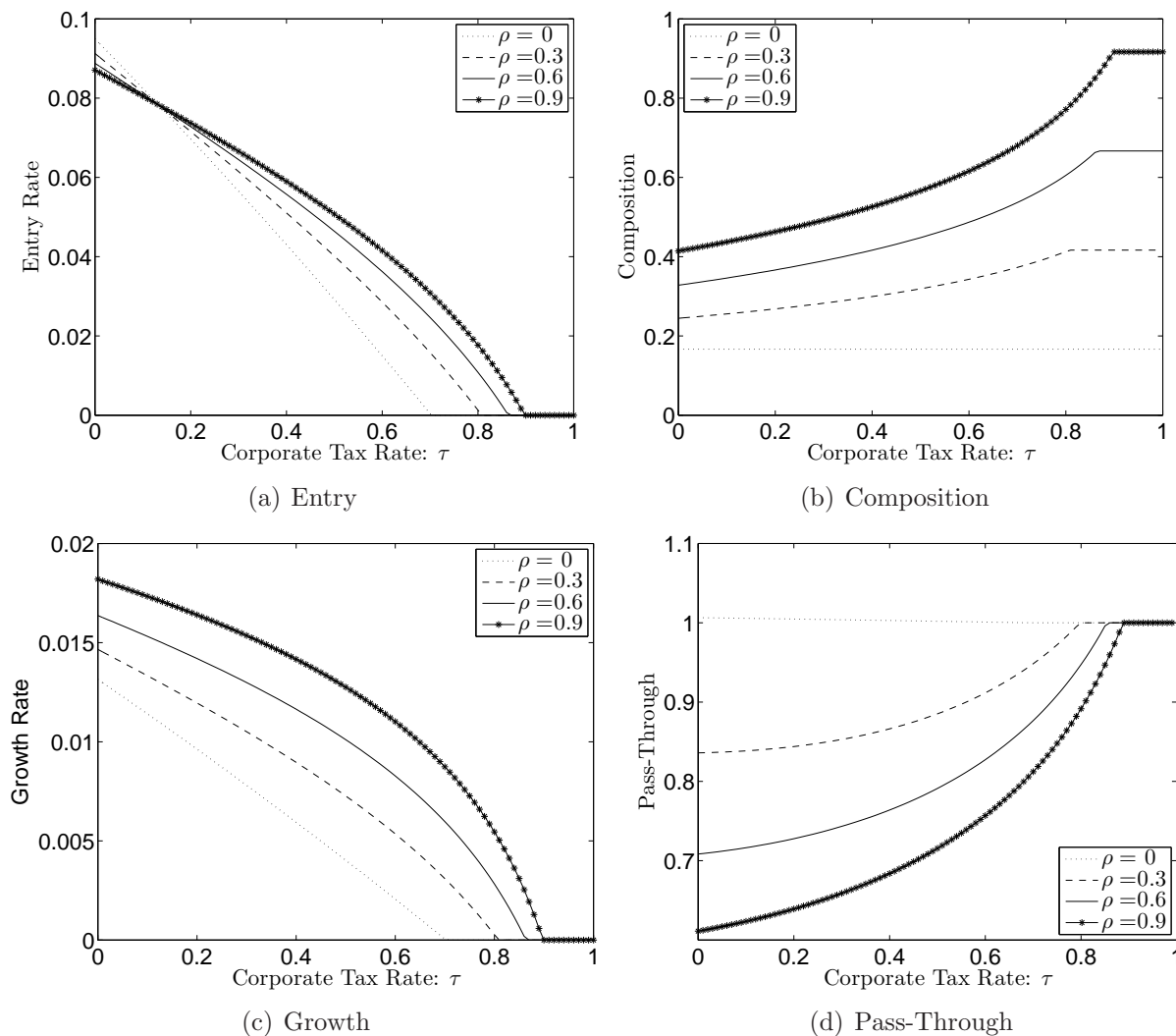


Figure 7: The Effect of Corporate Taxation on Growth and Entry

Figure 7 exhibits the same responses as Figure 2, both in line with the analytics results in Proposition 5. The main difference is that less financially developed economies are never able to grow more than more developed ones. In fact, the higher entry costs imply that even with zero taxation the entry rate is in the range where financial development leads to more entry, as seen in Proposition 6. Hence, more financially developed economies dominate less developed ones in both, mass and composition margins.

J.2 Financial Development and Resource Allocation

Figure 8 shows long run responses comparable with Figure 3 on the main text. The main

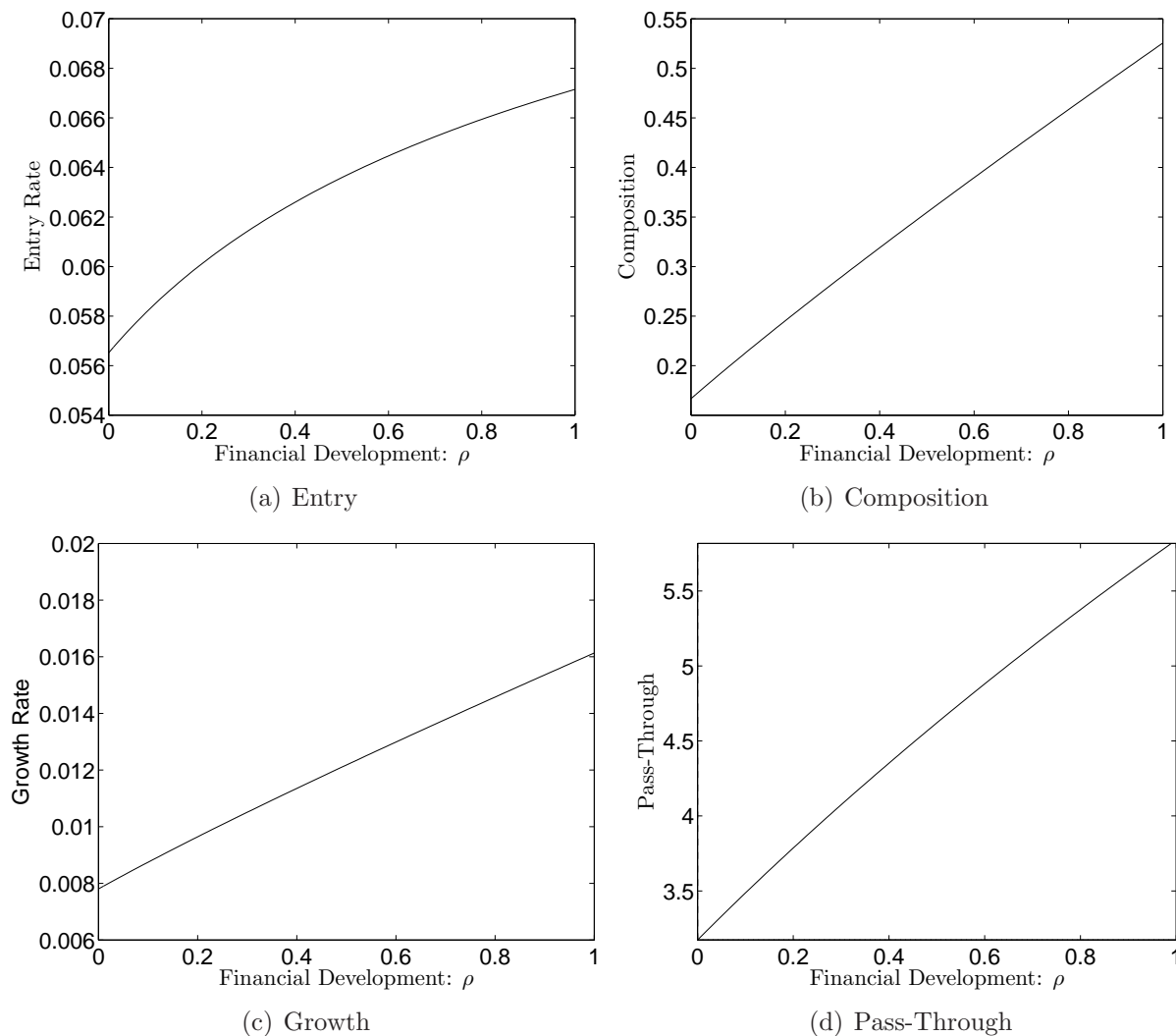


Figure 8: The Effect of Financial Development on Growth and Entry

difference with respect to the baseline parametrization is the response of the entry rate to financial development. In fact, Figure 8(a) displays an increasing entry rate in ρ , in line with the low entry level region of Proposition 6. This means that the mass effect contributes positively to growth. Composition now is subject to two effects, a direct positive effect given the increase in ρ and an indirect negative effect coming from the increase of the entry. The second effect dominates and hence, mass and composition stimulate economic growth when financial development increases. Also note that, the entry rate increases at decreasing rates, hence for high levels of financial development most of the growth comes from the composition margin, just as in the main text. In fact, Figure 8(d) shows the same pattern than Figure 3(d), the absolute value of the growth-entry Pass-Through is increasing in ρ .