Fewer but Better:  
Sudden Stops, Firm Entry, and Financial Selection

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Abstract

In this paper, we build an endogenous growth model into a stochastic small open economy framework to study the long-run economic cost of a sudden stop. In this economy, productivity growth is determined by successful implementation of business ideas, yet the quality of ideas is heterogeneous and good ideas are scarce. A representative financial intermediary screens and selects the most promising ideas, which gives rise to a trade-off between mass (quantity) and composition (quality) in the entrant cohort. Chilean firm-level data from the sudden stop triggered by the Russian sovereign default in 1998 confirms the main mechanism of the model, as firms born during the credit shortage are fewer, but better. A calibrated version of the economy shows the importance of accounting for heterogeneity and selection, as otherwise the permanent loss of output generated by the forgone entry after a 100 basis point increment in the interest rate is overestimated by 45%.

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1 Introduction

In August 1998, the Russian sovereign default triggered a violent sudden stop in the developing world.¹ Interest rate spreads for the seven biggest Latin American economies tripled in the weeks after this crisis, decreasing the availability of external funding by 40% between 1998 and 2002.² Most of the economic analysis of these crises of interest rate spreads is centered on the short-run detrimental effects that they imposed on the real economy. Nevertheless, cross-country empirical studies have documented persistent output losses associated with large economic downturns, due to permanent losses in total factor productivity.³ Because firm entry is an important driver of productivity growth, and because start-ups are in need of external funding, distortions in firm entry are likely to cause part of this long-run cost.⁴

Evaluating the cost of forgone entry is not an easy task. On the one hand, behind every firm lies an entrepreneur’s idea, and ideas are not born alike. In fact, drastic innovations are a scarce resource.⁵ On the other hand, because the financial system does not allocate funding randomly, not every idea has the same chance of being granted an opportunity.⁶ Not surprisingly, when resources are scarce, banks adopt higher lending standards, and fund only the most promising projects.⁷ Therefore, the better the financial system is at picking the most promising start-ups, the higher will be the average contribution of this smaller cohort. The main novelty of this paper is the recognition that the scarcity of good ideas and the presence of financial selection induces a trade-off between the size of the entrant cohort and the average contribution of each firm within that cohort to aggregate productivity. Consistent with this intuition, we show empirically that firms born during a sudden stop are fewer, but better. Failure to consider this trade-off would imply that discarded projects are just as productive as actual entrants, magnifying the productivity cost of a crisis, and potentially misleading public policy. Thus, the ability of the financial system to allocate resources between heterogeneous projects needs to be taken into account when facing the main question of this paper: what is the productivity cost of the forgone entry during a sudden stop?

An innovative model is then needed to answer this question, specifically one that allows us to separate and quantify the effects of the size and the quality of the entrant cohort on the long-run

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¹A sudden stop in capital flows is a large and abrupt decrease in capital inflows, characterized by jumps in sovereign spreads and quick reversals of current accounts deficits.
²These numbers are from Calvo and Talvi (2005).
³See, for instance, Cerra and Saxena (2008), Blyde et al. (2010), and Queralto (2013).
⁴The importance of the entry margin is discussed by Bartelsman et al. (2009), and Nofsinger and Wang (2011) document how start-ups are in need of external funding; see Section 2 for details. Moreover, Klapper and Love (2011) use a cross-country panel of 91 countries to document a 25% decrease in business formation during the Great Recession of 2008 − 2009.
⁵For the heterogeneity and scarcity of ideas, see Scherer (1998), and Silverberg and Verspagen (2007), among others.
⁶The masterful survey on financial development and growth by Levine (2005) discusses the allocative function of the financial system.
productivity loss. Three ingredients are fundamental to building an appropriate model: (i) generating a sudden stop requires a small open economy subject to stochastic interest rate fluctuations; (ii) creating a connection between these short-run episodes and the long-run level of productivity implies that growth has to be endogenous; and, (iii) a meaningful selection margin requires a financial intermediary that allocates resources among heterogeneous projects. The next paragraph digs deeper into the structure of this model.

In a nutshell, aggregate productivity in this economy evolves following a Schumpeterian concept of growth, where new firms (entrants) replace established firms (incumbents). In particular, because new intermediate goods producers are more productive than incumbents, Bertrand monopolistic competition implies that the newcomer sets a price that forces the old incumbent to exit. In order to study the role of financial selection in firm entry and productivity accumulation during a sudden stop, three main innovations are added to this traditional endogenous growth framework. The first variation introduces \textit{ex-ante} and \textit{ex-post} heterogeneity in productivity improvements. A representative financial intermediary owns business plans that can generate either a drastic or a marginal productivity improvement in the production technology of an intermediate variety. Every project is characterized by its idiosyncratic probability distribution over those two outcomes. Hence, projects are \textit{ex-post} heterogeneous in terms of the productivity advantage that they enjoy after entering an industry, and they are also \textit{ex-ante} heterogeneous with respect to their idiosyncratic probability of generating a drastic innovation. This ingredient allows us to model the underlying scarcity of the economy, where only a few ideas are highly likely to give birth to outstanding incumbents. The second addition adds an imperfect screening device to the model. The financial intermediary cannot unveil the \textit{ex-ante} heterogeneity of its projects but it can observe noisy signals of their potential. The optimal allocation of funding follows a cut-off rule based on the signal. This ingredient introduces a linkage between the size of the entrant cohort and the average efficiency gain generated by its members. In fact, periods of laxer credit standards (low cut-off) are characterized by a larger cohort and lower average efficiency gains. The strength of this link and its implications for entry and productivity are determined by the accuracy of the screening device of the financial system. The third modification incorporates elements from the stochastic small open economy literature. This feature introduces economic dynamics into an otherwise deterministic model. Note that, since the financial intermediary borrows at the stochastic interest rate to finance start-ups, interest rate shocks trigger entry and productivity dynamics that are absent in a traditional open economy framework. The model has a unique non-stochastic interior balanced growth path that allows for quantitative solutions of the stochastic dynamic equilibrium. In the model economy, a mass/composition trade-off (that is, a quantity/quality trade-off) arises at the cohort level: periods of high interest rates are characterized by high credit standards that give rise to smaller cohorts with higher expected average productivity.

The empirical section of this paper studies the Chilean sudden stop to validate the trade-off between mass and composition at the core of the model. We focus on Chile for three reasons: (i) it is
a small open economy; (ii) we have access to plant level data for Chilean manufacturing firms, which allows us to directly study entrant cohorts; and, (iii) -as argued by Calvo et al. (2006)- the sudden stop after the Russian sovereign default is mainly exogenous to the Chilean economy. We show that firm entry in Chile from 1996 to 2007 decreased by 40% during the sudden stop, even at the three digit industry level. However, firms born in crisis are not just fewer, they are also better. In fact, the econometric analysis in Section 4 shows that cohorts born in crisis are 14.4% more profitable than cohorts born in normal times.

In the quantitative section of the paper, we calibrate the model to the Chilean economy between 1996 and 2007. We then use the Chilean sudden stop to assess the performance of the model, fitting the real interest rate faced by the country during this episode. Although the model is stylized, with its single shock it is able to approximate the non-targeted behavior of the macro aggregates during the crisis. For example, the model can explain 80% of the decrease in hours, consumption, and firm values. Moreover, entry rate falls by 25% in the model during the crisis, and the average profitability for those cohorts increases by 7%. Hence, this parsimonious model can account for roughly 65% of the decrease in entry and more than 45% of the increase in profitability of entrants documented in the empirical section. After validating the model, we introduce two modified economies in order to assess the role of heterogeneity and selection in shaping the effect of a sudden stop: a model with exogenous growth, and a model with endogenous growth but no heterogeneity. We use those alternative economies to highlight the role of firm entry and financial selection when the economy is hit by a shock that increases the interest rate by 100 basis points.

Three important features arise from the comparisons of these models. First, acknowledging the endogeneity of technological progress amplifies the short-run effects of a crisis. For instance, the baseline model amplifies the effects of a sudden stop in output by 15%, compared to the model with exogenous growth. Second, including heterogeneity among intermediate goods producers triggers compositional dynamics that increase the short-run persistence of these episodes. Third, distortions in the entry margin trigger permanent losses in output in the models with endogenous technological change. The composition margin dramatically shapes the long-run cost of these short-run crises. In fact, the model with no heterogeneity generates a permanent loss in output of 0.8%, while, in the baseline model, the long-run permanent loss in output is 0.55%. Thus, if we ignore the existence of heterogeneity and selection and judge the forgone entry using successful start-ups as the measure, then the cost of the forgone entry is overestimated by 45%. This is a large economic magnitude that can bias public policy during a crisis toward entry subsidies or indiscriminate government lending.

The structure of the paper is as follows. The next section (Section 2) revisits both the empirical literature that motivates the main mechanism of the paper and the theoretical literature to which our model contributes. Section 3 introduces our model and characterizes the existence and uniqueness of an interior balanced growth path. Section 4 presents the analysis of the Chilean economy as a natural experiment for the model, exploring at the macro and micro level the consequences of the sudden stop.
for the Chilean economy. Section 5 presents the calibration of the model and the quantification of the long-run cost of a sudden stop. Finally, Section 6 concludes the paper and suggests avenues for future research.

2 The Mechanism and the Literature

Increasing attention has been driven to the lack of recovery from large economic downturns. For instance, Cerra and Saxena (2008) document highly persistent output losses associated with a variety of economic crises. In their main specification, less than one percentage point of the deepest loss in output is regained after a decade. In this sense, the neoclassical catch-up intuition, where stationary fluctuations have no long-run effects on output, would be just a myth. Queralto (2013) uses the same methodology to show that financial crises have long-lasting effects on labor productivity. Blyde et al. (2010) focus their analysis on measured total factor productivity (TFP).8 They document large and persistent TFP losses associated with output collapses characterized by negative interest rate shocks. Therefore, they suggest that a long-run loss of productivity triggered by those episodes could explain the myth of economic recovery. In this paper, we explore how financial crises generate long run costs by disrupting the process of firm creation.

In the Schumpeterian concept of long-run growth, firm entry is a powerful engine of productivity gains as more efficient entrants replace less productive incumbents. The importance of this margin is confirmed by the empirical literature. Bartelsman et al. (2009) perform a cross-country firm level productivity decomposition that suggests that the entry margin accounts for 20% to 50% of labor productivity growth for the 15 countries in their sample. Then, if a sudden stop affects the entry of new firms, it could potentially reduce the productivity level of the economy. What can we infer about this link from the empirical literature?

On the one hand, cross-country entrepreneurial data points to external financing as an important source for start-up capital. For instance, Nofsinger and Wang (2011) document that, in their entrepreneurial dataset for 27 countries, 41% of start-up capital on average comes from external financing. Therefore, periods characterized by low availability of funds could dramatically reduce the size of the entrant cohort and dampen aggregate productivity. On the other hand, ideas are heterogeneous, and good projects are scarce. In fact, the empirical study by Silverberg and Verspagen (2007) shows a highly skewed distribution of citation of patents, and Scherer (1998) derives the same pattern from the distribution of profits related to innovation. Hence, ideas are not born equal, even before entering an industry; projects are heterogeneous, and success is scarce among them. Therefore, in order to assess the cost of difficult financial times, it is fundamental to understand which ideas are being discarded.

The fundamental question is then, how good is the financial system at selecting the most promising

8They measure TFP using a Solow residual approach.
projects? In fact, if the financial system just randomly allocates credit, then promising projects are just as likely to be accepted as mediocre ones. Accordingly, in a financial crisis, many good projects would be dismissed and the productivity loss would be considerable. But the empirical literature suggests that the financial system is in fact quite able to assess the quality of different projects. In particular, Jayaratne and Strahan (1996) use the relaxation of bank branch restrictions in the United States to study the effects of competition on growth. Their main finding is that competition induced a tighter selection in lending instead of augmenting the availability of resources, so the increase in the average quality of entrants implied higher growth in the liberalized states. Dell’Ariccia et al. (2012) also provide evidence of financial selection. Using data from rejection rates during the sub-prime mortgage crisis, they find evidence of systematic changes in credit standards, even after controlling by the quality of the pool. Moreover, they point to a trade-off between the volume of credit granted and the average quality of those loans. Therefore, the financial system has the ability to willingly affect the average quality of the projects that are financed.

In a nutshell, the main motivation of the economic mechanism that drives our model is drawn from recent empirical research. In fact, if projects are heterogeneous and good ideas are scarce, because loans for start-ups are not given randomly, the expected contribution of the forgone projects should be considerably lower than the average contribution of the entrant cohort. Therefore, the long-run cost of a financial crisis is strongly related to the ability of the financial system to select the most promising projects.

On theoretical grounds, we build an endogenous growth model, where ex-ante heterogeneous projects materialize in ex-post heterogeneous firms with a financial system that screens and selects the more promising projects. We nest this model in an open economy stochastic framework in order to study the effects that external shocks to the interest rate trigger on the mass and composition of the entrant cohort, and, thus, on the aggregate productivity of the economy. The latter implies that we can relate to at least two distinct strands of literature.


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9 Jimenez et al. (2009) show how banks react to changes in the cost of funding, adjusting the standards used for rejection; in particular, a lower overnight interest rate is associated with more loans to firms with higher ex-post probability of default.
the pro-cyclical nature of research and development expenditure, and studies optimal research subsidies throughout the economic cycle.

This paper makes at least two contributions to the existing literature. First, it formalizes the intuition that good ideas are scarce and that the financial system does not select projects randomly. Second, it includes a link between \textit{ex-ante} and \textit{ex-post} heterogeneity that allows a meaningful composition discussion. There have been diverse attempts to include \textit{ex-ante} heterogeneity and selection in the three main frameworks of endogenous growth models. Examples include Bose and Cothren (1996) in the Romer (1986) tradition, Jaimovich and Rebelo (2012) in the Romer (1990) framework, and King and Levine (1993) in the Schumpeterian tradition.\footnote{See Ates and Saffie (2013) for more details.} Nevertheless, since there is no \textit{ex-post heterogeneity} in those models, no compositional dynamics arise. Moreover, those models are fully deterministic, and hence cannot study the long-run cost of a financial crisis.

Secondly, it builds on the framework of Mendoza (1991) for real business cycles models in small open economies. In particular, we build on the models of Neumeyer and Perri (2005) and Uribe and Yue (2006) to include endogenous growth, heterogeneity, and financial selection.\footnote{Aguiar and Gopinath (2007), document that developing small open economies exhibit substantial volatility in trend growth. This suggests that a model with a deterministic trend is not appropriate for those countries. Nelson and Plosser (1982) show that, even for the US, the hypothesis of a stochastic trend component cannot be rejected.} A recent paper by Queralto (2013) also includes an endogenous growth framework in a small open economy model. The endogenous growth model at the core of that paper is the framework that Comin and Gertler (2006) build around Romer (1990). Queralto (2013) studies the long lasting productivity effects of a financial crisis; in particular, in his model an interest rate shock triggers a balance sheet channel, as in Gertler and Kiyotaki (2010), which harms the process of invention and implementation. Ergo, fewer firms enter the market and fewer ideas are developed for future use. The first effect amplifies the impact of the crisis, and the second effect delays the recovery. Another recent paper by Gornemann (2013) combines the endogenous default framework of Mendoza and Yue (2012) with the variety model of Romer (1990) to study how endogenous growth affects the decision of the sovereign to default. Because default increases the price of imported intermediate goods in his model, it decreases the expected profits of potential entrants, and hence, depresses productivity growth. Besides the Schumpeterian framework of our model and the focus on financial selection, we have two other differences with respect to those articles. First, there is no heterogeneity in either of them, so the only driver of growth is the mass of entrants, and therefore no compositional dynamics can arise. Second, we use firm level data to support our channel, calibrate the model, and assess its performance.

Finally, a related literature has focused on the short-run reallocation effects of recessions between incumbent firms. These articles point to three different effects. First, recessions facilitate the exit of less productive incumbents (\textit{cleansing effect}). Second, these downturns destroy promising firms before they mature (\textit{scarring effects}). Third, market frictions dampen the efficient allocation of the resources freed
by the exiting firms ("sullying effect"). This paper differs in two aspects from that literature. Firstly, its main focus is on the contribution to aggregated productivity of the entry margin during financial crises. A recent empirical study by Hallward-Driemeier and Rijkers (2011) evaluates the different effects of recessions using firm level data from Indonesia during the Asian crisis of 1997. They do not find conclusive evidence of better reallocation among incumbents. Nevertheless, the data does show that during that crisis entrants were fewer, but better. In particular, the contribution to labor productivity of those smaller cohorts was significantly higher. Secondly, the aim of this paper is to characterize the long-run effects of those short-run crises, a question that cannot be explored with models that do not account explicitly for the endogenous evolution of productivity. The next Section introduces a model that explicitly accounts for the link between short-run crises and long-run productivity.

3 Model

In this section, we introduce a tractable endogenous growth model with heterogeneity and financial selection, for a small open economy, subject to exogenous interest rate shocks. Aggregate productivity in this economy is modeled in the Grossman and Helpman (1991) and Aghion and Howitt (1992) tradition. This means that we follow a Schumpeterian concept of growth, where new firms (entrants) replace established firms (incumbents). In particular, because new intermediate goods producers are more productive than incumbents, Bertrand monopolistic competition implies that the newcomer sets a price that forces the old incumbent to exit. In order to study the role of financial selection in firm entry and productivity during a sudden stop, three main innovations are added into this traditional endogenous growth framework.

The first variation introduces ex-ante and ex-post heterogeneity in productivity improvements. A representative financial intermediary owns business plans (projects or potential firms) that can generate either a drastic (H) or a marginal (L) productivity improvement (step size) in the technology for producing a particular variety of an intermediate good. Every project is characterized by its idiosyncratic probability distribution over those two outcomes. Hence, projects are ex-post heterogeneous in terms of the productivity advantage that they enjoy after entering the business (\{H, L\}), and they are also ex-ante heterogeneous with respect to the idiosyncratic probability of generating a drastic innovation \(P^H \in (0, 1)\). This first ingredient allows us to model the underlying scarcity of the economy, where only few ideas are very likely to give birth to outstanding incumbents.

The second addition to the framework introduces an imperfect screening device to the model. The financial intermediary cannot unveil the ex-ante heterogeneity of its projects, but it can observe noisy signals of their potential. The optimal allocation of funding follows a cut-off rule based on the signal.

13A detailed review of this literature can be found in Aghion et al. (2013).
This ingredient introduces a linkage between the size of the entrant cohort and the average efficiency gain generated by its members. In fact, periods of laxer credit standards (low cut-off) are characterized by larger cohort and lower average step sizes. The strength of this link and its implications for entry and productivity are determined by the accuracy of the screening device of the financial system.

Finally, the third modification follows the framework of Mendoza (1991) to introduce exogenous interest rate shocks into the model. This feature introduces economic dynamics into an otherwise deterministic model. Note that, because the financial intermediary borrows at the stochastic interest rate to finance start-up businesses, interest rate shocks trigger entry and productivity dynamics that are absent in a traditional open economy framework. The next sub-section introduces the model, defines an equilibrium for this economy and proves the existence and uniqueness of an interior balanced growth path (BGP).

3.1 Model Components

Time is discrete in this economy. We denote a history \((s_0, s_1, ..., s_t)\) by \(s^t\), where \(s^t\) contains all the relevant past information that agents need in period \(t\) to make decisions. For instance, \(Y(s^t)\) is the output at period \(t\) under history \(s^t\), but, because capital used in production at time \(t\) is decided at \(t-1\), we index it by \(s^{t-1}\).

3.1.1 Final Good Producer

There is a representative final good producer that combines intermediate inputs \(\{X_j(s^t)\}_{j \in [0, 1]}\), indexed by \(j \in [0, 1]\), with capital \((K(s^{t-1}))\), to produce the only final good of this economy \((Y(s^t))\). The constant return to scale production function is given by:

\[
\ln Y(s^t) = \alpha \int_0^1 \ln X_j(s^t) dj + (1 - \alpha) \ln K(s^{t-1}). \tag{1}
\]

Equation (1) is an extension of a standard Cobb-Douglas production function, where \(\alpha\) determines the production share of intermediate varieties. Production is subject to a working capital constraint. In particular, the final good producer needs to hold a proportion \(\eta > 0\) of the intermediate goods bill before production takes place. To do so, he borrows at the interest rate at the beginning of the period and pays back just after production takes place. \(\text{Uribe and Yue (2006) show that this constraint can be summarized as a wedge in the cost of the input. In particular, given input prices } (p_j(s^t)), \text{ interest}

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\(^{14}\) The open economy part of the model follows closely Neumeyer and Perri (2005) and Uribe and Yue (2006) articles.

\(^{15}\) This is a standard modeling assumption in the open economy literature. It is mostly used to amplify interest rate shocks using a labor channel. The main mechanism of the model does not need this feature; in fact, as Appendix E shows, the long-run effect of this channel is negligible. We include it only to compare the baseline model with a standard open economy model with exogenous growth.
rate \((R(s^t) - 1)\), and utilization cost of capital \((r(s^t))\), the final good producer demands intermediate goods and capital in every period in order to solve:

\[
\max_{\{X_j(s^t)\}_{j \in [0,1]}, K(s^{t-1})} \left\{ Y(s^t) - \left(1 + \eta(R(s^t) - 1) \right) \int_0^1 X_j(s^t)p_j(s^t) dj - K(s^{t-1})r(s^t) \right\}
\]

where the final good price is used as the numeraire. An interior solution to (2) is characterized by the following set of first order conditions:

\[
X_j(s^t) = \frac{\alpha Y(s^t)}{p_j(s^t)(1 + \eta(R(s^t) - 1))}
\]

\[
K(s^{t-1}) = \frac{(1 - \alpha)Y(s^t)}{r(s^t)}.
\]

Both demands are unit elastic; in particular, a monopolist facing the demand in equation (3) would choose \(p_j(s^t) \to \infty\) and hence \(X_j(s^t) \to 0\). Only the existence of a potential competitor can force the intermediate producer to set a finite price.

### 3.1.2 Intermediate Goods Sector: Ex-post Heterogeneity

There is a continuum of incumbents, each producing a differentiated intermediate good indexed by \(j\). Labor \((L_j(s^t))\) is the only input used in intermediate production, using a technology with constant marginal productivity \((q_j(s^t))\).\(^{16}\) Thus, the production of variety \(j\) is given by:

\[
X_j(s^t) = L_j(s^t)q_j(s^t).
\]

The efficiency of labor \((q_j(s^t))\) in the production of intermediate goods evolves with each technological improvement generated by a successful entrant. Entrants are heterogeneous in their capacity to improve the existing technology. Drastic innovations (type \(H\)) improve the efficiency level by a factor of \(1 + \sigma^H\), while marginal innovations (type \(L\)) generate improvements with a smaller factor \(1 + \sigma^L\), where \(\sigma^H > \sigma^L > 0\).\(^{17}\) Innovations in this economy come exclusively from newcomers.\(^{18}\) Then, we define the indicator functions \(I_j^d(s^{t-1}, s_t)\), taking the value 1 if product line \(j\) receives an entrant of type \(d \in \{L, H\}\) under \(s^t = (s^{t-1}, s_t)\), and 0 otherwise. We can summarize the evolution of the productivity of the most efficient

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\(^{16}\)This is the most common assumption in both the Romer (1990) and the Schumpeterian tradition of Grossman and Helpman (1991) and Aghion and Howitt (1992).

\(^{17}\)We only allow for two types in order to summarize the composition of the product line with only one variable: the fraction of leaders with \(\sigma^H\) advantage. More types complicate the analysis and do not add new insights to the mechanism.

\(^{18}\)A simplified version of Klette and Kortum (2004) could be accommodated to allow undirected innovations by incumbents without loss of tractability. But incumbents’ dynamics are not the focus of this paper.
firm in product line $j$ as follows:

$$q_j(s^t) = [1 + I_j^H(s^{t-1}, s_t) \times \sigma^H + I_j^L(s^{t-1}, s_t) \times \sigma^L] \times q_j(s^{t-1}).$$  \quad (6)

Hence, productivity in product line $j$ remains unchanged in the next period if, and only if, no entry takes place in that product line; in that case, last period incumbent continues to dominate the product line. In line with the endogenous growth literature, we assume Bertrand monopolistic competition in each product line. In order to understand how this framework allows us to abstract from the distribution of productivity along product lines, we solve the partial equilibrium problem of the intermediate good producer before continuing with the exposition of the model.

This monopolistic competition 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 ($p_j(s^t)$), equal to the marginal cost of the closest follower. We can denote the efficiency of the closest follower by $\tilde{q}_j(s^t)$. Then given wage ($W(s^t)$) the optimal price is set to:

$$p_j(s^t) = \frac{W(s^t)}{\tilde{q}_j(s^t)}.$$  \quad (7)

Note that (6) implies that a leader with type $d$ has productivity $q_j(s^t) = (1 + \sigma^d) \times \tilde{q}_j(s^t)$. Then, using the demand for varieties of the final good producer from (3), we can find the following expression for the profits ($\Pi_d^j(s^t)$) of the leader in product line $j$ with productivity advantage $d$:

$$\Pi_d^j(s^t) = X_j(s^t) \left( p_j(s^t) - \frac{W(s^t)}{\tilde{q}_j(s^t)} \right) = \frac{\alpha \sigma^d}{(1 + \sigma^d)(1 + \eta(R(s^t) - 1))} Y(s^t).$$  \quad (8)

Note that profits are independent of the product line, as the only relevant characteristic of product line $j$ is the type of the current leader. Moreover, type $H$ leaders enjoy higher profits than type $L$ leaders in every period. Profits are subject to corporate taxation rate ($\tau$). The value of the firm is determined by the present discounted value of its after-tax profits in the current period. Nevertheless, in the next period, the firm will continue to produce if, and only if, it is not replaced by a new leader. In fact, at time $t + 1$, when a mass $M(s^t, s_{t+1})$ of projects is funded, a portion $0 < \lambda < 1$ of them will randomly enter the intermediate sector; at that time, every incumbent firm faces a time-variant exit probability of $1 - \lambda M(s^t, s_{t+1})$. Finally, using the stochastic discount factor of the household ($m(s^t, s_{t+1})$), the expected discounted value $V^d(s^t)$ of owning any product line $j$ at time $t$ for a type $d$ leader can be defined recursively by:\footnote{See 3.1.5 for the characterization of $m(s^t, s_{t+1})$.}

$$V^d(s^t) = (1 - \tau) \Pi_d^j(s^t) + E \left[ m(s^t, s_{t+1}) \left( 1 - \lambda M(s^t, s_{t+1}) \right) V^d(s^t, s_{t+1}) | s^t \right].$$
where $E[\bullet|s^t]$ denotes the conditional expectation over every possible $s_{t+1}$ event after history $s^t$. Note that ex-post firm heterogeneity can be summarized by $d \in \{L, H\}$, since every type $d$ leader charges the same price, hires the same number of workers, and earns the same profits. Therefore, we do not need to keep track of the distribution of labor productivity across product lines; we can instead summarize the relevant information of the intermediate sector by the fraction of leaders with step size $H$, namely, the time-variant fraction $\mu(s^t) \in [0, 1]$.

### 3.1.3 Projects: Ex-ante Heterogeneity

There is a financial intermediary that owns a continuum of projects indexed by $z$ and uniformly spread on the unit interval ($z \in [0, 1]$). The fixed cost of starting (enacting) a project is $\kappa$ units of labor.\footnote{As Bollard et al. (2013) show, cross country industry level data suggests that entry cost is mostly associated with labor. The main mechanism of the model would not change if the entry cost were instead denominated in final goods units.} After a successful beginning, a project materializes into a new firm generating an undirected innovation. One of the key novelties in this model is the way heterogeneity and scarcity are introduced, and how the ex-ante heterogeneity in projects is related to the ex-post heterogeneity of incumbents. Projects are heterogeneous in their expected step size; every project has an unobservable idiosyncratic probability $P^H(z) = z^\nu$ ($\nu > 0$) of generating a drastic improvement in productivity characterized by a step size $\sigma^H > \sigma^L$. The higher the index $z$, the more likely it is that project $z$ will generate a drastic (type-$H$) innovation, and, hence, the higher the expected increase in productivity. In this sense, $z$ is more than an index; it is a ranking among projects based on their idiosyncratic and unobservable $P^H(z)$. Note that $\nu$ governs the scarcity of good ideas in this economy. In fact, the implied probability distribution of $P^H$ is given by:

$$f(P^H) = \frac{1}{\nu} \left( \frac{1}{P^H} \right)^{1 - \frac{1}{\nu}}.$$

The mean of this distribution reflects the expected proportion of type $H$ entrants when projects are enacted randomly. In fact, for any $M(s^t) \in (0, 1]$, random selection implies that, for all $z$, $prob(e \in M) = M$. Therefore, the fraction of high-type improvements ($\tilde{\mu}$) when enacting a set of projects randomly is given by:

$$\tilde{\mu} = \frac{1}{\lambda M} \int_0^1 \lambda \times prob(z \in M) \times P^H(z) \, dz = \int_0^1 P^H f(P^H) dP^H = \frac{1}{\nu + 1}.$$

As an example, if $\nu = 3$, the expected proportion of type $H$ projects in the portfolio of the financial intermediary is 25%. Therefore, if a mass of $M(s^t)$ of projects is enacted randomly, a quarter of the $\lambda M(s^t)$ entrants generate a step size $\sigma^H$. Moreover, we can characterize the skewness of $f(P^H)$ as
follows:

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

Note that the skewness is fully determined by \( \nu \), and it is positive and increasing for every \( \nu > 1 \). Intuitively, note that \( \nu = 1 \) implies a uniform distribution for \( f(P^H) \); hence, \( S(1) = 0 \) because the distribution is symmetric. However, for \( \nu > 1 \), the skewness is strictly positive, indicating that the left tail concentrates most of the probability density. This means that only a few ideas have strong chances of generating drastic improvements in productivity. Thus, \( \nu \) summarizes the underlying scarcity of good ideas in the economy.

### 3.1.4 The Representative Financial Intermediary: Selection

In this economy, projects are heterogeneous and good ideas are scarce. Therefore, as the ranking \( z \) is unobservable, project selection is not a trivial task. We thus introduce a screening device in order to study the effects of financial selection.

The representative financial intermediary has access to a unit mass of projects every period. It borrows funds and selects projects in which to invest according to the expected present value of the projects, and pays back the profits generated by its portfolio to the household every period.\(^{21}\) Note that, because \( V^H(s^t) > V^L(s^t) \), the financial intermediary strictly prefers to enact projects with higher \( z \). In particular, if \( z \) were observable, a financial intermediary willing to finance \( M(s^t) \) projects would enact only the projects with \( z \in [1 - M(s^t), 1] \). However, \( z \) is unobservable. In order to introduce selection, we define a costless, yet imperfect, screening technology that delivers the following stochastic signal \( \tilde{z} \) of the underlying ranking \( z \):

\[
\tilde{z} = \begin{cases} 
\tilde{z} = z & \text{with probability } \rho \\
\tilde{z} \sim U[0, 1] & \text{with probability } 1 - \rho.
\end{cases}
\]

The financial intermediary can observe the true ranking of the project with probability \( \rho \in [0, 1] \); otherwise, the ranking of the signal is drawn uniformly from the unit interval. Intuitively, \( \rho \) characterizes the accuracy of the screening, with \( \rho = 1 \) implying the perfect screening case.\(^{22}\)

**Proposition 1** The optimal strategy for a financial intermediary financing \( M(s^t) \) projects at time \( t \) is to set a cut-off \( \bar{z}(s^t) = 1 - M(s^t) \), and to enact projects only with signal \( \tilde{z} \geq \bar{z}(s^t) \).

\(^{21}\)Alternatively, we can assume that the representative household owns the projects but does not have access to any screening technology. Hence, it sells in equilibrium the projects to the representative financial intermediary at the expected profits net of financing costs, and the financial intermediary earns no profits. A similar story is used by Jovanovic and Rousseau (2009).

\(^{22}\)We assume that the battery of questions and procedures that commercial banks use to discriminate among borrowers is sometimes truly informative about the potential of the projects, but false positives and false negatives also happen.
Proposition 1 shows that the optimal strategy is to set a cut-off for the signal. When the financial intermediary uses this technology optimally to select a mass \( M(s^t) = 1 - \tilde{z}(s^t) \) of projects, the proportion \( \tilde{\mu}(\tilde{z}(s^t)) \) of high type projects in the successfully enacted \( \lambda M(s^t) \) mass is given by:

\[
\tilde{\mu}(\tilde{z}(s^t)) = \frac{1}{\lambda M(s^t)} \int_0^1 \lambda \times \text{prob}(\tilde{z} \geq \tilde{z}(s^t)|z) \times P^H(z) \, dz = \frac{1}{\nu + 1} \times \left[ 1 - \rho + \frac{1 - (\tilde{z}(s^t))^{\nu+1}}{1 - \tilde{z}(s^t)} \right] 
\]

Note that for any cut-off \( (\tilde{z}(s^t)) \), the composition of H-types \( (\tilde{\mu}(\tilde{z}(s^t))) \) increases with the level of accuracy \( (\rho) \) and decreases with the scarcity of high type projects \( (\nu) \). Moreover, in terms of the resulting composition, financial selection performs at least as well as random selection does. Because screening is costless, the financial intermediary will always use its device to select projects. Then, the financial intermediary borrows exactly \( W(s^t)M(s^t)\kappa \) in order to enact \( M(s^t) = 1 - \tilde{z}(s^t) \) projects every period. In particular, given \( \{V^H(s^t), V^L(s^t), R(s^t), W(s^t)\} \), the financial intermediary chooses \( \tilde{z}(s^t) \) in order to solve:

\[
\max_{\tilde{z}(s^t)} \left\{ \begin{array}{c}
\lambda(1 - \tilde{z}(s^t)) \text{Cohort’s mass} \\
\tilde{\mu}(\tilde{z}(s^t))V^H(s^t) + (1 - \tilde{\mu}(\tilde{z}(s^t)))V^L(s^t) \text{Cohort’s expected value} \\
(1 - \tilde{z}(s^t))(R(s^t)W(s^t)\kappa) \text{Total cost of enaction}
\end{array} \right\} .
\]

The bracketed term is the expected return of the portfolio with composition \( \tilde{\mu}(\tilde{z}(s^t)) \). The intermediary needs to pay back the borrowed amount plus the interest. As the objective function is strictly concave, the first order conditions are sufficient for optimality.\(^{24}\) As equation (9) shows, a financial intermediary with \( \rho > 0 \) faces a trade-off between mass and composition of the enacted pool: lower \( \tilde{z}_t(s^t) \) increases the mass of projects enacted, but it also decreases the composition of the entrant cohort. If an interior solution \( (\tilde{z}(s^t) \in (0, 1)) \) exists, it is unique and characterized by:

\[
\tilde{z}_t(s^t) = \left( \frac{W(s^t)\kappa R(s^t) - \left[ \frac{1}{1+\nu}V^H(s^t) + \frac{\nu}{1+\nu}V^L(s^t) \right]}{\rho(V^H(s^t) - V^L(s^t)) + \frac{1}{\nu + 1}} \right)^{\frac{1}{\nu}}
\]

Note that, from a partial equilibrium perspective, for \( \rho > 0 \) the cut-off \( (\tilde{z}_t(s^t)) \) increases with the interest rate. Nevertheless, from a general equilibrium perspective, the interest rate also affects the intermediary’s choice of cut-off through wages and values.\(^{25}\) Finally, using the mass \( (\lambda(1 - \tilde{z}(s^t)) \) and composition \( (\tilde{\mu}(s^t))) \) of the entrant cohort, we derive the law of motion of the composition of incumbents in the intermediate sector \( (\mu(s^t)) \). In fact, as entry is undirected, the evolution of the composition

---

\(^{23}\)As the expected value is strictly increasing in the signal, and the enacting cost is fixed, the cut-off strategy is optimal and unique. See Ates and Saffie (2013) for details.

\(^{24}\)The second derivative is given by \( -\rho\nu(\nu + 1) [V^H(s^t) - V^L(s^t)] (\tilde{z}(s^t))^{\nu-1} < 0 \).

\(^{25}\)Random selection \( (\rho = 0) \) boils down to a zero profit condition with constant composition \( \tilde{\mu} \), with the intermediary either at a corner, or indifferent between any cut-off.
among incumbents is given by:

\[ \mu(s^t) = \mu(s^{t-1}) + \lambda \left[ 1 - z(s^t) \right] \left[ \bar{\mu}(\bar{z}(s^t)) - \mu(s^{t-1}) \right] . \] (12)

Note that, given last period composition, and the value of this period cut-off, we can pin down this period composition.

### 3.1.5 The Representative Household

There is a representative consumer in this economy, and it is modeled following the open economy literature that builds on Mendoza (1991). In particular, as in Neumeyer and Perri (2005) and Uribe and Yue (2006), we include both capital adjustment costs, and a bond holding cost. Capital adjustment cost are very popular in the business cycle literature, and they become especially important in an open economy set-up with an exogenous interest rate. Without them, moderate fluctuations in the interest rate can generate implausible variations in investment. Bond holding costs are even more important in this literature because a fundamental indeterminacy arises between consumption and bond holdings.\(^{26}\) Schmitt-Grohe and Uribe (2003) discuss several alternatives to solve this issue, and show that every method delivers the same quantitative results. From an economic perspective, bond holding costs can be thought to capture legal and bureaucratic issues related to levels of debt that differ from their usual long-run level. In particular, the household chooses state-contingent sequences of consumption \(C(s^t)\), labor \(L(s^t)\), bond holding \(B(s^t)\), and investment \(I(s^t)\), given sequences of interest rate \(R(s^t)\), wages \(W(s^t)\), capital rental rates \(r(s^t)\), and initial bond and capital positions, in order to solve:

\[
\max_{\{B(s^t), C(s^t), L(s^t), I(s^t)\}} \sum_{t=0}^{\infty} \beta^t E \left[ u(C(s^t), L(s^t)) \right]_{s_0}
\] (13)

subject to:

\[
C(s^t) \leq W(s^t)L(s^t) + r(s^t)K(s^{t-1}) + B(s^{t-1})R(s^{t-1}) + T(s^t) - I(s^t) - B(s^t) - \psi(B(s^t), Y(s^t)) \] (14)

\[
I(s^t) = K(s^t) - (1-\delta)K(s^{t-1}) + \Phi(K(s^{t-1}), K(s^t))).
\] (15)

where \(E[\bullet|s_0]\) is the expectation over history \(s^t\), conditional on the information at \(t = 0\); \(0 < \beta < 1\) is the constant discount factor; investment is subject to convex adjustment costs \(\Phi(\bullet)\); and bond holdings are subject to the convex cost function \(\Psi(\bullet)\). The household also receives the profits of the financial intermediary \(\Pi(s^t)\), as well as the revenue generated by corporate taxation \(T(s^t)\), which the government levies on intermediate firms. As shown in the sequences of budget constraints defined by equation (14),

\(^{26}\)In a nutshell, because the interest rate is completely inelastic with respect to the demand of bonds, consumption shows excessive smoothing and its level cannot be pinned down independently of the amount of bond holdings. This becomes critical in a dynamic setting as the Lagrange multiplier associated with the bond holding decision exhibits a unit root. Then, in the absence of bond holding costs, when a shock hits the economy, the level of debt never returns to its stationary value.
the price of consumption is set to unity since we use final good as the *numeraire*. The program also requires the usual transversality conditions, and a *no-Ponzi-game* condition on bonds holdings.

Following Neumeyer and Perri (2005), we modify Greenwood et al. (1988) preferences (GHH) to allow for a balanced growth path equilibrium. However, in our set-up, because aggregate labor productivity grows at an endogenous rate, the scaling $A(s^t)$ is time-variant.\(^{27}\) We also take from them the functional forms for $\Psi$ and $\Phi$:

\[
\begin{align*}
    u(C(s^t), L(s^t)) &= \frac{1}{1-\gamma} \left( C(s^t) - \Theta_l A(s^t) (L(s^t))^\chi \right)^{1-\gamma} \quad (16) \\
    \Psi(B(s^t)) &= \frac{\psi}{2} Y(s^t) \left( \frac{B(s^t)}{Y(s^t)} - \bar{b} \right)^2 \quad (17) \\
    \Phi(K(s^{t-1}), K(s^t)) &= \frac{\phi}{2} K(s^{t-1}) \left[ \frac{K(s^t)}{K(s^{t-1})} - (1 + g_{bgp}) \right]^2. \quad (18)
\end{align*}
\]

where $\Theta_l > 0$ is the labor weight, $\chi > 1$ determines the Frisch elasticity of labor $\left( \frac{1}{\chi - 1} \right)$, $\gamma$ is the utility curvature, and $\phi > 0$ and $\psi > 0$ determine the convex cost functions. Note that, as $\bar{b}$ is the long-run household debt-output ratio, and $g_{bgp}$ the long-run growth of the economy, the household pays neither adjustment nor bond holding costs along the balanced growth path. In order to characterize the interior first order conditions of this problem, we define the stochastic discount factor of the household $(m(s^t, s_{t+1}))$ as:

\[
m(s^t, s_{t+1}) = \beta \frac{\partial u(C(s^{t+1}), L(s^{t+1}))}{\partial C(s^{t+1})} \frac{\partial u(C(s^t), L(s^t))}{\partial C(s^t)}
\]

where

\[
\frac{\partial u(C(s^t), L(s^t))}{\partial C(s^t)} = (C(s^t) - \Theta_l A(s^t) (L(s^t))^\chi)^{-\gamma}.
\]

---

\(^{27}\)The usual economic intuition used to justify the scaling of labor dis-utility by labor productivity is that the opportunity cost of labor consists mostly of home production, and non-market labor productivity might grow at the same rate as market labor productivity. Benhabib et al. (1991) study how home production shapes participation in the formal labor market, and how that intuition can be modeled by the preferences used in this paper.
Then, the interior first order conditions can be stated as:

\[ B(s^t) : 1 + \psi \left( \frac{B(s^t)}{Y(s^t)} - \bar{b} \right) = E \left[ m(s^t, s_{t+1}) | s^t \right] R(s^t) \]  

\[ K(s^t) : 1 = E \left[ m(s^t, s_{t+1}) \frac{r(s^t, s_{t+1}) + (1 - \delta) \left( [1 + g_{bop}]^2 - \left[ \frac{K(s^t, s_{t+1})}{K(s^t)} \right]^2 \right)}{1 + \phi \left[ \frac{K(s^t)}{K(s^t-1)} - (1 + g_{bop}) \right]} | s^t \right] \]  

\[ L(s^t) : W(s^t) = \Theta_l A(s^t) \chi (L(s^t))^{\chi - 1} \Rightarrow L(s^t) = \left( \frac{W(s^t)}{\Theta_l A(s^t) \chi} \right)^{\frac{1}{\chi - 1}}. \]  

Note that as equation (21) shows, if in the long-run, wage and aggregate productivity grow at the same rate, then labor supply is constant. Therefore, these preferences can support a balanced growth path. Moreover, labor supply is independent of household consumption due to the lack of income effect on the labor decision; therefore, the efficiency adjusted wage \( W(s^t) / A(s^t) \) is always positively correlated with the labor supply.

3.1.6 Interest Rate Process and Open Economy Aggregates

In this small open economy, the interest rate is completely exogenous, and we use the following AR(1) process to model it:\(^{28}\)

\[ \ln \left( \frac{R(s^t)}{\bar{R}} \right) = \rho_r \ln \left( \frac{R(s^{t-1})}{\bar{R}} \right) + \sigma_\epsilon \epsilon_t \quad \text{where} \quad \epsilon_t \overset{iid}{\sim} N(0, 1). \]  

Because only the final good can be traded in this model, we can easily define net exports as the difference between production and all its uses (i.e., consumption, investment, and the bond holding cost):\(^{29}\)

\[ NX(s^t) = Y(s^t) - C(s^t) - I(s^t) - \Psi(B(s^t)). \]  

We can also define the foreign debt of the country as the sum of the debt of the household, the debt that the final good producer incurs in holding working capital, and the debt that the financial intermediary

---

\(^{28}\)Neumeyer and Perri (2005) use two uncorrelated autoregressive processes: one for the spread and one for the international interest rate. Uribe and Yue (2006) use a VAR to estimate the determinants of the domestic interest rate, and then feed it into their model. Both procedures do alter the qualitative behavior of the model.

\(^{29}\)Intermediate goods can be thought of as specialized labor, and hence as non-tradable goods.
holds in order to enact projects every period.\(^{30}\)

\[
D(s^t) = B(s^{t-1}) - \eta \frac{\alpha Y(s^t)}{1 + \eta (R(s^t) - 1)} - (1 - \bar{z}(s^t)) \kappa W(s^t).
\]

### 3.1.7 Total Factor Productivity and Growth

In the remainder of this section, we derive the expression for the total factor productivity (TFP) in this economy; we then define an equilibrium for the stationary version of the economy; and finally we state the existence and uniqueness of an interior balanced growth path for the model.

We can re-write the production function from equation (1) using equation (5), recognizing that intermediate labor depends only on the step size of the incumbent.

\[
Y(s^t) = (A(s^t))^{\alpha} \left[ (L^H(s^t))^{\mu(s^t)} (L^L(s^t))^{1-\mu(s^t)} \right] \left( K(s^t) \right)^{1-\alpha}
\]

where \( A(s^t) \) is defined as:

\[
\ln(A(s^t)) \equiv \int_0^1 \ln q_j(s^t) dj.
\]

The TFP in this economy is endogenous and we can characterize it using the evolution of firm level labor productivity in equation (6), together with the entry rate of the economy. In particular, the following expression for TFP growth explicitly accounts for both mass and composition of the entrant cohort:

\[
\ln \left( \frac{A(s^t)}{A(s^{t-1})} \right) = \int_0^1 \ln \left( \frac{(1 + I_j^H(s^{t-1}, s_t) \sigma^H + I_j^L(s^{t-1}, s_t) \sigma^L) q_j(s^{t-1})}{q_j(s^{t-1})} \right) dj
\]

\[
= \int_0^1 \ln \left( (1 + I_j^H(s^{t-1}, s_t) \sigma^H + I_j^L(s^{t-1}, s_t) \sigma^L) \right) dj
\]

\[
= \lambda (1 - \bar{z}(s^t)) \left[ \bar{\mu}(s^t) \ln (1 + \sigma^H) + (1 - \bar{\mu}(s^t)) \ln (1 + \sigma^L) \right].
\]

We get the following intuitive expression that characterizes TFP growth:

\[
1 + a(s^{t-1}, s_t) = \frac{A(s^{t-1}, s_t)}{A(s^{t-1})} = \left( (1 + \sigma^H)^{\bar{\mu}(s^t)} (1 + \sigma^L)^{1-\bar{\mu}(s^t)} \right)^{\lambda (1 - \bar{z}(s^t))}.
\]

Note that TFP growth boils down to a scaled geometric weighted average of the step sizes, where the

\(^{30}\)Usually in this literature, a country as an aggregate can only borrow at the domestic interest rate, because the rest of the world is not subject to the same spread. Thus, an important point that must hold along the equilibrium path is that the country should always be a net borrower (\(D(s^t) < 0\)), so that private savings should not be enough to fund the domestic sector.
weights are given by the fraction of each type in the entrant cohort (composition) and the scale is given by the size of the cohort (mass). This highlights once again the interplay between mass and composition effects in the determination of the productivity growth of this economy.

### 3.2 Stationary System and Definitions

In order to render the model stationary, we define the following convention: any lower case variable represents the TFP scaled version of its upper case counterpart; for instance, the stationary transformation of output is given by $y(s^t) = \frac{Y(s^t)}{A(s^t)}$. This transformation is performed for consumption, bond holdings, capital, wages, intermediate goods production, investment, and output. With this transformation, we define a stationary competitive equilibrium for this economy:

**Definition 1** A competitive equilibrium for this small open economy, given an initial efficiency level $q_j(0)$ for every product line, an initial fraction of type $H$ incumbents, and initial levels of bond holding and capital for the household is given by:

1. Household optimally chooses $\{c(s^t), b(s^t), k(s^t), L(s^t)\}$ given prices to solve (13) subject to (14) and (15).
2. Final good producer optimally chooses $\{\{x_j(s^t)\}_{j \in [0,1]}, k(s^{t-1})\}$ given prices to solve (2).
3. Intermediate good producers optimally choose $\{p_j(s^t), L_j(s^t)\}_{j \in [0,1]}$ given wages and their type following the pricing rule in (7).
4. Financial intermediary optimally chooses $\{\bar{z}(s^t)\}$ given values and prices in order to maximize (10).
5. Government budget is balanced in every period.
6. Labor, asset, capital, and final and intermediate good markets clear in every history, and product line (if applicable):\(^{32}\)

$$L(s^t) = \bar{\mu}(s^t)L^H(s^t) + (1 - \bar{\mu}(s^t))L^L(s^t) + \kappa(1 - \bar{z}(s^t))$$
$$d(s^t) = b(s^{t-1}) - \eta\frac{\alpha y(s^t)}{1 + \eta(R(s^t) - 1)} - (1 - \bar{z}(s^t))\kappa w(s^t)$$
$$nx(s^t) = y(s^t) - c(s^t) - i(s^t) - \psi(b(s^t) - \bar{b})^2$$

\(^{31}\)Appendix A justifies this normalization, derives the normalized system that characterizes the model, and provides a proof for the theorem 2.

\(^{32}\)Intermediate good market clearing implies that the demand of the final good producer is equal to the supply of the intermediate good producer, and capital market clearing implies that the demand of the final good producer is satisfied by the household capital holdings.
7. \( \{v_j(s^t), q_j(s^t)\}_{j \in [0,1]} \) and \( \mu(s^t) \) evolve according to (6), (9), and (12).

8. Transversality, no-Ponzi-game, and non-negativity conditions are met.

We can also define a balanced growth path (BGP) for this economy as follows:

**Definition 2** A BGP is a non-stochastic (\( \sigma_e = 0 \)) equilibrium where \( \{\bar{z}(s^t)\} \) is constant, and consumption, bond holdings, capital, wages, intermediate goods production, investment, net exports, and output grow at a constant rate.

Appendix A derives the BGP for this economy and shows that, as the long-run growth is determined by the growth rate of productivity, every normalized endogenous variable is constant. Moreover, that section also proves the following proposition:

**Proposition 2** There is a well-defined parameter space where this economy has a unique interior BGP \( (\bar{z} \in [0,1]) \).

Proposition 2 is fundamental for the quantitative analysis in Section 5. In fact, it allows us to use a perturbation method to solve the stochastic system that characterizes this economy, centered on its unique BGP. Before exploring the quantitative implications of the model, Section 4 uses plant level data from the Chilean sudden stop of 1998 to provide empirical evidence of the mass-composition trade-off at the heart of the model.

## 4 Empirics

This section explores Chilean macroeconomic and microeconomic data to assess empirically the main mechanism of the model, i.e., the existence of a mass-composition trade-off on the entry margin. We focus the analysis in Chile mainly for three reasons. First, it is a small open economy with detailed macroeconomic data. Second, the violent sudden stop triggered by the Russian default provides the perfect natural experiment to test our mechanism. Third, we have access to detailed plant level panel data that can be used to directly study firm entry. We start presenting the basic macroeconomic picture of the sudden stop, then we introduce our firm level data set, and finally, we show that firms born in crisis are not just fewer, they are also better.

### 4.1 The Chilean Sudden Stop

In August 1998, the Russian government declared a moratorium on its debt obligations to foreign creditors. This default triggered a sudden and radical increase in the interest rates faced by emerging
Latin America was not an exception. Calvo and Talvi (2005) present a detailed analysis of the impact of the Russian default on the seven biggest economies of the region. One of the most successful economies of the region, Chile, also suffered the consequences of the Russian default.

Figure 1: The Chilean Sudden Stop

Figure 1 shows the evolution of the annualized real lending interest rate between 1996 and 2005, where the grey area spanning the period between 1998:II and 2000:III highlights the crisis period. The real interest rate peaked in 1998:III, increasing by 5 percentage points in a quarter. The interest rate spread, as reported by Calvo and Talvi (2005), increased from 120 basis points before the crisis to 390 basis points in October 1998, triggering a 47% decrease in cumulative external financial flows between 1998 and 2002. Figure 2 explores some of the macroeconomic consequences of this imported crisis.

Figure 2(a) shows a drop of more than 30% in real investment over just one quarter. In that same period, Figure 2(b) points to a drop of more than 6% in hours worked. Figures 2(c) and 2(d) show that both output and consumption decreased by 5% and took more than a year to return to the pre-crisis level. These macroeconomic consequences of a sudden stop in emerging markets have been widely studied, but the effects of firm entry dynamics triggered by these episodes have been considerably less explored. From a Schumpeterian point of view, those changes in entry can potentially be harmful even in the long-run, when the well-studied short-run effects are no more. In this section, while presenting

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33For a detailed time-line of the Russian default, see Chiodo and Owyang (2002). Calvo and Mendoza (2000) propose a model where the de-leveraging of international financial intermediaries can cause extreme movements in the prices of bonds in countries that seem unrelated to the country where the original phenomenon started.

34The LAC-7 group is composed by: Argentina, Brazil, Chile Colombia, Mexico, Peru, and Venezuela. Calvo and Talvi (2005) also perform a thorough empirical analysis for Argentina and Chile.

35Chile has the largest GDP per capita in Latin America (46th of the world in 2012, according to World Bank Data WDI database). Its economic freedom score is 79, (the 7th freest country in the world in the 2013 Index of Economic Freedom), and its trade-weighted average tariff rate is 4 percent. See Table 9 in Appendix C for more details. The main two sources of the macroeconomic data in this section are the IFS database and the Chilean Central Bank. See Appendix C for a description of the macroeconomic data used in this section.

36The macroeconomic aggregates of Figure 2 are in real terms and in logarithms.
empirical support for the composition effect, we aim to contribute to the empirical research on the microeconomic consequences of a sudden stop.

4.2 Mass and Composition During a Sudden Stop

There was no change in the domestic fundamentals of Chile that could have caused or predicted an increase in the interest rate as sudden and substantial as the one observed in the data. In fact, the average annualized real GDP growth of Chile between 1990:IV and 1997:IV was 8.6%, its fiscal policy was steady and responsible, and the monetary policy of its autonomous Central Bank was not expansionary. Moreover, as argued by Calvo et al. (2006), the generalized and synchronized nature of the...
increase in spreads charged in emerging markets also points to an exogenous and common origin for this episode. Thus, taking the Russian crisis as an exogenous shock, unrelated to Chilean fundamentals, and completely unforeseen by firms and authorities, we can use it to perform a natural experiment in order to test the main intuition of the model: cohorts born during the sudden stop window should be smaller but more profitable.

Chile’s National Institute of Statistics (INE) performs a manufacturing census (ENIA) every year, collecting plant level data from every unit with more than ten employees. The survey contains yearly plant information on sales, costs, value added, number of workers, energy consumption, and other variables. For the empirical analysis in this section, we use the information in the surveys between 1995 and 2007 to build a panel. We take the first appearance in the data as the entry year and the last appearance as the exit date. We also restrict our attention to 20 of the 29 industries, since some of them lack variation in entry and exit dynamics. For example, the tobacco industry is characterized by only 1–2 plants, and we observe a positive entry in only two years. We also build a measure to capture the profitability \( P_{i,t} \) of each plant every year:

\[
P_{i,t} = \frac{\text{Revenue}_{i,t} - \text{Cost}_{i,t}}{\text{Revenue}_{i,t}}.
\]

After cleaning the data and checking for consistency, our restricted sample contains 3675 plants with an average of 4.9 observations per plant. The sub-sample is representative, as it has 90% of the total number of workers, and 95% of the total observations in the data.

We first calculate entry rates at year \( t \) at the industry level for each cohort, dividing the number of new plants in year \( t \) by the average of the total plants in years \( t \) and \( t - 1 \). Table 8 in Appendix (B) presents two year average entry rates for every industry in the sample. Figure 3 plots two-year average entry rates by industry for the two-years preceding the crisis and the first two years of the sudden stop. Every industry below the 45° line decreased its two-year entry rate during the crisis.

For all industries but two (355 and 369), the average entry rate in 1998–99 is lower than in 1996–97. Moreover, Table 8 shows that, for practically every industry, entry rates remain low until 2002–03. The average percentage change on the entry rate is \(-39\%\) between 1996–97 and 1998–99. Accordingly, entry rate dropped dramatically, even at the industry level, during the Chilean sudden stop.

---

37 Most of the firms in the survey are single plants. In the recent literature, Alvarez and Lopez (2008) use this data to study the determinants of entry into and exit from, international markets. Alvarez and Vergara (2010) also use ENIA to assess the importance of economic reforms in entry dynamics.

38 We restrict attention to this period because the questionnaire and the identification number of each firm are practically invariant.

39 Note that a small firm might appear in the panel after passing the threshold of ten employees, and it should not be counted as an entry. The results are robust if we eliminate all the plants that appear the first time with less than fifteen workers, which reduces the likelihood of this phenomenon.

40 Appendix (B) shows the details of the data construction. For example, we eliminate observations with negative energy consumption and we restrict \( P_{i,t} \) to be between \(-150\%\) and \(150\%\).
Although it is clear that fewer firms are born during crisis, we still have to see whether they are better. In this sense, we want to show that firms born during the sudden stop are intrinsically more profitable. In particular, we would like to estimate the following equation:

$$P_{i,t} = \alpha + \beta_1 X_{i,t}^1 + \beta_2 X_{i,t}^2 + \gamma_1 Z_i^1 + \gamma_2 Z_i^2 + \mu_i + u_{i,t}$$

where $X_{i,t}^1$ represents exogenous time-varying variables (e.g., vacancy index of the economy), $X_{i,t}^2$ refers to endogenous time-variant variables (e.g., number of workers), $Z_i^1$ correspond to exogenous time-invariant variables (e.g., region of the country), and $Z_i^2$ are endogenous time-invariant variables (e.g., workers in the entry year). Note that variables with a superscript 2 are endogenous in the sense that they are likely to be correlated with the unobserved fixed effect $\mu_i$. The main challenge of this panel estimation is that the coefficient of interest, being born in crisis, is not only time-invariant, but also endogenous. On the one hand, time-invariant variables can be consistently and efficiently estimated by random effect, but the estimation is not consistent when the variable is also endogenous. On the other hand, fixed effect panel regression can consistently estimate every coefficient associated with the time-variant variables, but it cannot identify the coefficients of the time-invariant variables.

In this situation, the Hausman and Taylor (1981) procedure delivers consistent and efficient estimators for every coefficient in equation (30). The method can be summarized as a four-step procedure. First, a fixed effect regression delivers consistent estimators $\hat{\beta}_1$ and $\hat{\beta}_2$ that are used to retrieve estimators $\hat{u}_{i,t}$ and $\hat{\sigma}_u$. The second step is an instrumental variable (IV) regression with $\hat{u}_{i,t}$ as dependent variable, $Z_i^1$ and $Z_i^2$ as independent variables, and $Z_i^1$ and $X_i^1$ as instruments; this delivers a consistent estimator for $\hat{\sigma}$ (the dispersion of the residual). Third, an estimator for the variance of the unobserved
fixed effect component can be built as $\hat{\sigma}_\mu^2 = \tilde{\sigma}^2 - \hat{\sigma}_u^2$, in order to form the usual generalized least squares (GLS) correction. Finally, the GLS correction is used to transform the original equation and estimate all the coefficients simultaneously in equation (30) using an IV procedure where the instruments are given by $Z^1$, the mean of $X^1$ and the deviations from the mean of $X^1$ and $X^2$. After every estimation we perform the Sargan-Hansen test to assess the validity of the instrumental procedure.\footnote{Intuitively, we can think that this procedure aims to remove the endogenous component from the original regression in order to meet the main assumption of random effects. More details on this method can be found in Wooldridge (2010), Chapter 11. STATA software has built-in routines for both procedures. The null hypothesis is that the instruments are valid, so the higher the p-value, the better.}

Table 1 presents the results for three different specifications. In all three regressions the dependent variable is $P_{i,t}$. The only difference is the coefficient of interest. In the first regression we use a single dummy to determine whether the cohorts born in 1998 – 2000 perform better than every other cohort. In the second regression, we use two dummies in order to allow a differential effect for cohorts pre and post crisis. The third specification studies the effect of the three-digit industry entry rate at the moment of entry. This means that it is a continuous variable common to every firm in the same industry born in the same year and is also time-invariant. Note that all the coefficients of interest are associated with time-invariant endogenous variables, because better firms (with higher unobserved fixed effect $\mu_i$) are expected to enter in years of crisis. In the case of the third specification, when fewer firms enter, we expect them to be better.
signs suggest that older and bigger firms are more profitable. The negative correlation associated
with the number of workers. All three variables are associated with significant and stable coefficients. The
are three endogenous time-variant variables (42).

high wages, and as the producer price index might be pointing to slightly counter-cyclical mark-ups.

macro controls also have reasonable signs as bad business years have high unemployment and good business years have
high wages, and as the producer price index might be pointing to slightly counter-cyclical mark-ups.

We use as time-variant exogenous variables (X1i,t) four macroeconomic aggregates: an index of manufacturing production, the unemployment rate, an index of whole-sale producer prices, and an index of the cost of labor. The estimated values are practically unchanged in the three specifications. There are three endogenous time-variant variables (X2i,t), the age of the plant, its electricity consumption, and the number of workers. All three variables are associated with significant and stable coefficients. The signs suggest that older and bigger firms are more profitable. The negative correlation associated with

42Because this method relies on X1i,t to build instruments, and because they are all aggregated variables, we cannot include year dummies, which are perfectly correlated with our instruments.

43Although not significant, the negative sign of the first control seems to point to a competition effect. The other macro controls also have reasonable signs as bad business years have high unemployment and good business years have high wages, and as the producer price index might be pointing to slightly counter-cyclical mark-ups.
electricity consumption could be rationalized as an efficiency proxy. We use five geographic regions and two digit industry controls as time-invariant exogenous variables \((Z_i^1)\). Finally, besides the coefficients of interest, we include the initial size of the plant, specified as the natural logarithm of the plant’s initial number of workers, among the time-invariant endogenous variables \((Z_i^2)\); this coefficient is significant, stable and positive, as suggested by the empirical literature.

Back to our main question: are those fewer firms born in crisis better? The first specification shows that firms born in crisis are significantly more profitable than firms born in normal times. In fact, after correcting for initial size, macroeconomic conditions, and post-entry decisions, firms born during the sudden stop have, on average, a profitability index 7% higher; relative to the mean of \(P_{i,t}\), they are 14.4% more profitable. As the second specification shows, this result is robust when allowing for differential effects; in fact, pre and post crisis firms are not statically different, but firms born in crisis still have a profitability index 7% higher than firms born in normal times. The third specification is more general in the sense that it aims to directly unveil a mass-composition trade-off at the entry level. Although the Sargan-Hansen test is barely above 5%, the coefficient suggests that firms born in smaller cohorts have a permanently positive effect in their profitability measure. In particular, every extra percentage point in entry decreases the profitability of the firm by 0.55%.

One caveat can be added to the preceding result as it might be related to post entry selection. In fact, if firms born during crisis are more likely to die early, then, after that initial selection, those cohorts would seem more profitable. Appendix D estimates a proportional hazard model in order to evaluate that concern. The main empirical question in that section is whether firms born during the crisis window are more likely to exit. The answer is not only negative, but, if anything, firms born during crisis have lower hazard rates in each of their first six years of life.\(^{44}\) A second concern with the analysis might be due to the nature of selection. In fact, one might think that those cohorts are better just because of self-selection: when the interest rate is high, only good firms apply for credit. Although it is likely that some self-selection arises during these episodes, the hypothesis of complete self-selection is at odds with the real world. In fact, this argument implies that every firm that applies for credit is granted a loan. This is clearly not true in the data. For instance, according to Eurostat firm level data for 20 countries (showing access to finance for small and medium-sized enterprises in the European Union), 28% of firms applied for loans in 2007 (before the 2009 crisis), with a success rate of 84%. In 2010, although more firms were applying for loans (31%), the success rate decreased to only 65%.

Finally, as a robustness check, we estimate equation 30, comparing each cohort against all the others. This means that we estimate the equation eleven times, one for each cohort \(c\), using as the time invariant endogenous variable a dummy that takes a value of 1 only for the firms in cohort \(c\).\(^{45}\) Figure

\(^{44}\)Kerr and Nanda (2009) find that start-ups born in the United States before the banking deregulation period have higher survival probabilities than those born after that period. So, in that case also, tighter credit standards are related to stronger firms.

\(^{45}\)We do eleven different regressions instead of one regression with ten dummies because, in order to perform the procedure correctly, we need at least as many time variant exogenous variables as there are time invariant endogenous
4 plots the estimated profitability for each cohort when all the regressors are set to the sample mean; it also includes a two standard deviation confidence interval. The markers in some years indicate cohort dummies significant at 10%.

![Figure 4: Composition (quality)](image)

The message is robust to this more flexible estimation: only cohorts born in 1998 – 2000 have positive and significant coefficients.\(^{46}\) Note that cohort 1999 is significantly better than the average predicted profitability evaluated at the mean of the regressors. Moreover, the inverted U shape in Figure 4 completes the story of Table 8: as the mass effect gains strength, the composition effect weakens.\(^{47}\)

Summarizing, the Chilean sudden stop had strong macroeconomic consequences: real output, real consumption, real investment and hours worked decreased drastically. At the firm level, the effect is relatively more complex. Cohorts born during the crisis, and in its aftermath, are 40% smaller; nevertheless, firms in those cohorts are at least 14% more profitable. Hence, taking the average quality of the entrant cohort as a reference to evaluate the forgone entry is extremely misleading, as the unborn firms are substantially worse than the observed ones. As these unborn firms are often the excuse for policy interventions, such as indiscriminate government credit, the correct assessment of the economic cost of that forgone entry is crucial. For this reason, we proceed to calibrate our model and assess the long-run cost imposed by a sudden stop.

\(^{46}\)Cohort 2001 is significant at 10%, pointing to a longer crisis window, as in Calvo and Talvi (2005).

\(^{47}\)Because the Sargan-Hansen p-value is low for some of the later years, we prefer the original specification to document the differences in profitability.
5 Quantitative Exploration: The Role of Financial Selection

This section presents a quantitative exploration of the model. First we calibrate the baseline model using Chilean data. To assess the performance of the calibrated model, we feed it with a smoothed series of the quarterly interest rate observed in the data. Although the model is stylized, with its single shock it is able to approximate the non-targeted behavior of the macro aggregates during the crisis. For instance, the model replicates the behavior of consumption, labor, investment, and the stock market. Moreover, the entry rate falls by 25% in the model during the crisis, and the average profitability for those cohorts increases by 7%. Hence, this parsimonious model can account for roughly 65% of the decrease in entry and more than 45% of the increase in profitability during the Chilean sudden stop. Then, in order to assess the role of heterogeneity and selection in shaping the effect of a sudden stop, we introduce two modified economies: a model with exogenous growth, and a model with endogenous growth but no heterogeneity. We use those alternative economies to highlight the role of firm entry and financial selection when the economy is hit by a shock that increases the interest rate by 100 basis points. For instance, including heterogeneity and selection amplifies the effects of a sudden stop in output by 15%, compared to the exogenous growth model, and also increases the persistence of the effects of the crisis. Moreover, in the baseline model, the shock generates a long-run permanent loss in output of 0.55%. The composition effect plays a considerable role in shaping the long-run cost of the crisis. In fact, the model with no heterogeneity generates a considerably higher permanent loss in output, amounting to 0.8%. Thus, even at the macro level, the existence of selection is fundamental when assessing the cost of the forgone entrants.

5.1 Calibration to the Chilean Economy

5.1.1 Externally Calibrated Parameters

The nineteen parameters of the model are calibrated to Chilean data on a quarterly basis. A first group of eight parameters is externally calibrated. The depreciation rate of capital ($\delta$) is set at 8% annually, and the share of intermediate goods in the final good production ($\alpha$) is set to 0.65, both numbers consistent with Bergoeing et al. (2002). The corporate tax rate ($\tau$) is set to 20%, in line with Chilean legislation; the long-run interest rate ($\bar{R}$) is set to the average quarterly real Chilean interest rate on loans performed by commercial banks between 1991:I and 2007:II, a value of 1.7% quarterly (6.5% per year); and the persistence of the interest rate process ($\rho_r$) is also set to its empirical value of 0.811. We follow Neumeyer and Perri (2005) and set the working capital requirement ($\eta$) to 1; this implies that the final good producer needs to keep as working capital 100% of the cost of intermediate goods. The capital adjustment cost ($\phi$) is set to 8, a quite small number when compared to Neumeyer and Perri.

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48Because intermediate goods are just a transformation of labor, we use the labor share in the final good production suggested in that paper for Chile.
The bond adjustment cost \( (\psi) \) is set to \( 3 \cdot 10^{-4} \), a small number that renders the model stable. Table 2 presents the values for every externally calibrated parameter.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate share</td>
<td>( \alpha )</td>
<td>0.650</td>
<td>Bergoeing et al. (2002)</td>
</tr>
<tr>
<td>Depreciation</td>
<td>( \delta )</td>
<td>1.95%</td>
<td>Bergoeing et al. (2002)</td>
</tr>
<tr>
<td>Profit tax</td>
<td>( \tau )</td>
<td>20%</td>
<td>data</td>
</tr>
<tr>
<td>Working capital</td>
<td>( \eta )</td>
<td>1</td>
<td>Neumeyer and Perri (2005)</td>
</tr>
<tr>
<td>Bond adjustment</td>
<td>( \psi )</td>
<td>( 3 \cdot 10^{-4} )</td>
<td>low</td>
</tr>
<tr>
<td>Capital adjustment</td>
<td>( \phi )</td>
<td>8</td>
<td>low</td>
</tr>
<tr>
<td>Persistence</td>
<td>( \rho )</td>
<td>0.81</td>
<td>1991:I-2007:IV</td>
</tr>
</tbody>
</table>

Table 2: Externally Calibrated Parameters

5.1.2 Internally Calibrated Parameters

The remaining eleven parameters are internally calibrated to match some salient features of the Chilean economy. Although every moment is related to the whole set of parameters, we can point to some strong relationships between targets and parameters. The two step sizes of the model \( (\sigma^d) \) and the scarcity of drastic ideas \( (\nu) \) are mostly related to the first two moments of the mark-up distribution and to the average growth rate of labor productivity in the economy. We set the first two targets to 0.4 and 0.17, following the empirical research on mark-up by Dobbeelaere et al. (2013), for the Chilean manufacturing sector. The growth rate of real GDP is 1% per quarter; for the period 1996 – 2007, we target two-thirds of that as the long-run growth rate per quarter in order to recognize that Chile might not be on its balanced growth path, and that there are sources of long-run growth other than entry. The success probability \( (\lambda) \) is highly related to the long-run entry rate of start-ups in the model; we set that target to the average entry of the pre-crisis years in our sample, 2.48% per quarter. The accuracy of the financial system \( (\rho) \) governs the proportion of firms in the entrant cohort that are below the threshold set by the financial intermediary. A proportion of the entrant cohort dies during the first year (as for every year in our data set); we use that percentage as a proxy for the firms that were able to enter, although their true type was below the threshold. We set the former target to 11.4%, the average of that proportion in the pre-crisis portion of the data. The average cost of starting a firm as a proportion of the gross national income is obtained from the Doing Business Indicators from World Bank database; it pins down the cost of enacting a project \( (\kappa) \). In the model, we set this target to 12.1% of 2003, the earliest year available. The dis-utility of labor \( (\theta_l) \) and the parameter that determines the Frisch elasticity \( (\chi) \) are pinned down by the labor share and the employment of the Chilean economy. We target a labor share of 52% and an employment of 44% of the available time. Both are in line with the data in Appendix C and with Bergoeing et al. (2002). The discount factor \( (\beta) \) and the curvature of the utility function \( (\gamma) \) need to be consistent with the growth rate of the economy, the long-run debt-output ratio, and the consumption-output ratio. The first target was already set; the other two are set to their 1996 – 2007 quarterly average, i.e., 73% for the consumption-output ratio and 1.78 for
the long-run debt-output ratio (44.6% per year). Finally, the long-run household debt ($\bar{b}$) is internally determined, as no debt cost is paid along the balanced growth path, by assumption.49

5.1.3 Calibration Results

Considering the simplicity of this economy, the model is able to match the targets successfully. The main challenge of the model is to reconcile the spectacular growth of Chile during the period with the average entry and average mark-ups in the data. Because this is a long-run calibration, and some of the growth observed in Chile is likely to be transitional, an annualized productivity growth rate of 2.5% seems on the high end of economic intuition. Table 3 presents the performance of the model regarding the ten targets and Table 4 presents the calibration for the reminding parameter in the model.

<table>
<thead>
<tr>
<th>Target</th>
<th>Model</th>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. mark-up</td>
<td>35%</td>
<td>40%</td>
<td>Dobbelare et al. (2013)</td>
</tr>
<tr>
<td>Std. mark-up</td>
<td>22%</td>
<td>17%</td>
<td>Dobbelare et al. (2013)</td>
</tr>
<tr>
<td>Entry1997</td>
<td>2.21%</td>
<td>2.48%</td>
<td>1996 – 1997</td>
</tr>
<tr>
<td>Fast exit1997</td>
<td>12%</td>
<td>11.4%</td>
<td>1996 – 97</td>
</tr>
<tr>
<td>long-run Growth</td>
<td>0.63%</td>
<td>0.66%</td>
<td>4 of 1996-2007</td>
</tr>
<tr>
<td>Debt/GDP</td>
<td>−167%</td>
<td>−178.4%</td>
<td>1996 – 2007</td>
</tr>
<tr>
<td>Consumption/GDP</td>
<td>72.4%</td>
<td>73%</td>
<td>1996 – 2007</td>
</tr>
<tr>
<td>Working hour</td>
<td>36.5%</td>
<td>44%</td>
<td>Microdatos, Bergoeing et al. (2002)</td>
</tr>
<tr>
<td>Labor share</td>
<td>55%</td>
<td>52%</td>
<td>Bergoeing et al. (2002)</td>
</tr>
<tr>
<td>Entry Cost</td>
<td>15.2%</td>
<td>12.1%</td>
<td>World Bank</td>
</tr>
</tbody>
</table>

Table 3: Targets: Model and Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step sizes</td>
<td>$a^L, a^H$</td>
<td>(19.4%, 65.7%)</td>
</tr>
<tr>
<td>Success prob.</td>
<td>$\lambda$</td>
<td>5.2%</td>
</tr>
<tr>
<td>Scarcity</td>
<td>$\nu$</td>
<td>4.97</td>
</tr>
<tr>
<td>Screening accuracy</td>
<td>$\rho$</td>
<td>79.1%</td>
</tr>
<tr>
<td>Enaction cost</td>
<td>$\kappa$</td>
<td>10.1%</td>
</tr>
<tr>
<td>Private debt</td>
<td>$\bar{b}$</td>
<td>97.8%</td>
</tr>
<tr>
<td>Utility curvature</td>
<td>$\gamma$</td>
<td>1.32</td>
</tr>
<tr>
<td>Labor disutility curv.</td>
<td>$\chi$</td>
<td>1.28</td>
</tr>
<tr>
<td>Labor disutility level</td>
<td>$\theta_l$</td>
<td>1.71</td>
</tr>
<tr>
<td>Discount rate</td>
<td>$\beta$</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Table 4: Internally Calibrated Parameters

The calibrated step sizes point to a significant heterogeneity in mark-ups in the Chilean economy; specifically, drastic ideas are three times more productive that incremental ones. These values are in line with the empirical studies of Navarro and Soto (2006) and Dobbelare et al. (2013) for the Chilean manufacturing sector.50 The success probability is in line with the success in adoption in Queralto

49Equation (27) can be thought as an implicit target for $\bar{b}$.
50Dobbelare et al. (2013) mark-up estimation by industry ranges from 20% to 70%.
Considering that this is a quarterly calibration, it is consistent with the annual range used in the endogenous growth literature. The scarcity of good ideas implies that, under random selection, one out of six ideas generates a high step size. This corresponds to an *ex-ante* skewness of 1.66, and, given the screening accuracy of 80%, translates into an *ex-post* skewness in profitability of 0.7, in line with the fat tails documented by Silverberg and Verspagen (2007) and Scherer (1998). In our dataset, the skewness of this measure in 2007, for cohorts born between 2002 – 2007, ranges from 0.05 to 0.28, with an average of 0.16. The fixed cost of enacting a project is 10% of the real wage; this implies that 11% of working hours are used in enacting the project. This second non-targeted moment is in line with the data from the first entrepreneurship survey for Chile (*Encuesta de Microemprendimiento*), where 13% of the Chilean workforce declared themselves to be entrepreneurs in 2011. The preference parameters are in the usual range for a quarterly calibrated real business cycle model. Note that the private debt to GDP ratio corresponds to 24.5% annually, which is a reasonable value for developing countries. In term of non-targeted macro moments, the model generates an investment-output ratio of 25.6%, consistent with the data of Table 9 in Appendix C, and slightly above the 23% average in the period 1996 – 2007. The capital-output ratio in the model is 2.5 in annual terms, above the average 2.0 in the period 1996 – 2007. Table 5 summarizes the former non-targeted moments.

<table>
<thead>
<tr>
<th>Moment</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skewness of Profitability</td>
<td>0.7</td>
<td>0.16</td>
</tr>
<tr>
<td>% of L as entrepreneurs</td>
<td>11%</td>
<td>13%</td>
</tr>
<tr>
<td>Investment-output ratio</td>
<td>25.6%</td>
<td>23%</td>
</tr>
<tr>
<td>capital-output ratio</td>
<td>2.5</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5: Non-Targeted Moments

Before exploring the role of financial selection during sudden-stops through the lens of this model, we evaluate the quantitative performance of this economy when compared with the Chilean episode described in Section 4.

### 5.2 Validation of the Model: The Chilean Sudden Stop

In this section, we test the quantitative behavior of the model when compared to the macroeconomic aggregates during the Chilean sudden stop. In particular, we feed the model with a smoothed version of the quarter real interest rate, and we compare several non-targeted time series between 1998:I and 2002:I. In particular, we transform the interest rate of Figure 1 using the following function:

\[
R_t = 0.5R_{t-1} + 0.5R_{t-2}
\]

Because the model has only two type of incumbents, this measure reflects only the relative weights of the types.
We chose to use this smoothed series for two reasons. First, decisions like investment or labor are not taken every quarter; thus, instead of introducing a time to adjust friction, as in Uribe and Yue (2006), or a delay in the pass-through between the external shocks and the domestic variables, as in Neumeyer and Perri (2005), we decided to smooth the effect of the financial crisis. The second reason has to do with the empirical analysis in Section 4. Because our firm level data is annual, at every observation we have entrants that were subject to the interest rate of different quarters; hence, a two quarter backward-looking moving average seems to be a parsimonious alternative. Note that, as the model has only one shock, it can perfectly replicate only one time series, in this case, the smoothed quarterly interest rate. Figure 5 shows the logarithmic series for the baseline model and the actual data between 1998:I and 2002:I, for total hours, real investment, the Chilean stock index (IPSA) in real terms, and real consumption. Note that the long-run calibration previously introduced did not target any of the information in these time series.

We set the state variables of the model to be at their balanced growth path level in 1998:I and adjust the initial logarithmic scale such that model and data coincide at that quarter. Define the depth of the crisis as the difference between the initial point of the series and the lowest point reached during the episode. Despite its simplicity, and the fact that none of these moments are targeted, the ability of the model to replicate this measure is impressive. The model can account for around 80% of the decrease in hours, investment, and the stock index. It slightly overshoots the effect on consumption. Table 6 summarizes these results.

<table>
<thead>
<tr>
<th>Series</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>Investment</td>
<td>30%</td>
<td>37%</td>
</tr>
<tr>
<td>IPSA</td>
<td>11%</td>
<td>14%</td>
</tr>
<tr>
<td>Consumption</td>
<td>6%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 6: Depth of the Crisis

The economic recovery predicted by the model, other than some slight timing issues, matches the data extremely well for labor, the stock index, and consumption. However, the model predicts a much stronger recovery for investment. Including another source of stochasticity in the model, for instance, a shock to the labor supply or a demand shock, would of course increase the fitting of the model. Moreover, standard frictions in labor and investment can improve the timing of the model. Because it is easy to enrich this framework, it is more interesting to see how far a single stochastic component in a simple environment can go in explaining the effects of a sudden stop.

Finally, we use the empirical results of Section 4 to assess the ability of the model to capture the mass-composition trade-off at the heart of this paper. Figure 6 shows the implied path for quarterly investment.

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52 The corresponding series for the IPSA is the average value of an intermediate good producer.
entry and the average profitability of the entrant cohort, expressed as percentage deviations from their balanced growth path level.

As Figure 6(a) shows, the change in the interest rate can account for roughly a 25% decrease in the entry rate. This is almost 65% of the average decrease observed at the industry level on Table 8. Figure 6(b) shows the increase in the average profitability of the entrant cohort. Cohorts born in the worst part of the crisis are 7% more profitable than an average cohort. Therefore, the model can explain around 45% of the increase in profitability. The biggest challenge of the model is once again to generate enough persistence in both entry and profitability.

To summarize, this highly stylized model performs surprisingly well when compared to non-
targeted macroeconomic time series. In particular, it can explain around 80% of the decrease in labor, investment, and the stock market. Moreover, it can also explain 65% of the decrease in entry, and 45% of the increase in profitability documented in Section 4. Having provided evidence to support the quantitative behavior of the model, we finally focus our attention on quantifying the role of financial selection in shaping the long-run cost of a sudden stop.

5.3 Long-Run Loss, Amplification, and Persistence

In this section, we study the long-run cost imposed by a sudden stop on an economy where heterogeneous entrants subject to financial selection contribute to the process of productivity accumulation. To highlight the relevance of endogenous growth and financial selection when analysing these episodes, we introduce two modified versions of the baseline model. The first version \((\text{Exo})\) is a model with exogenous growth, and no financial intermediation. In particular, \(\text{Exo}\) has no entry on its intermediate product line; it experiences a constant growth rate equal to the balanced growth path of the \(\text{Baseline}\). We can think of \(\text{Exo}\) as Neumeyer and Perri (2005) with intermediate goods, and a constant mixture of \(H\) and \(L\) incumbents equal to the BGP level of the \(\text{Baseline}\). The second version \((\text{NoHet})\) is a model with no heterogeneity and with endogenous growth. In this model, there is neither \(\text{ex-ante}\) nor \(\text{ex-post}\) heterogeneity, since every entrant has the same step size. This unique step size is set in order that \(\text{NoHet}\) exhibits the same long-run growth as the baseline. Finally, \(\text{Exo}\) and \(\text{NoHet}\) share every common parameter with the \(\text{Baseline}\) model. Before conducting a quantitative exploration of the models, note that growing variables, such as output or investment, are normalized by \(A_t\) in all the models. Denoting percentage deviations of a variable \(P\) from its last period value by a hat \((\hat{P}_t = \frac{P_t - P_{t-1}}{P_{t-1}})\), we can use
output to approximate the following relationship:

\[ y_t = \frac{Y_t}{A_t} \Rightarrow \hat{Y}_t \approx \hat{y}_t + \hat{A}_t \]  

(30)

Along the non-shocked path, because \( y_t \) is constant there, we get \( \hat{Y}_t = \hat{A}_t = a_{ss} \). Hence, for scaled variables, we define the percentage deviation at time \( t \) between the non-shocked economy and the one subject to the shock as \( \tilde{x}_t^Y \):

\[ \tilde{x}_t^Y \approx \sum_{i=1}^{t} \left\{ \hat{y}_i + \hat{A}_i \right\} - t * a_{ss} \]  

(31)

The main difference between \( Exo \) and the other two models is that, because growth is exogenous, \( \hat{A}_t = a_{ss} \), and then \( \tilde{x}_t^Y = \sum_{i=1}^{t} \hat{y}_i \). Because \( y_t \) is stationary, this term converges to zero when time goes to infinity. This illustrates why there is no long-run cost of a sudden stop for a model with exogenous growth. But a model with endogenous growth has a long-run cost (\( LRC \)), in any normalized variable, approximately equal to:

\[ LRC \approx \lim_{t \to \infty} \left\{ t * a_{ss} - \sum_{i=1}^{t} \left\{ \hat{A}_i \right\} \right\} \]  

(32)

Note that, as \( \hat{A}_t \) converges to \( a_{ss} \), this long-run cost is finite. Moreover, as is clear from equation (31), this long-run cost arises only for variables that exhibit long-run growth. Therefore, the analysis of a sudden stop in a model with endogenous growth needs to consider the long-run impact that comes through this TFP-driven loss. Moreover, the long-run effect is the same for every growing variable. Also note that, because \( NoHet \) and \( Baseline \) have the same long run growth, the path of \( \hat{A}_t \) fully determines their relative long-run cost. We turn now to the quantitative response of the models to a 100 basis point increase on the interest rate \( R \). Figures 7 to 10 show the responses of the model to this shock. The units on the y-axis are the percentage deviation from a counter-factual non-shocked path, as defined in equation (31).

Figure 7(a) displays a one-time 100 basis point increase in the interest rate for the three economies. This washes away with an autocorrelation of 0.81. Figure 7(b) shows the response of firm entry in the two models that feature this margin. The decrease in entry is more than two times larger in impact for \( NoHet \) when compared to the baseline model. The main reason behind this difference lies on the compositional dynamics displayed in Figure 7(c). In fact, the proportion of high type entrants in the enacted cohort in \( NoHet \) is constant, while the baseline economy is able to adjust this fraction. In particular, the entrant cohort contains on impact an extra 15% of high type leaders. The last panel of Figure 7 shows the change in productivity growth generated by the disruption in the entry margin. Note that \( NoHet \) exhibits a large decrease in productivity growth on impact of more than 40%, while
the decrease in the baseline model is less than 15%. The reason behind this difference is seen in Figures 7(b) and 7(c); in fact, when the shock hits the economy, the only margin of adjustment for NoHet is the mass of the entrant cohort. Because there is only one step size, the contribution of the forgone entrants to growth is the same as the contribution of the actual entrants. But the compositional margin of the baseline model implies that, on average, the contribution to productivity of the forgone entrants is lower than the contribution of the selected projects; hence, the productivity cost is smaller. Figure 7(d) can also be used to illustrate the long-run effect of a sudden stop in the three models; we can calculate $LRC$ for each model as the area between their productivity path and the zero change path of Exo. In this particular case, the long-run cost is 0.8% for NoHet and 0.55% for the baseline. Therefore, the model with no heterogeneity generates a long-run cost 45% larger. Hence, taking into account heterogeneity
and selection is critical when assessing the economic cost of a sudden stop. Figure 8 sheds more light on the role of financial selection.

![Graph](image)

(a) Expected Entrant Value Random Selection

(b) Expected Entrant Value

Figure 8: The Impact of Selection.

In order to understand the value of selection for the financial intermediary, Figure 8(a) displays the deviations of the average expected revenue per entrant under random selection: \( \frac{1}{n} V^H(s^t) + (1 - \frac{1}{n}) V^L(s^t) \). Note that, for the baseline model, the average value of a randomly enacted project drops 3% more on impact than for \( \text{NoHet} \). In this sense, the decrease in values for the baseline model is more violent than for the model without selection. An important part of this difference comes from the sharp drop in entry exhibited by \( \text{NoHet} \). In fact, lower entry implies higher survival probabilities, and hence more valuable product lines. Going back to Figure 8(a), the higher return of a randomly enacted project in \( \text{NoHet} \) in comparison to the baseline implies that, if the financial intermediary in the baseline model had no access to selection, she would enact even fewer projects.\(^{53}\)

Figure 8(b) shows how this relationship is reversed when we take into account the change in the composition of the entrant cohort in the baseline model. In fact, financial selection allows the financial intermediary to increase the average value of each member of the entrant cohort and counteract most of the decrease in the value of product lines. The difference in the average value of an entrant displayed in the second panel of Figure 8 illustrates why the financial intermediary decreases project enactment twice as much in \( \text{NoHet} \).

Having characterized the source and magnitude of the long-run cost, we focus our attention in the behavior of output. Figure 9(a) shows the response of output for the three models. Moreover, following

\(^{53}\)Note that the analysis from the cost side does not reverse this partial equilibrium intuition; as seen in Figure 10(d), the marginal cost of enacting a project decreases more for \( \text{NoHet} \).
equation (25), we can distinguish the following three components:

\[ Y(s^t) = (A(s^t))^\alpha \left[ (L^H(s^t))^\mu(s^t) (L^L(s^t))^{1-\mu(s^t)} \right]^\alpha \left( K(s^t-1) \right)^{1-\alpha} \]

(33)

Figures 9(b), 9(c), and 9(d) display the evolution of those three components for each model.

The most striking fact in Figure 9(a) is the positive response of output for NoHet on impact. This counter-factual response is explained by the evolution of labor in relation to intermediate good production. In fact, the radical decrease in entry in NoHet releases much more labor than the decrease that is absorbed by the contraction in labor supply, ergo the use of labor in the intermediate good
production rises in the short-run, generating an increase in production. This means that, from the point of view of the intermediate good producers, the drop in their costs due to the decrease in wages is more powerful than the drop in their benefit due to the decrease in the demand for intermediate goods triggered by the working capital constraint.\textsuperscript{54} Note that the L component in Figure 9(c) increases by more than 1%, reversing, in the short-run, the decrease in the other two components. Nevertheless, as labor is a stationary variable, it returns in the long-run to its balanced growth path level. On the contrary, the K and A components feature a long-run loss that drives the shocked path of output to be permanently 0.8% lower. Less striking, but equally interesting, is the amplification and persistence of the baseline model when compared to \textit{Exo}. In fact, besides the long-run cost in output, the baseline model exhibits an amplitude roughly 15% larger, as well as more persistent, as can be seen from the delay in the lower point of the path in Figure 9(a). Comparing the sources of output in both models, we can identify the drivers of both effects. First, the amplification is driven by the extra drop in the K component; this is, in turn, due to the decrease in the return of capital triggered by the reduction in aggregated productivity.\textsuperscript{55} Second, the persistence is due to the hump shape of the L component. This shape is driven by the compositional dynamics in the intermediate product line. In fact, the slow convergence of \(\mu(s_t)\) delays the return of the L component to its long-run value. To complete the macroeconomic picture triggered by this episode, Figure 10 presents the deviations of capital, consumption, total hours, and wages for the three models.

First note that capital, total hours, and consumption are subject to the same long-run cost as output. In this sense, those variables close the gap with the un-shocked path in the long-run only for \textit{Exo}. For \textit{NoHet} and the baseline model, they remain permanently lower; the difference stabilizes at 0.8% for the first, and 0.55 for the second. Second, Figure 10(c) shows the response of total hours in the three models. On impact, the model with exogenous growth has the lower decrease in labor (−1.5%), while the baseline model almost doubles the effect, and the model with no heterogeneity shows an even larger decrease (−5.5%). The main reason behind this amplification is the decrease in labor productivity in the models with endogenous growth; this amplifies the decrease in real wages and so, given GHHH preferences, this unambiguously reduces the labor supply of the household. As this is a stationary variable, there is no long-run cost, and employment goes back to its un-shocked path for the three models.

Summarizing, models with endogenous growth exhibit a long-run cost of a sudden stop in every growing variable, but failing to account for heterogeneity and selection induces a considerable overestimation of this cost. The experiment also showed that the baseline model generates persistence and amplification of interest rate shocks, while the model with no heterogeneity can deliver counter-factual predictions. Finally, it is interesting to explore the accuracy of the response of the financial system in

\textsuperscript{54} Neumeyer and Perri (2005) document, for \(\eta = 0\), a counter-factual positive correlation between output and spreads.
\textsuperscript{55} Note that \textit{NoHet} exhibits a lower decrease in the K component, although the loss in TFP is higher. The reason lies once again in the rise of the L component in \textit{NoHet}, as the complementarity between inputs increases the marginal productivity of capital.
both the long-run cost of a crisis and its short-run effects. Figure 11 compares the deviation of productivity and output of the baseline calibration with two alternative parametrizations: one with perfect selection ($\rho = 1$), and one with lower accuracy ($\rho = 0.6$).

In line with economic intuition, Figure 11(a) shows that the long-run cost of a sudden stop decreases with the accuracy of the financial system. In fact, the better the selection, the stronger the composition effect, and, hence, the less detrimental the decrease in entry. Moreover, Figure 11(b) shows that economies with better selection technology endure the crisis better, as output not only drops less, but also recovers faster. In a nutshell, economies with higher selection technology have a lower long-run cost and a faster recovery from a sudden stop. A recent country report by IMF (2012) compares the effects of the 2008 global financial crisis on Brazil and Chile. They show that the latter country has a
faster and less costly recovery from the crisis. Figure 11 suggests that part of this might be due to the development of the Chilean financial system.\textsuperscript{56}

6 Conclusion

In this paper, we revisited the effects of a sudden stop, introducing a new element into consideration: the effect of the crisis on firm entry. With that aim, we presented an open economy endogenous growth model subject to interest rate shocks. The engine of growth in this economy is the creative destruction induced by new entrants. But, as potential entrants are heterogeneous, and promising ones are scarce, financial selection introduces a trade-off between the mass (quantity) and the composition (quality) of the entrants. In particular, an interest rate shock increases credit standards, giving rise to a smaller cohort with higher productivity during the crisis. We use the Chilean sudden stop to test the main intuition of the model. In fact, although fewer firms are born during the crisis, they are better.

While the model is highly stylized, it is able to convey some interesting insights about the role of firm entry during a financial crisis. For instance, in the quantitative section, we explored the long-run cost of a sudden stop driven by the changes in TFP growth. An increase of 100 basis points in the interest rate has a permanent effect on output, investment and consumption of $-0.55\%$ with respect to the un-shocked path. Not accounting for heterogeneity and selection overstates the cost of the crisis by 45%. As governments often use the forgone entry as an excuse for massive credit subsidies, a correct

\textsuperscript{56}In a companion paper Ates and Saffie (2013), we analyze the effect of financial selection on long-run growth. One of the conclusions in that paper is that the growth of more financially developed economies is mainly due to better resource allocation and not to an increase in the total resources allocated.
assessment of that cost is critical. Moreover, this model provides a framework to analyze the costs and benefits of those policies. A second interesting point from the quantitative analysis is the role of the financial system in an interest rate crisis. In fact, more developed financial systems are able to take better advantage of the trade-off between mass and composition, reducing both the short-run and long-run impact of a financial crisis. In this sense, financial reforms that increase the ability of the financial system to better allocate resources, such as the reforms empirically studied by Jayaratne and Strahan (1996) and Galindo et al. (2007), are not only desirable from a balanced growth path perspective, but also as a buffer against large crises. This paper provides a framework for the design and evaluation of such policies.

Future research along these lines could include in the model rich dynamics of incumbent behavior, in order to understand how a financial crisis affects both the investment and exit decisions of incumbents. This would include both a cleansing channel and a competition for funding between entrants and incumbents. This framework could study the debate between preventing exit and supporting entry during downturns. Another interesting avenue for future exploration is the role of banking competition in shaping the efficiency of selection. As we pointed out in the second section of the paper, the empirical literature has suggested that banking deregulation and financial competition have improved credit allocation. Hence, the cost of banking collusion or rent-seeking behavior in long-run productivity growth could be addressed using this tractable framework. In summary, the scope of this model is far beyond sudden stop episodes, or the particular Chilean experience. In fact, the mass-composition trade-off at the core of this paper can be triggered by any economic shock that disrupts the entry margin. The long-run economic cost of those fluctuations depends on the ability of the financial system to efficiently allocate scarce resources to the most promising projects.
References


Appendices

A Model Solution

In this section, we derive the system of equations that characterizes the normalized model. We follow the same order as in the main text, but here we report only the main equations. Then we derive the system that characterizes the balanced growth path, and finally we prove the theorem that is shown in the main text.

A.1 Normalized Model: System of Equations

A.1.1 Final Good Producer

\begin{align*}
y(s^t) &= \left( (L^H(s^t))^\mu(s^t) (L^L(s^t))^{1-\mu(s^t)} \right)^\alpha \left( \frac{k(s^{t-1})}{1+a(s^{t-1},s_t)} \right)^{1-\alpha} \tag{34} \\
x_j(s^t) &= \frac{\alpha y(s^t)}{p_j(s^t) (1+\eta (R(s^t)-1))}, \tag{35} \\
k(s^{t-1}) &= \frac{(1-\alpha) y(s^t)}{r(s^t) (1+a(s^{t-1},s_t))} \tag{36}
\end{align*}

A.1.2 Intermediate Good Producer

\begin{align*}
L^d(s^t) &= \frac{\alpha y(s^t)}{w(s^t)(1+\sigma^d)(1+\eta (R(s^t)-1))} \Rightarrow \frac{L^H(s^t)}{L^L(s^t)} = \frac{1+\sigma^L}{1+\sigma^H} \tag{37} \\
\pi^d_j(s^t) &= \frac{\alpha \sigma^d}{(1+\sigma^d)(1+\eta (R(s^t)-1))} y(s^t) \tag{38} \\
v^d(s^t) &= (1-\tau)\pi^d(s^t) + E \left[ m(s^t, s_{t+1}) (1+\lambda M(s^t, s_{t+1})) v^d(s^t, s_{t+1}) | s^t \right] \tag{39}
\end{align*}
A.1.3 Financial Intermediary and Composition

\[ \hat{\mu}(\bar{z}(s^t)) = \hat{\mu}^H(\bar{z})(s^t) = \frac{1}{\nu + 1} \left[ 1 - \rho + \frac{1 - (\bar{z}(s^t))^{\nu+1}}{1 - \bar{z}(s^t)} \right] \]  

(40)

\[ \rho(\bar{z}(s^t))^\nu = \frac{w(s^t)\kappa(R(s^t)) - v^L(s^t)}{(v^H(s^t) - v^L(s^t))} - \frac{1 - \rho}{(\nu + 1)} \]  

(41)

\[ \mu(s^t) = \mu(s^{t-1}) + \lambda(1 - \bar{z}(s^t)) (\hat{\mu}(\bar{z}(s^t)) - \mu(s^{t-1})) \]  

(42)

A.1.4 Representative Household

\[ 1 = E[m(s^t, s_{t+1})|s^t] R(s^t) - \psi \left( \frac{b(s^t)}{y(s^t)} - \bar{b} \right) \]  

(43)

\[ 1 = E \left[ \frac{r(s^t, s_{t+1}) + \frac{\phi}{2} \left[ (1 + gb_{gg})^2 - \left( \frac{k(s^t, s_{t+1})}{k(s^t)}(1 + a(s^t, s_{t+1})) \right)^2 \right]}{1 + \phi \left[ \frac{k(s^t)}{k(s^t-1)} - (1 + gb_{gg}) \right]} \right] |s^t \]  

(44)

\[ L(s^t) = \left( \frac{w(s^t)}{\Theta t \chi} \right) \frac{1}{\chi - 1} \]  

(45)

with:

\[ m(s^{t+1}) = E \left[ \frac{b}{1 + a(s^t, s_{t+1})} \left\{ (c(s^{t+1}) - \Theta_t (L(s^{t+1}))^\chi)^{-\gamma} \right\} |s^t \right] \]  

\[ (c(s^t) - \Theta_t (L(s^t))^{\chi})^{-\gamma} \]

A.1.5 Open Economy Variables

\[ \ln \left( \frac{R(s^t)}{R} \right) = \rho_t \ln \left( \frac{R(s^{t-1})}{R} \right) + \sigma_t \epsilon_t \quad \text{where} \quad \epsilon_t \overset{iid}{\sim} N(0, 1) \]  

(46)

\[ n.x(s^t) = y(s^t) - c(s^t) - i(s^t) - \frac{\psi}{2} \left( \frac{b(s^t)}{y(s^t)} - \bar{b} \right)^2 \]  

(47)

\[ d(s^t) = \frac{b(s^{t-1})}{1 + a(s^{t-1}, s_t)} - \eta \frac{\alpha y(s^t)}{1 + \eta (R(s^t) - 1)} - (1 - \bar{z}(s^t))\kappa w(s^t) \]  

(48)
A.1.6 Labor Market Clearing

\[
\left( \frac{w(s^t)}{\Theta_t \chi} \right)^{\frac{1}{\chi - 1}} = \alpha y(s^t) \left( \mu(s^t) + (1 - \mu(s^t)) \frac{1 + \sigma^H}{1 + \sigma^L} \right) + (1 - \bar{z}(s^t)) \kappa
\]  

(49)

A.1.7 Output Growth

\[
\ln(1 + g(s^{t-1}, s_t)) = \alpha \int_0^1 \ln \left( \frac{L_j(s^t)}{L_j(s^{t-1})} \right) + \ln \left( \frac{q_j(s^t)}{q_j(s^{t-1})} \right) dj + (1 - \alpha) \ln \left( \frac{K(s^{t-1})}{K(s^{t-2})} \right)
\] 

(50)

Let’s work term by term:

First term:

\[
\int_0^1 \ln \left( \frac{L_j(s^t)}{L_j(s^{t-1})} \right) dj = \mu(s^t) \ln \left( \frac{L^H(s^t)}{L^L(s^t)} \right) - \mu(s^{t-1}) \ln \left( \frac{L^H(s^{t-1})}{L^L(s^{t-1})} \right) + \ln \left( \frac{L^L(s^t)}{L^L(s^{t-1})} \right)
\]

Second term:

\[
\int_0^1 \ln \left( \frac{q_j(s^t)}{q_j(s^{t-1})} \right) dj = \lambda(1 - \bar{z}(s^t)) \left( \bar{\mu}(s^t) \ln(1 + \sigma^H) + (1 - \bar{\mu}(s^t)) \ln(1 + \sigma^L) \right)
\]

Third term:

\[
\ln \left( \frac{K(s^{t-1})}{K(s^{t-2})} \right) = \ln \left( \frac{k(s^{t-1})}{k(s^{t-2})} (1 + a(s^{t-2}, s_{t-1})) \right)
\]

A.2 Balanced Growth Path

First note that the three components of equation (50) imply that the long-run growth rate is given by:

\[
1 + g(\bar{z}) = \left( (1 + \sigma^H)^{\mu(\bar{z})} (1 + \sigma^L)^{1 - \mu(\bar{z})} \right)^{\lambda(1 - \bar{z})} = 1 + a(\bar{z})
\]

From equation (44) we get:

\[
\frac{(1 + a(\bar{z}))^\gamma}{\beta} = 1 + r - \delta
\] 

(51)
From equation (37) we get:

\[ L^d(y, w) = \frac{\alpha y}{w(1 + \sigma^d) (1 + \eta (\bar{R} - 1))} \]  \( (52) \)

And we characterize \( k(y, \bar{z}) \) using (36) and (51):

\[ k(y, \bar{z}) = \frac{(1 - \alpha) (1 + a(\bar{z}))}{(1 + a(\bar{z}))^\gamma} \beta - 1 + \delta \]  \( (53) \)

Replacing equations (53), and (52) in equation (34), we write \( w(\bar{z}) \) as:

\[ w(\bar{z}) = \left( \frac{\alpha (1 + a(\bar{z}))^{\frac{1}{n(\bar{z}) - 1}}}{(1 + \eta (\bar{R} - 1))} \right) \left( \frac{(1 - \alpha)}{(1 + a(\bar{z}))^{\gamma}} - 1 + \delta \right) \]  \( (54) \)

We characterize \( y(\bar{z}) \) using (49):

\[ y(\bar{z}) = \frac{(1 + \sigma^H) (1 + \eta (\bar{R} - 1)) \left( (w(\bar{z}))^{\frac{1}{n(\bar{z})}} \Theta \chi \right)^{\frac{1}{n(\bar{z})}} - (1 - \bar{z}) \kappa w(\bar{z})}{\alpha \left( \frac{1 + a^H}{1 + \sigma^L} - \mu(\bar{z}) \frac{\sigma^H - \sigma^L}{1 + \sigma^L} \right)} \]

Given \( y(\bar{z}) \), we write \( L^d(\bar{z}) \) and \( k(\bar{z}) \) using equations (53) and (52). Moreover, as normalized profits are constant over the BGP, we write \( v^d(\bar{z}) \) as:

\[ v^d(\bar{z}) = \frac{\alpha (1 - \tau) \sigma^d}{(1 + \sigma^d) (1 + \eta (\bar{R} - 1)) (1 - (1 - \lambda (1 - \bar{z})) \beta (1 + a(\bar{z}))^{1-\gamma})} y(\bar{z}) \]

Finally, \( \bar{z} \) must also be the unique solution to the Financial Intermediary problem:

\[ \rho(\bar{z})^\nu = \frac{w(\bar{z}) \kappa (\bar{R}) - v^L(\bar{z})}{v^H(\bar{z}) - v^L(\bar{z})} - \frac{1 - \rho}{\nu + 1} \]  \( (55) \)

The former equation pins down \( \bar{z} \), and hence the complete balanced growth path of this open economy model. The long-run level of bond holding \( b(\bar{z}) \) is characterized by equation (43):

\[ \frac{\bar{R}}{1 + \psi \left( \frac{b(\bar{z})}{y(\bar{z})} - \bar{b} \right)} = \frac{(1 + a(\bar{z}))^\gamma}{\beta} \Rightarrow b(\bar{z}) = \left( \frac{\beta \bar{R}}{1 + a(\bar{z})^\gamma} - 1 \right) \frac{1}{\psi} + \bar{b} \]  \( y(\bar{z}) \)

This is the only level of debt consistent with the exogenous interest rate and the endogenous growth rate of the economy. Hence, it uniquely pins down household consumption, as the budget constraint holds with equality. Also note that imposing \( \frac{b(\bar{z})}{y(\bar{z})} = \bar{b} \) implies \( \beta \bar{R} = (1 + a(\bar{z})^\gamma \), no matter what the value of \( \bar{b} \) is.
A.3 Existence and Uniqueness

A.3.1 Uniqueness of an Interior Solution

Recall that $\chi > 1$ and $\gamma > 1$. Let’s first find an expression for the right hand side of (55). Let’s work term by term, first noting that:

$$v^H(\bar{z}) - v^L(\bar{z}) = \frac{(1 - \tau) \left( (w(\bar{z}))^{\frac{\chi}{\chi - 1}} (\Theta l \chi)^{1 - \chi} - (1 - \bar{z}) k w(\bar{z}) \right)}{(1 - (1 - \lambda (1 - \bar{z})) \beta (1 + a(\bar{z}))^{1 - \gamma}) \left( \frac{1 + \sigma^H}{\sigma^H - \sigma^L} - \mu(\bar{z}) \right)}$$

Then we get:

$$\frac{v^L(\bar{z})}{v^H(\bar{z}) - v^L(\bar{z})} = \frac{1}{\frac{v^H(\bar{z})}{v^L(\bar{z})} - 1} = \frac{\sigma^L (1 + \sigma^H)}{\sigma^H - \sigma^L}$$

Note that:

$$w(\bar{z}) \kappa \frac{\lambda}{\lambda (1 - \tau)} = \left( 1 - (1 - \lambda (1 - \bar{z})) \beta (1 + a(\bar{z}))^{1 - \gamma} \right) \left( \frac{1 + \sigma^H}{\sigma^H - \sigma^L} - \mu(\bar{z}) \right)$$

Then, the right hand side of equation (55) is decreasing in $\bar{z}$ if and only if equation (56) also decreases in $\bar{z}$. Taking the natural logarithm of equation (56) and dropping the constant, we define the following function:

$$S(\bar{z}) = \ln \left( 1 - (1 - \lambda (1 - \bar{z})) \beta (1 + a(\bar{z}))^{1 - \gamma} \right) + \ln \left( \left( \frac{1 + \sigma^H}{\sigma^H - \sigma^L} - \mu(\bar{z}) \right)^{1 - \gamma} - (1 - \bar{z}) \kappa \right)$$

Some preliminary derivatives are given by:

$$\mu(\bar{z}) = \frac{1}{\nu + 1} \left[ 1 - \rho + \frac{\rho}{1 - \bar{z}} \left( 1 - \bar{z}^{1 + \nu} \right) \right]$$

$$\frac{d(\mu(\bar{z}))}{d\bar{z}} = \frac{\rho}{1 + \nu} \frac{1 + \bar{z}^{\nu} \left( \nu \bar{z} - (\nu + 1) \right)}{(1 - \bar{z})^2} > 0 \quad \text{and} \quad \lim_{\bar{z} \to 1} \frac{d(\mu(\bar{z}))}{d\bar{z}} = \frac{\rho \nu}{2}$$

$$\frac{d(1 + a(\bar{z}))}{d\bar{z}} = -(1 + a(\bar{z})) \lambda \left[ \left( \frac{1 - \rho}{\nu + 1} + \rho \bar{z}^{\nu} \right) \ln \left( \frac{1 + \sigma^H}{1 + \sigma^L} \right) + \ln(1 + \sigma^L) \right] < 0$$

$$\frac{d(w(\bar{z}))}{d\bar{z}} = \frac{\gamma \lambda (1 - \alpha)}{\alpha} \left[ \left( \frac{1 - \rho}{\nu + 1} + \rho \bar{z}^{\nu} \right) \ln \left( \frac{1 + \sigma^H}{1 + \sigma^L} \right) + \ln(1 + \sigma^L) \right] - \frac{d(\mu(\bar{z}))}{d\bar{z}} \ln \left( \frac{1 + \sigma^H}{1 + \sigma^L} \right) w(\bar{z}) \equiv \Gamma_0 w(\bar{z})$$
It is easy to show that the first two components of $S(\bar{z})$ are decreasing in $\bar{z}$. Now we find a condition that guarantees that the third component is also decreasing in $\bar{z}$.

$$
sign \left( \frac{d \ln \left( \left( \frac{w(\bar{z})}{\Theta l \chi} \right)^{\frac{1}{\chi-1}} - (1 - \bar{z})\kappa \right)}{d\bar{z}} \right) = \text{sign} \left( \frac{\Gamma_0}{\chi - 1} \left( \frac{w(\bar{z})}{\Theta l \chi} \right)^{\frac{1}{\chi-1}} + \kappa \right)
$$

Let’s focus on the problematic region where $\Gamma_0 \leq 0$. Note that:

$$
\Gamma_0 \geq \left( \frac{\gamma \lambda (1 - \alpha)}{\alpha} \left( \frac{\kappa - \beta}{\kappa (1 - \chi)} \right) \ln \left( \frac{1 + \sigma_H}{1 + \sigma_L} + 1 \right) + \ln \left( 1 + \sigma_L \right) \right) - \frac{\nu \rho}{2} \ln \left( \frac{1 + \sigma_H}{1 + \sigma_L} \right) \equiv \Gamma_1 \leq 0
$$

So, a sufficient condition is given by:

$$
\left( \frac{w(\bar{z})}{\chi \left( \frac{\kappa \left( 1 - \chi \right)}{\Gamma_1} \chi - 1 \right)} \right) \leq \Theta l
$$

Note also that:

$$
w(\bar{z}) \leq \left( \frac{\alpha}{1 + \eta \left( \frac{1}{\beta} - 1 \right)} \right) \left( \frac{(1 - \alpha)}{\frac{1}{\beta} - 1 + \delta} \right) = \Gamma_3
$$

So, a sufficient condition for the existence of a unique solution to the above problem is given by:

$$
\frac{\Gamma_3}{\chi \left( \frac{\kappa \left( 1 - \chi \right)}{\Gamma_1} \chi - 1 \right)} \leq \Theta l
$$

Note that the third term of $S(\bar{z})$ is the labor used in intermediate production. Moreover, in the region where $\Gamma_0 < 0$ wages decrease in $\bar{z}$, given GHH preferences this implies that the supply of labor decreases in $\bar{z}$. Hence, a higher level of $\Theta_1$ decreases the response of labor supply to wages, so that part of the labor released by the decrease in project enactment is absorbed by intermediate producers. This translates into higher $y(\bar{z})$, increasing the value of each product line, and hence, increasing the incentives to enact projects.
A.3.2 Existence and Uniqueness of an Interior Solution

We need to find conditions such that equation (55) for \( \bar{z} = 0 \) becomes:

\[
\rho(0)^\nu < \frac{w(0)\kappa(\bar{R})}{\lambda} \frac{(R - v^L(0)) - 1 - \rho}{(\nu + 1)}
\]

\[
\frac{w(0)}{v^H(0) - v^L(0)} \frac{1 - (1 - \lambda)\beta(1 + a(0))^{1 - \gamma}}{(\frac{w(0)}{\Theta l X})^{\frac{1}{\gamma - 1}} - \kappa} > (1 - \tau)\lambda \frac{1 - \rho}{(\nu + 1)} + \frac{\sigma^L(1 + \sigma^H)}{\sigma^H - \sigma^L}
\]

A sufficient condition for this to hold is given by:

\[
\kappa > \frac{1 - (1 - \lambda)\beta}{(\frac{\Gamma l}{\Theta l X})^{\frac{1}{\gamma - 1}} - \kappa} > (1 - \tau)\lambda \frac{1 - \rho}{(\nu + 1)} + \frac{\sigma^L(1 + \sigma^H)}{\sigma^H - \sigma^L}
\]

\[
\kappa > \frac{1 - (1 - \lambda)\beta R\frac{1 - \rho}{(\nu + 1)} + \frac{\sigma^L(1 + \sigma^H)}{\sigma^H - \sigma^L}}{(1 - (1 - \lambda)\beta) R\frac{1 - \rho}{(\nu + 1)} + (1 - \tau)\lambda \frac{1 - \rho}{(\nu + 1)} + \frac{\sigma^L(1 + \sigma^H)}{\sigma^H - \sigma^L}}
\]

We also need to have:

\[
\rho(1)^\nu > \frac{w(1)\kappa(\bar{R})}{\lambda} \frac{(R - v^L(1)) - 1 - \rho}{(\nu + 1)}
\]

\[
\lambda \frac{\left(\rho + \frac{1 - \rho}{(\nu + 1)} + \frac{\sigma^L(1 + \sigma^H)}{\sigma^H - \sigma^L}\right)}{\bar{R}} \frac{w(1)}{v^H(1) - v^L(1)} > \kappa \frac{1 - \beta(1 + a(1))^{1 - \gamma}}{(\frac{w(1)}{\Theta l X})^{\frac{1}{\gamma - 1}} - \kappa} (1 - \tau)
\]

\[
\kappa < \frac{\lambda \frac{\left(\rho + \frac{1 - \rho}{(\nu + 1)} + \frac{\sigma^L(1 + \sigma^H)}{\sigma^H - \sigma^L}\right)}{\bar{R}} \frac{w(1)}{\Theta l X}}{(1 - \beta(1 + a(1))^{1 - \gamma}) \left(\frac{1 + \sigma^H}{\sigma^H - \sigma^L} - \mu(1)\right)} (1 - \tau)
\]

We can state a sufficient condition as:

\[
\kappa < \frac{\lambda \frac{\left(\rho + \frac{1 - \rho}{(\nu + 1)} + \frac{\sigma^L(1 + \sigma^H)}{\sigma^H - \sigma^L}\right)}{\bar{R}} \frac{w(1)}{\Theta l X}}{(1 - \beta) \left(\frac{1 + \sigma^H}{\sigma^H - \sigma^L} - \frac{1 + \nu a}{\nu + 1}\right)} (1 - \tau)
\]

55
Intuitively, there is a lower and an upper bound on the enactment cost $\kappa$ that guarantees an interior solution. In fact, when the cost is too low, every project is enacted; when it is too high, no project is realized.
B  ENIA and Empirical Analysis

Annual National Industrial Survey (ENIA) conducted by National Statistics Institute (INE) of Chile covers all manufacturing firms in Chile with more than 10 workers. Our version extends from 1995 to 2007. According to Bergoeing et al. (2003), around 96.5% of plants observed in the 1980-1999 version of the data belong to single-plant enterprises. In addition to the procedures mentioned in the text, we apply further measures against potential measurement errors regarding entry and exit in the data, following Micco (1995). In particular, we eliminate observations with one or more of the following inconsistencies: worked days less than or equal to 0, electricity consumption less than or equal to 0, gross value of the production less than or equal to 0, value added less than or equal to 0, remuneration of workers equal to 0, size equal to zero, ISIC code less than 3000, and sales less than exports. Finally, as mentioned in the text, we dropped some industries due to an insufficient number of observations or inadequate entry dynamics. The 3-digit level ISIC codes of the eliminated industries are 314, 323, 353, 354, 361, 362, 371, 372 and 385. The following table presents descriptive statistics of key variables that are used in the empirical analysis.

Table 7: Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profitability</td>
<td>0.486</td>
<td>0.211</td>
<td>18355</td>
</tr>
<tr>
<td>log(electricity_{i,t})</td>
<td>-0.598</td>
<td>1.891</td>
<td>18195</td>
</tr>
<tr>
<td>log(worker_{i,t})</td>
<td>3.453</td>
<td>0.913</td>
<td>18365</td>
</tr>
<tr>
<td>log(worker_{i,t0})</td>
<td>3.384</td>
<td>0.872</td>
<td>*18365</td>
</tr>
<tr>
<td>log(age_{i,t})</td>
<td>1.092</td>
<td>0.760</td>
<td>18365</td>
</tr>
<tr>
<td>Unemployment_{t}</td>
<td>0.078</td>
<td>0.012</td>
<td>*18365</td>
</tr>
<tr>
<td>log(manufacture_{t})</td>
<td>4.496</td>
<td>0.117</td>
<td>*18365</td>
</tr>
<tr>
<td>log(ppi_{t})</td>
<td>4.469</td>
<td>0.195</td>
<td>*18365</td>
</tr>
<tr>
<td>log(labor cost_{t})</td>
<td>4.545</td>
<td>0.057</td>
<td>*18365</td>
</tr>
<tr>
<td>Crisis dummy</td>
<td>0.234</td>
<td>0.424</td>
<td>18365</td>
</tr>
</tbody>
</table>

Table 8 shows two-year average entry rates at the industry level. Note that almost every industry displays a U-shaped entry pattern that coincides with the Chilean sudden stop.
<table>
<thead>
<tr>
<th>Cohort</th>
<th>Industry</th>
<th>311</th>
<th>312</th>
<th>313</th>
<th>321</th>
<th>322</th>
<th>324</th>
<th>331</th>
<th>332</th>
<th>341</th>
<th>342</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996 − 97</td>
<td></td>
<td>10.70%</td>
<td>12.85%</td>
<td>9.86%</td>
<td>8.98%</td>
<td>14.88%</td>
<td>6.08%</td>
<td>9.72%</td>
<td>17.53%</td>
<td>11.18%</td>
<td>5.93%</td>
</tr>
<tr>
<td>1998 − 99</td>
<td></td>
<td>4.83%</td>
<td>3.52%</td>
<td>7.85%</td>
<td>3.17%</td>
<td>5.57%</td>
<td>4.91%</td>
<td>6.14%</td>
<td>7.30%</td>
<td>5.42%</td>
<td>4.52%</td>
</tr>
<tr>
<td>2000 − 01</td>
<td></td>
<td>3.44%</td>
<td>4.23%</td>
<td>7.07%</td>
<td>3.44%</td>
<td>4.24%</td>
<td>3.30%</td>
<td>5.45%</td>
<td>8.63%</td>
<td>6.94%</td>
<td>5.64%</td>
</tr>
<tr>
<td>2002 − 03</td>
<td></td>
<td>8.88%</td>
<td>8.83%</td>
<td>12.27%</td>
<td>5.26%</td>
<td>10.08%</td>
<td>4.73%</td>
<td>12.02%</td>
<td>10.65%</td>
<td>8.17%</td>
<td>18.25%</td>
</tr>
<tr>
<td>2004 − 05</td>
<td></td>
<td>6.14%</td>
<td>6.72%</td>
<td>18.55%</td>
<td>5.09%</td>
<td>3.77%</td>
<td>1.79%</td>
<td>6.13%</td>
<td>10.25%</td>
<td>7.99%</td>
<td>5.07%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Industry</th>
<th>351</th>
<th>352</th>
<th>355</th>
<th>356</th>
<th>369</th>
<th>381</th>
<th>382</th>
<th>383</th>
<th>384</th>
<th>390</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996 − 97</td>
<td></td>
<td>8.88%</td>
<td>8.50%</td>
<td>3.45%</td>
<td>6.29%</td>
<td>10.78%</td>
<td>11.76%</td>
<td>8.69%</td>
<td>8.45%</td>
<td>7.95%</td>
<td>21.94%</td>
</tr>
<tr>
<td>1998 − 99</td>
<td></td>
<td>7.12%</td>
<td>4.06%</td>
<td>6.08%</td>
<td>4.25%</td>
<td>10.82%</td>
<td>3.63%</td>
<td>4.76%</td>
<td>5.09%</td>
<td>4.38%</td>
<td>4.42%</td>
</tr>
<tr>
<td>2000 − 01</td>
<td></td>
<td>6.48%</td>
<td>2.69%</td>
<td>2.37%</td>
<td>4.25%</td>
<td>6.78%</td>
<td>7.13%</td>
<td>5.34%</td>
<td>5.73%</td>
<td>3.36%</td>
<td>6.95%</td>
</tr>
<tr>
<td>2002 − 03</td>
<td></td>
<td>5.58%</td>
<td>10.32%</td>
<td>8.34%</td>
<td>11.83%</td>
<td>6.18%</td>
<td>10.95%</td>
<td>13.92%</td>
<td>12.20%</td>
<td>8.05%</td>
<td>4.74%</td>
</tr>
<tr>
<td>2004 − 05</td>
<td></td>
<td>8.84%</td>
<td>5.32%</td>
<td>6.52%</td>
<td>6.02%</td>
<td>7.61%</td>
<td>8.13%</td>
<td>8.59%</td>
<td>5.31%</td>
<td>8.35%</td>
<td>8.03%</td>
</tr>
</tbody>
</table>

Table 8: Two year average entry rates by industry.
C Macroeconomic Data

In this section, we present the sources of the macroeconomic data used in this paper. We first present a general description of the Chilean economy from the World Bank Database, in Table 9.

<table>
<thead>
<tr>
<th></th>
<th>1995</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>14,440,103</td>
<td>17,464,814</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>7,400.8</td>
<td>22,362.5</td>
</tr>
<tr>
<td>Trade to GDP</td>
<td>56.4%</td>
<td>66.6%</td>
</tr>
<tr>
<td>Gross capital formation to GDP</td>
<td>26.2%</td>
<td>25.6%</td>
</tr>
<tr>
<td>External debt to GNI</td>
<td>32.1%</td>
<td>41.0%</td>
</tr>
</tbody>
</table>

Table 9: Chilean Economy

To start, note that Chile is a small economy, both in terms of population and aggregate output. It has also experienced spectacular growth, which led it to be the first OECD member in South America (2010). Its trade and debt ratio justify the small open economy framework adopted in this paper. In particular, while its trade to GDP ratio is quite high, according to the World Trade Organization database, in 2011 Chile had 0.45% of world’s exports and 0.41% of world’s imports. Chile is also the 7th freest economy in the world (2013 International Economic Freedom Ranking).

The main source of data is the International Financial Statistics database from the IMF. From that, we use the following series between 1996:I and 2011:II: GDP volume index (22899BVPZF...), nominal GDP (22899B.ZF...), gross fixed capital formation (22893E.ZF...), changes in inventory (22893I.ZF...), exchange rate (228..RF.ZF...), exports (22890C.ZF...), imports (22898C.ZF...), financial accounts (22878BJDZF...), direct investment abroad (22878BDDZF...), direct investment in Chile (22878BEDZF...), net errors and omissions (22878CADZF...), household consumption (22896F.ZF...), and government consumption (22891F.ZF...). We use employment data from the INE and hours worked per week from the Encuesta de Ocupacion y Desocupacion from the Economic Department of Universidad de Chile. We also use the average interest rate charged by commercial banks for one to three month loans from the Chilean Central Bank database. All the data is seasonally adjusted with the standard X-12 procedure of the US Census. We follow the data appendix of Bergoeing et al. (2002) to build real aggregate macroeconomic variables.57

57We build capital series using the perpetual inventory method; we assume an annual depreciation rate of 8%, and we solve for the initial stock that delivers an average annual capital to output ratio of 1.96.
D  Cox Estimation

This section complements the empirical results of Section 4. In particular, we show that the higher profitability of the cohorts born during the sudden stop is not due to *ex-post* selection. In order to show that firms born during that period are not more likely to die, we perform the following stratified proportional hazard estimation.

\[
h_{mn}(t, X_i) = h_{0mn}(t) \exp \left[ \beta_1 \log(elec_{it}) + \beta_2 \log(worker_{it}) \right. \\
+ \left. \beta_3 \log(worker_{it0}) + \beta_4 \log(elec_{it0}) + \beta_5 \log(proft_{jt}) + \gamma \cdot industry \right]
\]

The two strata are geographical region and time period. This means that the baseline hazard \( h_{mn} \) varies across these two dimensions. We divide Chile into five geographical regions. The time periods correspond to the *pre-crisis*, *crisis*, and *post-crisis* period of the second specification in the Hausman and Taylor estimation of Section 4. The following table shows the estimates of the common covariates.

<table>
<thead>
<tr>
<th>Table 10: Cox Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazard</strong></td>
</tr>
<tr>
<td>log(electricity(_{i,t}))</td>
</tr>
<tr>
<td>log(worker(_{i,t}))</td>
</tr>
<tr>
<td>log(worker(_{i,t0}))</td>
</tr>
<tr>
<td>log(electricity(_{i,t0}))</td>
</tr>
<tr>
<td>log(profitability(_{j,t}))</td>
</tr>
<tr>
<td><strong>Industry control</strong></td>
</tr>
<tr>
<td><strong>Observations</strong></td>
</tr>
</tbody>
</table>

Stratified by region and period.
Standard errors in parentheses.
* \( p < 0.10 \), ** \( p < 0.05 \), *** \( p < 0.01 \)

The Cox-Snell test cannot reject the proportional hazard structure with 95% confidence. Sub-index \( t \) refers to time, while \( i \) refers to a plant, and \( j \) to an industry. Note that bigger plants have less probability of exiting (for both electricity consumption and number of workers), while the initial size increases the probability of exiting. The specification controls for the industry cycle (using the average time varying profitability of the industry) and industry specific effects. Figure 5(d) plots the hazard rates at different horizons for cohorts born during the three different time periods in the central zone of Chile. We pick this zone because it concentrates most of the plants in the sample; the main message does not change when considering the other four regions.

Note that firms born during the crisis do not exit more than other cohorts. Moreover, they even
seem stronger in this dimension, since, until year 6, they have a higher predicted survival probability than firms born either before or after the episode. Hence, *ex-post* selection does not explain the higher profitability of cohorts born during the sudden stop.
E The Working Capital Channel

This section studies the role of working capital friction in the model. In particular, Figure 12 displays the responses of TFP growth, GDP, labor, and investment to a 100 basis point shock to the interest rate for three different levels of $\eta$, i.e., baseline ($\eta = 1$), low ($\eta = 0$), and high ($\eta = 2$).

First, note that most of the impact of the working capital constraint takes place in the short run. In fact, a higher working capital constraint amplifies the effect on output through a labor channel. As shown in Figure 12(c), labor decreases 50% more on impact when comparing the high $\eta$ case with the baseline. Also note that Figure 12(d) shows no major differences in term of investment. Thus, $\eta$ provides amplification in the short run by exacerbating the labor channel. Second, and more importantly for
the main point of this paper, Figure 12(a) does not display strong differences in terms of TFP growth. Nevertheless, Figure 12(b) can be used to assess the long-run effect of $\eta$. Interestingly, greater working capital constraints reduce the long-run cost of the crisis. Note that higher $\eta$ reduces the demand for intermediate goods, and, hence, intermediate good producers scale down their production and reduce their labor demand. But $\eta$ does not have a direct effect on the cost of enacting new projects; in fact, it affects the problem of the financial intermediary only through general equilibrium effects, i.e., reduction in wages and in the value of each product line type. In this sense, the higher $\eta$ is, the more the reduction in labor is directed to intermediate good production (this generates the short-run amplification mentioned above), and the less is absorbed by the financial intermediary. Hence, the higher the working capital friction is, the lower the effect on entry is, and thus, the lower the long run cost of the crisis. Note that, quantitatively, the long run conclusions are not highly affected by $\eta$; this parameter is mostly useful to match the short run response of labor and output.