Finance and Misallocation: Evidence from Plant-Level Data*

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Abstract

We study a model of industry dynamics in which idiosyncratic risk is uninsurable and establishments are subject to a financing constraint. We ask: does the model, when parameterized to match salient characteristics of plant-level data (Colombia and South Korea), predict large aggregate TFP losses from misallocation of factors across productive units? Our answer is: no. We estimate financing frictions that are fairly large: one-half of the establishments in both countries are constrained and face an external finance premium of 5% on average. Efficient establishments are, nonetheless, able to accumulate internal funds and quickly grow out of their borrowing constraints. Parameterizations of the model that hinder this process of internal accumulation can, in principle, cause very large TFP losses. Such parameterizations are, however, at odds with important features of plant-level data, most notably the difference in returns to factors across establishments that expand/contract (young vs. old) and the variability and persistence of plant-level sales.

Keywords: Productivity. Misallocation. Finance Frictions

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1. Introduction

Differences in GDP per capita across countries are large and mostly accounted for by differences in total factor productivity: the efficiency with which these countries' aggregate stock of capital and labor is utilized. A key question in economic development is thus: what accounts for the large disparity in aggregate productivity across nations? An intriguing hypothesis[1] is that an important source of dispersion in cross-country TFP are not simply differences in the efficiency of individual productive units, but rather, differences in the extent to which the most efficient units in each of these countries can acquire the capital and labor they need. According to this hypothesis, poor countries are poor not only because individual establishments are less efficient, but also because those establishments that are efficient and should operate at a higher scale are unable to do so.

A number of conjectures have been advanced to explain how countries may differ in the extent of misallocation of factors of production. Popular among these are distortionary government policies[2], frictions that distort factor mobility[3], credit frictions[4] or lack of insurance against the risk associated with entrepreneurial activity[5].

We study, in this paper, the role of credit constraints in generating aggregate TFP losses. There is substantial evidence that financial markets are much less developed in poorer countries. For one, external finance is a much smaller share of GDP in developing economies, suggesting that firms mostly rely on internal finance. Micro-level evidence shows that the rates at which entrepreneurs can borrow in poor countries are large and dispersed[6]. Finally, existing quantitative studies of the impact of financing frictions on aggregate TFP generally find an important role for finance. For example, Jeong and Townsend (2006) attribute 70% of Thailand's TFP growth from the 70s to the 90s to an improvement of the financial sector. Amaral and Quintin (2005), Buera, Kaboski and Shin (2009), Moll (2009), Greenwood, Sanchez and Wang (2009) provide careful quantitative estimates of the effect of finance on misallocation. The TFP losses that these studies report are staggering: TFP would double if one were to increase the access to external finance in poor countries to levels similar to those

[1] Bartelsman and Doms (2000) and Tybout (2000) review the evidence; Restuccia-Rogerson (2008), Hsieh and Klenow (2008), Bartelsman, Haltiwanger and Scarpetta (2008) are several important recent contributions.

[2] Restuccia and Rogerson (2008), Hsieh and Klenow (2008), Guner,Ventura, Xu (2008)

[3] Hopenhayn and Rogerson (1993), Lagos (2006).

[4] Banerjee and Duflo (2005), Goldstein and Udry (1991), Jeong and Townsend (2006), to name a few.

[5] Banerjee and Duflo (2005) and references therein. See also Angeletos (2008).

[6] See the survey in Banerjee and Duflo (2005).

in developed countries like US. For example, 80% of the TFP gap between US and Mexico and 50% of the gap between US and Colombia is accounted for by finance frictions alone, according to these studies.

Our goal in this paper is to use micro-level data in order to revisit the question of whether financial frictions distort resource allocation across productive units. We study, through the lens of a model of firm dynamics with financing frictions, plant-level data from manufacturing firms in Korea and Colombia. We choose these two countries as these provide us with relatively high quality micro-level data, but also because the two are at opposite ends of the finance spectrum. Korea is a country with relatively well-functioning credit markets with an external finance to GDP ratio greater than 150 % and thus similar to that of the US, while Colombia has relatively poor credit markets and an external finance to GDP ratio of around 30 %.

Our point of departure is the observation that 'misallocation' is a statement about differences in rates of return to capital, labor and other factors across plants. An economy is relatively more efficient at allocating resources if a highly productive plant is able to purchase as much capital as needed so as to equate the returns to capital to that of a less productive plant. In contrast, if financing frictions are severe, highly productive firms are unable to raise enough capital and thus have relatively high rates of return. The more severe the frictions are, the larger the gap in returns to capital and other factors across productive and unproductive plants, and hence the lower is aggregate TFP.

We therefore propose to measure the impact finance frictions have on resource allocation by explicitly requiring our model to account for salient features of the data on returns to capital and other factors, in addition to other features of plant-level dynamics. This contrasts to the approach in existing work where one mostly pins down the strength of the borrowing frictions by relying on data on the size of the financial sector. The latter, we argue, is not sufficient to pin down how severe financing frictions are. Indeed, a country may have a low external finance to GDP ratio because firms are severely financially constrained. But a second possibility is that firms in this country have little need for external finance, either because there are fewer productive opportunities to finance, or because entrepreneurs are more risk-averse and thus prefer to accumulate a sufficiently large stock of assets that permits them to mostly rely on internal finance. In the latter scenario a low external finance to GDP ratio is not necessarily evidence of more misallocation. Our goal is to distinguish between these

two alternatives by using both micro-level data, together with aggregate data on the share of finance to GDP.

The model we study is a standard model of industry dynamics in the spirit of Hopenhayn (1992). A continuum of plants differ in the efficiency with which they operate. Efficiency fluctuates over time, thus giving rise to micro-level dynamics and the need for external credit to finance expansions. We assume, given the evidence in Moskowitz and Vissing-Jorgensen (2002), that entrepreneurial risk is not diversified and that dividends from the establishment are the only source of income for risk-averse owners. Plant owners can trade a one-period risk-free security, but the amount they can borrow is subject to a collateral constraint, as in Kiyotaki and Moore (1997).

In addition to the amount of the collateral required for borrowing, several parameters are crucial in determining the amount of misallocation that financing frictions generate. The more volatile and less persistent is a plant's productivity, the larger the need for external finance and hence the stronger is the impact of borrowing frictions. A greater span-of-control parameter magnifies the losses from finance frictions. Finally, the rate of time-preference (relative to the risk-free rate) plays an important role as well: the more patient plant owners are, the more they save to avoid the possibility of a binding borrowing constraint, and thus the less important financing frictions are. We pin down all of these parameters by using data on the volatility and persistence of establishment-level sales, the share of capital and variable factors in total revenue, the aggregate debt-to-sales ratio in the manufacturing sectors of the two countries we study, as well as several moments of the dispersion in returns to factors that we describe next.

Our approach to measuring the severity of the collateral constraint is to recognize that if firm dynamics is driven mostly by shocks to the efficiency with which plants operate (or by initial conditions for entering establishments that start with little wealth), then finance frictions disproportionately affect establishments that expand rather than those that contract. Establishments that expand need to acquire more capital and labor to finance the increase in efficiency and borrowing constraints are more likely to bind. If borrowing constraints are severe such plants will have high returns to capital and other factors. In contrast, firms whose efficiency is worsening need to sell capital and labor and for them the borrowing constraint is less likely to bind. These firms will have lower returns to capital and other factors. We show that the model predicts that the worse the collateral constraints are, the larger the gap

in rates of return for plants that expand vs. plants that shrink are and hence we use these statistics to gauge the severity of the collateral constraint.

We briefly summarize our findings. We find that financing frictions are quite large, both in Korea and Colombia. In both countries approximately one-half of the plants (more than two-thirds of those that borrow) are financially constrained. Agents in both countries are willing to pay a 4-5% premium on external finance in order to relax the constraint. The TFP losses from misallocation are however quite small, on the order of 2% for Korea and, interestingly, only 1% for Colombia, reflecting smaller variability in establishment-level productivity in the latter. The reason we find such small TFP losses is that we document fairly small differences in the returns to capital (27% Korea and 30% Colombia) and variable factors (3% in both countries) across establishments that expand versus establishments that shrink. The model thus interprets the smaller external finance to GDP ratio in Colombia as evidence of not only more severe borrowing frictions (we find that plants can borrow up to 60% of their assets in Colombia, and up to 18% in Colombia), but also as evidence of a stronger precautionary savings motive in Colombia. In contrast, if we were to attribute the entire difference in the external finance to GDP ratio between the two countries to differences in the size of borrowing constraints, we would find substantially larger TFP losses, in the neighborhood of 8%. Such a parametrization would, however, also imply a much larger gap in returns to capital (56% vs. 27% in the data) and variable factors (15% vs. 3% in the data) across establishments that expand and shrink.

In a similar vein, a model with more severe borrowing constraints than what we estimate would overpredict the difference in returns to factors for young plants (those that start small and are growing much faster) versus older plants (that grow slower). A version of our model with entry and exit accounts well for the growth-rate vs. age and returns to capital/labor vs. age pattern in the data, statistics that have been argued useful in gauging the extent of financing frictions in earlier work[7].

Our use of returns to capital and other factors to measure the severity of frictions is not new to macroeconomists. This approach is related to that of the "gap" (between actual and desired stock of, say, capital) approach to measuring adjustment costs in the work of Caballero, Engel and Haltiwanger (1995) and others. Assuming a CES production function, the gap between the desired and actual stock of capital is proportional to the returns to

[7] Cooley and Quadrini (2001).

capital, and hence the two methodologies are related. In fact, adjustment costs also give rise to a positive relationship between returns to capital and measures of firm growth. Hence our approach of attributing all variation in returns to borrowing constraints will overstate the importance of finance frictions.

That we find little dispersion in returns to capital and other factors may seem to contradict the findings of Hsieh and Klenow (2008) who find large unconditional variability in these returns using plant-level data for China and India. The difference between our results lies in the fact that we project measures of return to factors on measures of firm dynamics in order to isolate the role of intertemporal distortions. Thus, although we do find large cross-sectional dispersion in returns to factors (which may arise for a variety of reasons), we find small differences in returns once we condition on measures of firm growth. The latter conditional measures must be large for financing frictions to play an important role.

In addition to studying the TFP losses induced by finance frictions in a cross-section, we also briefly study the model's predictions for TFP in the aftermath of a financial crisis. In particular, Korea experienced a severe financial crisis in 1997 that was associated with a 9% increase in corporate bond spreads, a 70% exchange rate devaluation, as well as a 3.3%[8] drop in utilization-adjusted TFP relative to trend. When we feed the model a reduction in establishments' net worth large enough so as to generate the 9% increase in the external finance premium we observe in the data, we find that the model accounts for the bulk of the increase in the cross-sectional dispersion of returns to factors in Korea in the aftermath of the crisis. Moreover, the model generates a TFP decline of 2%, thus roughly sixty percent of the TFP drop in the data. Thus a crisis of large proportion produces a fairly small effect on TFP, both in the model and the data.

This paper proceeds as follows. Section 2 presents the model and discusses the approach we use to identify the strength of financing frictions. Section 3 describes the data for Korea and Colombia and discusses its salient features. Section 4 studies the data through the lens of the model and computes the TFP losses from misallocation. Section 5 conducts a number of additional experiments to gauge the robustness of our results and also allows for plant-level turnover. Section 6 studies the Korean financial crisis.

[8] Benjamin and Meza (2009)

2. Model

The economy is inhabited by a continuum of entrepreneurs, each of whom has access to a technology that produces output using a constant returns to scale production function. Each entrepreneur produces a variety of imperfectly substitutable goods and faces a downward-sloping demand curve. Dividends from the plant are the sole source of income for the entrepreneur. Because our focus is on aggregate TFP losses in the ergodic steady-state of a small open economy with no aggregate uncertainty, we conduct our analysis in a partial equilibrium setup. The general equilibrium extension is straightforward but requires additional notation and does not add much insights. We abstract from plant-level turnover at this point, and return to a variation of the model that allow for plant exit and entry below.

A. Environment

We assume that the plant owner maximizes

$$\sum_{t=0}^{\infty} \beta^t U\left(D_t\right)$$

where D_t are the firm dividends, the only source of the owner's income. We assume $U(D) = \frac{D^{1-\gamma}}{1-\gamma}$, with $\gamma > 0$. Plants produce output Y_t using inputs of capital, K_t, and a composite of labor and materials, $V_t = M_t^{s_m} L_t^{1-s_m}$[9], and operate under a Cobb-Douglas production function with constant returns:

$$Y_t = A_t V_t^{\alpha} K_t^{1-\alpha}$$

We assume that plant productivity grows over time at rate g and deviations around this trend follow an AR(1) process with serial correlation ρ.

$$\log\left(A_t\right) - gt = \rho\left[\log\left(A_{t-1}\right) - g\left(t-1\right)\right] + \varepsilon_t$$

[9]We collapse thus the problem into 2 dimensions given that the choice of M vs. L is static and can be optimized out. Clearly, optimization implies $V = pM + wL$, where pM is expenditure on intermediate inputs and wL is the labor bill.

Plants face a downward-sloping demand curve with constant elasticity $\tilde{\eta} < 0$:

$$P_t = Y_t^{\frac{1}{\tilde{\eta}}}$$

The entrepreneur owns the plant's capital stock, K_t, and decides how much to invest and how much of the variable factor to hire in each period. Capital depreciates at rate δ. Letting $\eta = 1 + \frac{1}{\tilde{\eta}}$ denote the inverse of the markup[10], the plant's profits, net of investment, are:

$$\Pi_t = \left(A_t V_t^{\alpha} K_t^{1-\alpha}\right)^{\eta} + (1-\delta) K_{t-1} - V_t - K_t$$

We next describe the assumptions we make regarding the financial side of the model. First, we assume that the plant owner cannot issue equity and so the bond is its only source of finance. Second, we assume that the entrepreneur must pay its workers, suppliers of capital and intermdiate inputs upfront, before receiving the revenue from sales, but after repaying its outstanding debt. In other words, we assume that proceeds from selling the good are received with a one period delay. As a result, the choice of both capital and variable factors are intertemporal and affected by the financial frictions.

We allow the plant owner to borrow and lend at an interest rate r using a one-period risk-free security. Let B_{t-1} be the amount of debt the plant owes at the beginning of period t. Let W_{t-1} denote the plant's net worth at the beginning of period t after repaying its debt:

$$W_{t-1} = \left(A_{t-1} V_{t-1}^{\alpha} K_{t-1}^{1-\alpha}\right)^{\eta} + (1-\delta) K_{t-1} - B_{t-1}$$

Let B_t be the amount the plant borrows at date t. Then dividends are:

$$D_t = \left(A_{t-1} V_{t-1}^{\alpha} K_{t-1}^{1-\alpha}\right)^{\eta} - V_t - K_t + (1-\delta) K_{t-1} + \frac{B_t}{(1+r)} - B_{t-1}$$

We assume $\beta(1+r) < 1$. For a given risk aversion parameter γ, the size of $\beta(1+r)$

[10] An alternative (identical for our purposes since we only observe data on total sales, PY), interpretation is that perflectly competitive firms produce with a decreasing-returns-to-scale technology with span-of-control parameter η. All our TFP calculations are identical under this interpretation since our focus is on measures of Revenue TFP.

governs the strength of the precautionary savings motive: the more impatient the plant owner is, the more she relies on external rather than internal finance and the more important financing frictions are. Finally, we assume a borrowing constraint similar to that in Kiyotaki and Moore (1997) so that the firm cannot borrow more than a fraction λ of its next period's assets:

$$B_t \leq \lambda \left[\left(A_t V_t^{\alpha} K_t^{1-\alpha} \right)^{\eta} + (1-\delta) K_t \right] = \lambda \left(W_t + B_t \right)$$

B. Decision rules

It is convenient to rewrite the entrepreneur's problem recursively, noting that net worth, W, together with the plant's productivity, A, are sufficient to describe an individual state. Hence, the value of the establishment, $F(W, A)$, satisfies[11]:

$$F(W, A) = \max_{V,K,W'} \frac{D^{1-\gamma}}{1-\gamma} + \beta \int F(W', A')\, dG(\varepsilon'),$$

where

$$D = W - V - K + \frac{\left(AV^{\alpha}K^{1-\alpha}\right)^{\eta} + (1-\delta) K}{(1+r)} - \frac{W'}{1+r},$$

subject to

$$W' \geq (1-\lambda) \left[\left(AV^{\alpha}K^{1-\alpha} \right)^{\eta} + (1-\delta) K \right].$$

The first-order conditions that characterize the optimum are:

$$D^{-\gamma} = \beta (1+r) \int F_1 (W', A')\, dG(\varepsilon') + (1+r)\, \Phi$$

where $\Phi \geq 0$ is the multiplier on the borrowing constraint, and

$$R_V = R_K = \left(\frac{\lambda}{1+r} + (1-\lambda) \frac{\beta \int F_1 (W', A')\, dG(\varepsilon')}{D^{-\gamma}} \right)^{-1}$$

[11] To keep the notational burden to a minimum, we describe the problem assuming the growth rate of productivity is 0. The extension to trend growth is straightforward by appropriately detrending all variables by $\exp(gt)$.

where

$$R_K = 1 - \delta + \eta (1 - \alpha) \frac{(AV^{\alpha} K^{1-\alpha})^{\eta}}{K}$$
$$R_V = \eta \alpha \frac{(AV^{\alpha} K^{1-\alpha})^{\eta}}{V}$$

If the borrowing constraint does not bind, then $\Phi = 0$ and $R_V = R_K = 1 + r$. That is, the returns to the two factors are equal to the gross interest rate. In contrast, if the entrepreneur is constrained, her marginal utility of consuming today is relatively high, $\frac{\beta \int F_1(W', A') dG(\varepsilon')}{D^{-\gamma}} < (1 + r)$, and so the plant hires less capital and variable factors than under the unconstrained optimum: $R_V = R_K > (1 + r)$. Importantly, differences in net worth across plants with the same productivity will induce difference in the returns to factors and thus TFP losses.

Figure 1 plots the decision rules for capital, as a function of the plant's efficiency, A, for two levels of initial plant net worth. The dashed line reflects the unconstrained optimum. Notice how (holding net worth fixed) more productive plants are eventually unable to finance the unconstrained level of capital and as efficiency increases, the gap between desired and actual level of the capital stock increases as well. Hence more productive firms (holding net worth constant) are more financially constrained. The decision rules for the variable factor are similar. The only difference is that a binding constraint distorts the allocation of capital relatively more than that of the variable factor (in the sensen that the gap between actual and desired level of capital is greater). This is because capital is a durable good and hence more sensitive to variations in the effective rate at which the plant owner borrows.

The fact that more productive plants in our model are more severely constrained may seem counter-intuitive, especially in light of the results of Kiyotaki and Moore (1997). The difference between our setup and that of Kiyotaki and Moore is that they study the response of the model economy to an *aggregate* productivity shock. An aggregate productivity shock, in the presence of adjustment costs, increases the price of capital and thus relaxes the borrowing constraint. This latter effect is absent here because we consider *idiosyncratic* productivity shocks that have no effect on prices. More generally, one can think of alternative enforcement scenarios in which the borrowing constraint reflects dynamic considerations (e.g., an option to default). Under such perturbations more productive firms may be less likely to default and

would also face a less severe borrowing frictions. Our conjecture is that such perturbations are likely to predict even less misallocation from borrowing frictions as the most productive firms would be exactly those able to borrow and finance the desired level of capital.

C. TFP losses from misallocation

We next describe how we compute the aggregate (revenue) productivity losses from factor misallocation in our model economy. Consider the problem of allocating the aggregate stock of capital $K = \int_0^1 K_i di$ as well as the aggregate stock of the variable factor, $V = \int_0^1 V_i di$, across the continuum of plants that operate in this economy, so as to maximize total revenue[12]:

$$\max_{K_i, V_i} R = \int_0^1 \left(A_i V_i^{\alpha} K_i^{1-\alpha}\right)^{\eta} di$$

$$\text{s.t.} \quad K = \int_0^1 K_i di \text{ and } V = \int_0^1 V_i di$$

Clearly, the solution to this problem requires that the planner equates the returns to factors across all plants and assigns each plant a share of capital that depends on its productivity:

$$\frac{K_i}{K} = \frac{V_i}{V} = \frac{A_i^{\frac{\eta}{1-\eta}}}{\int_0^1 A_i^{\frac{\eta}{1-\eta}}}$$

Then aggregate revenue is equal to

$$R = \left(A V^{\alpha} K^{1-\alpha}\right)^{\eta}$$

and the efficient level of total factor productivity (TFPR) is equal to

$$TFPR = A^{\eta} = \frac{R}{\left(V^{\alpha} K^{1-\alpha}\right)^{\eta}}$$

[12]That this is the objective of the planner is clear if we adopt the interpretation of perfectly competitive plants operating with a technology with decreasing returns to scale, η. The objective of the planner is the same however under the alternative interpretation of constant elasticity of substitution preferences over the different varieties of goods. Under such an interpretation the objective of the planner is to maximize the Dixit-Stigliz consumption aggregator, $C = \left(\int_0^1 Y_i^{\eta} di\right)^{\frac{1}{\eta}}$, which is clearly an identical objective to that above.

where

$$A = \left(\int_0^1 A_i^{\frac{\eta}{1-\eta}} \right)^{\frac{1-\eta}{\eta}}$$

Consider next the economy with borrowing frictions. We can rewrite the decision rules in the presence of borrowing frictions as

$$\alpha\eta \frac{R_i}{V_i} = \omega_i^V \text{ and } (1-\alpha)\,\eta \frac{R_i}{K_i} = \omega_i^K$$

where $\omega_i^V = 1 + r$ absent the finance frictions, and $\omega_i^V > 1 + r$ if the borrowing constraint binds. Similarly, $\omega_i^K = r+\delta$ absent the finance frictions and greater than $r+\delta$ if the constraint binds. With this notation in place, we again write the aggregate revenue in this economy as a function of aggregate productivity and the aggregate stock of capital and variable factor:

$$R = \left(A^c V^\alpha K^{1-\alpha}\right)^\eta$$

Total factor productivity, $(A^c)^\eta$, now depends on the joint distribution, μ, of the wedges, ω_i^K and ω_i^V and plant-level efficiency, A_i :

$$A^c = \Gamma\left(\mu\left(\omega_i^K, \omega_i^V, A_i\right); \alpha, \eta\right)$$

Although a closed-form expression for this term is easily available, the expression is too long for us to include it here. Suffices to say that this term decreases in the dispersion of ω_i^K and ω_i^V across plants. Thus, what matters for the TFP losses from financing frictions is the dispersion in the shadow cost of funds across entrepreneurs, not its average. The degree of returns to scale increases the TFP losses from misallocation as well: a greater span-of-control parameter, η, magnifies the losses from finance frictions. In the limit, if returns to scale are constant, only the most efficient plant should operate and in this case the losses are infinitely large.

This discussion suggests that the model's implications for aggregate TFP critically depend on its implications for the dispersion in returns to capital, $\frac{R_i}{K_i}$ and the variable factors, $\frac{R_i}{V_i}$ across plants. This motivates our empirical strategy of measuring the size of financing

frictions by requiring the model to match salient features of the distribution of these objects in the data. To illustrate our methodology, Figure 2 shows how the returns to capital vary with a plant's productivity and as a function of λ (the parameter governing the strength of the borrowing constraint). The lower λ is, the sooner will a plant hit its borrowing constraint and the larger the returns to capital will be. As a result, a lower λ raises the gap in returns to capital across productive and unproductive plants and thus causes larger aggregate productivity losses.

3. Data

In this section we briefly discuss the source of the plant-level data we use and discuss a number of salient features of the data.

A. Data Description

Korea

The data we use are from the Korean Annual Manufacturing Survey, which is collected by the Korean National Statistical Office. The survey is conducted every year from 1991 to 1998, except for the year of Industrial Census (1993) for which we supplement the data using the Census data (which covers all establishments). The survey covers all manufacturing plants with five or more workers.

The survey reports information about each plant's total revenue, number of employees, total wage bill, payments for intermediate inputs (materials), as well as energy use. The survey also reports the book value of a plant's capital stock, as well as purchases, retirement/sales, and depreciation for land, buildings, machinery and equipment. This information allows us to construct a measure of plant-level capital using a perpetual inventory method[13]. We follow earlier work and focus on buildings, machinery and equipment as our measure of capital stock. We construct this measure according:

$$\begin{aligned} I_t &= PUR_t - RET_t \\ K_{t+1} &= K_t - DEP_t + I_t \end{aligned}$$

where I_t is investment, PUR_t is purchases and DEP_t is the depreciation of capital stock. We

[13]See e.g. Caballero et al. (1995).

use a plant's book value of capital to initialize each series. All data (investment, retirements, depreciation, initial capital stock) is deflated using price deflators for capital for Korea's Manufacturing Sector available from the OECD STAN Industrial Database. We define labor expenditure as wage and welfare payment to workers. The intermediate inputs reported in Korean Manufacturing Survey include raw materials, water, fuel, and maintenance. All revenues and expenditures are deflated and correspond to 1991 Korean Won. Finally, we augment that measure of capital constructed above to include the amount leased by (primarily smaller) establishments.

We drop observations that are clearly an outcome of coding errors: observations with negative reported revenue, expenditure of variable inputs, depreciation, capital book value, and capital purchases. Our final sample consists of $591,665$ plant-year observations over an eight year period from 1991 to 1998. We mostly focus on the 1991-1996 period, the years before the financial crisis, and study the last two years of the crisis in the final section of this paper.

Our information about the debt positions of plants in the Manufacturing sector comes from the Bank of Korea Financial Statement Analysis. This is a survey of all large companies as well as a stratified random sample of smaller firms. The aggregate debt-to-sales ratio of firms in this dataset is equal to 0.50. Given that the share of value added in revenue is equal to roughly 1/3 in our sample, this number corresponds to a Debt-to-GDP ratio of 150%, thus in line with aggregates for Korea.

Colombia

The data are from the Colombian Industrial Survey and covers the years 1981 to 1991. The Census collects data on all establishments with more than 10 workers. The Colombian Manufacturing sector relies primarily on mostly food processing, textiles, apparel and metal products, and is thus less capital-intensive than its Korean counterpart.

The Colombia Industrial Survey reports detailed information of book value, purchases, sales, and depreciation of fixed assets categorized by building, machinery, and other transportation/office equipment. This allows us to construct measures of capital stock in a very similar fashion as for the Korean data described above. We measure labor expenditure as wage and benefits payments to workers. Intermediate inputs include energy, raw material, and various other industrial expenditures (such as fuels and lubricants, repairs and maintenance). All revenues and expenditures are denominated in 1981 Pesos.

After excluding observations that are an obvious outcome of coding error using the same criteria as in Korean data, we are left with $71,330$ plant-year observations for 1981 to 1991. Finally, we use aggregate data on the External Finance to GDP ratio for Colombia: 0.30[14], which then translates into a debt-to-sales ratio of 0.10 given the share of value-added in revenue for the plants in our sample.

B. Plant-level moments and identification

Table 1 presents the moments we will use in order to calibrate the parameters of the model. We focus on a balanced panel of plants that are in sample from 1991 to 1996 (Korea) and 1981 to 1991 (Colombia) in order to parameterize the version of the model without plant turnover.

These plant-level moments are remarkably similar across the two economies. As Table 1 indicates, the capital to sales ratio, which we use to pin down the share of capital, $1-\alpha$, in the production function, is equal to 1/3. The ratio of spending on variable inputs (labor and intermediate inputs, including energy, water, fuels and other expenditure) is equal to 0.72 in Korea, and somewhat higher, 0.80 in Colombia. These moments will help pin down the degree of returns to scale, η (the inverse of the markup), in the model. All else constant, a higher ratio of costs to revenue is interpreted by the model as evidence of a smaller markup, i.e., a higher η.

Aggregate (real) revenue grows at 6% per year in Korea and 5% in Colombia in the respective periods. The ratio of aggregate investment to capital is 20% in Korea and somewhat smaller, 12% in Colombia. Together, these two sets of moments will pin down the growth rate of plant-level productivity, g, as well as the rate at which capital depreciates, δ.

We will pin down the two parameters that govern the persistence and volatility of productivity shocks by requiring the model to account for the serial correlation of plant-level revenue, and the standard deviation of revenue growth rates. Notice that establishment-level sales are fairly persistent in the data: its serial correlation is equal to 0.96 in Korea and 0.99 in Colombia. Large plants thus stay large for long. Revenue is however quite volatile from one year to another: the standard deviation of its growth rate is equal to 46% in Korea and 29% in Colombia.

The next set of moments we report are the average returns to capital (variable factors)

[14] Beck et. al. (2000), Moll (2009).

for plants that expand ($\Delta \ln R_{it} > 0$) minus the average returns to capital (variable factors) for plants that contract ($\Delta \ln R_{it} < 0$). As we argue above and also illustrate below in a set of counterfactual experiments, the model predicts that more severe borrowing frictions translate into a larger gap in returns to factors across the two groups of plants because financing frictions disproportionately affect plants whose productivity has increased and need to purchase more capital, labor etc. in order to expand their scale of production.

That plants that grow are plants that have been subject to increases in their productivity is true of course only as long as variation in revenue over time is mostly driven by shocks to a plant's productivity and not to its net worth or collateral constraint. A firm subject to an exogenous tightening of the borrowing constraint may be forced to sell capital and it will contract and simultaneously experience an increase in its return to capital. We show below however that a model with shocks to the plant's ability to borrow, on their own, accounts for little of the size distribution of establishments in the data. Therefore most differences in plant dynamics, we argue, reflect variation in plant-level efficiency[15], as opposed to shocks to a firm's net worth or borrowing constraints.

Interestingly, differences in whether establishments contract or expand have similar effects on the returns to factors in the two countries we study. Plants that expand have returns to capital that are on average 27% (Korea) and 30% (Colombia) higher than those plants that contract. Similarly, the gap in returns to the variable factor across the two types of establishments are equal to only 3% in both countries.

The last rows of Table 1 report several additional features of the data that we will use to evaluate the model's predictions. These summarize moments of the size distribution of establishments which is highly concentrated (e.g. in Korea the top 10% of the plants account for 85% of the sales), as well as moments that summarize the shape of the tails of the distribution of revenue growth rates. In particular, a number of plants in the data experience quite large increases in their revenue (e.g. in Korea 1% of the plants experience increases in revenue in excess of 3 standard deviations, i.e, in excess of 150%). Since large expansions are more difficult to finance in the presence of borrowing constraints, we study the implications of these episodes for the model's predictions for aggregate TFP.

[15]Given our focus on revenue productivity, shocks to "efficiency" reflect both productivity (cost), as well as preference shocks.

4. Quantitative Results

We first discuss the approach we used to parameterize the model economy, and then compute the TFP losses from misallocation and conduct a number of robustness experiments.

A. Parametrization

The two parameters that we assign and are constant across countries/experiments are the parameter governing the curvature of the utility function, $\gamma = 2$, and the risk-free interest rate, $r = 2\%$. Both of these are standard parameters in earlier work.

We calibrate the rest of all other parameters (separately for each country) by minimizing the distance between the moments in the model and in the data. The parameters we calibrate are those described above, in addition to those characterizing the distribution of productivity shocks. We assume that productivity shocks, ε_{it}, are distributed according to

$$\varepsilon_{it} = \begin{cases} N\left(0, \sigma_{\varepsilon}^{2}\right) \text{ with prob } 1-p \\ \\ B\sigma_{\varepsilon} \text{ with prob } p \end{cases}$$

Thus, with probability $1-p$ the shock to productivity is drawn from a Gaussian distribution with variance σ_{ε}^{2}, while with probability p that plant experience a large productivity shock equal to B standard deviations. These infrequent but large bursts in productivity are necessary for the model to account for the fat upper tails of the distribution of revenue growth rates in the data.

The moments we target are those numbered 1-11 in Table 1: the plant-level moments described earlier, as well as the aggregate debt-to-sales ratios in the Manufacturing sector (0.5 in Korea and 0.10 in Colombia). Table 2 reports the two sets of moments in the model, for both countries: our parametrization allows a fairly good fit and matches all of these moments quite well. In particular, notice that the model accounts well for the relatively large gap in returns to capital across plants that shrink and expand and the relatively lower gap in returns to the variable factors. As mentioned above, this is driven by the fact that capital is a durable good and hence more sensitive to variations in interest rates.

As for the moments we do not explicitly target in our calibration, notice that the model accounts for the size distribution of plant revenue well. The model matches the unconditional variance of revenue, as well as the concentration of revenue among the top plants, especially

for Colombia. We slightly underpredict the amount of concentration among Korean plants (the top 10% of the plants account for 85% of sales in the data and only 72% in the model, while the top 20% of the plants account for 92% of sales in the data and only 84% in the model), but as we show below, this aspect of the model considerably improves once we allow for plant-level turnover.

Table 3 reports the parameter values, in both Korea and Colombia, that achieve this fit. The share of capital, $1 - \alpha$, is fairly low, 0.075 in Korea and only 0.04 in Colombia, reflecting that manufacturing in Colombia is less capital-intensive as well as the fairly high share of intermediate inputs in the manufacturing sector. The return-to-scale parameters is equal to 0.82 in Korea and 0.87 in Colombia, reflecting the relatively higher share of variable factors in revenue (80% vs. 72%) in Colombia. Both of these numbers are in the neighborhood of typical estimates of returns to scale (or markups) in the US[16].

Productivity grows in both countries at a rate of roughly 5% per year. We estimate a lower rate of depreciation in Colombia (7%) than in Korea (13.7%), reflecting the lower investment-to-capital ratio in the former.

The serial correlation of productivity shocks is 0.929 in Korea and 0.978 in Colombia, reflecting the more persistent process for revenue in the latter. Shocks to productivity are more volatile in Korea ($\sigma_\varepsilon = 0.095$) than in Colombia ($\sigma_\varepsilon = 0.05$), given the lower standard deviation of revenue growth rates. Our conjecture is that these differences reflect the fact that the Colombian data samples relatively large plants (those with more than 10 workers) while the Korean data samples some smaller plants (those with 5 workers). Notice also that in both countries a fairly large proportion of establishments (in excess of 4 %) are subject to large shocks to their productivity. This is especially true in Korea where the size of the shock is equal to 4.75 standard deviations.

Finally, we find that the borrowing constraint is more severe in Colombia than in Korea. Plants in Korea can borrow up to 61% of their assets, while those in Colombia only up to 18% of their assets. If these differences in the borrowing constraint were the sole source of the difference in the debt-to-sales ratios in the two economies, the model would predict much greater dispersion in returns to capital and variable factors in the more financially constrained Colombian establishments. This, however, is counterfactual given the evidence

[16]See, e.g. Basu and Fernald (1995,1997). Atkeson and Kehoe (2007) cite this and other evidence and argue for a span-of-control parameter equal to 0.85.

in Table 1. Hence, in addition to finding more severe borrowing constraints in Colombia, our algorithm concludes that Colombian plants have a stronger precautionary-savings motive and rely much more on internal finance. Mechanically, this implies an estimate of $\beta(1+r)$ that is greater in Colombia (0.985) than in Korea (0.90)[17]. Thus, the lower debt positions of plants in Chile reflect, according to our calibration, a combination of more severe borrowing frictions, but also a stronger precautionary savings motive.

B. Size of borrowing frictions and TFP losses from misallocation

We are now ready to discuss the extent to which establishments are constrained in the two parametrizations of the model. To this end, we define the shadow cost of external funds, $\tilde{r}$, as

$$\tilde{r} = \left(\frac{\lambda}{1+r} + (1-\lambda) \frac{\beta \int F_1(W', A')\, dG(\varepsilon')}{D^{-\gamma}} \right)^{-1} - 1$$

Recall that returns to capital and the variable factor, are equal to $R_V = R_K = (1+\tilde{r})$.We thus interpret $\tilde{r}$ is the implicit rate at which the plant owner is borrowing (cost of external funds). If the borrowing constraint does not bind, $\tilde{r} = r = 2\%$. We define a constrained plant as one for which $\tilde{r} > r$ and report a number of statistics from the ergodic distribution of plants in Table 4.

Notice in Table 4 that a larger share of Korean plants borrow (72%) than in Colombia (42%), reflecting the stronger precautionary-savings motive in the latter. Roughly 2/3 of the plants that borrow in Korea are constrained. In contrast, the vast majority (in excess of 99%) of plants that need external finance in Colombia are constrained as well, given the lower value of λ we estimate. For those plants that are constrained, the median external finance premium $(\tilde{r} - r)$ is equal to 4% in both countries. Given the greater volatility of productivity in Korea, the dispersion in the effective cost of funds for Korean plants is somewhat larger: the interquartile range of $\tilde{r}$ is equal to 9% (7% in Colombia), while the 90th percentile of $\tilde{r}$ is 19% (16% in Colombia).

As for the effect of these frictions on allocations, the median plant size is roughly 80% of that in the unconstrained economy. In this sense, finance frictions have a non-negligible effect. Most importantly, we find TFP losses (relative to the unconstrained optimum) equal

[17] Alternatively, if we fix $\beta(1+r)$ in the two countries, and allow the risk aversion parameter, γ, to vary, we find a higher risk-aversion parameter for Colombia which leads plants to hold less debt in response to the stronger precautionary savings motive.

to 1.7% in Korea and 1% in Colombia. Again, the smaller losses in the latter reflect a less volatile process for productivity, in conjuction with our requirement that the model accounts for the gap in returns to factors across plants that shrink/expand in the two countries.

C. A counterfactual experiment: the role of λ

We emphasize that the small TFP losses we find reflect the small gap in returns to capital and the variable factor across growing/shrinking plants we document in the data for Colombia and Korea. To see how the model's predictions change if we ignore these features of the data, we conduct the following counterfactual experiment. We start from the model's calibration for Korea (the relatively more financially developed country) and change one single parameter, λ, so as to change the debt-to-sales ratio predicted by the model from 0.50 to 0.10 (the value for Colombia). This counterfactual experiment is similar to that performed in earlier quantitative studies of the role of financing frictions we cite in the introduction. The idea is to attribute all variation in the size of the external finance sector across countries to differences in the severity of finance frictions alone (as opposed to differences in, say, the strength of the precautionary savings motive).

Table 5 reports the results of this counterfactual experiment: we need a value of λ equal to 0.12 in order to render the parameterization of the model for Korea consistent with a debt-to-sales ratio equal to that in Colombia of 0.10. Notice that in this counterfactual experiment plants are much more constrained; the median external finance premium much larger (15% on average vs. 6% earlier); and the model produces much more dispersion in the effective cost of external funds: 10% of the constrained plants face a shadow cost of capital in excess of 40%. As a result the median firm size is much smaller (1/2 relative to the unconstrained case), and the TFP losses from misallocation much greater (8%). These are 8 times greater than those we inferred for the Colombian calibration in which the debt-to-sales ratio was also equal to 0.10.

The large TFP losses in this counterfactual experiment are driven by the fact that the model now generates much more dispersion in returns to factors than in the data. The gap in returns to capital across plants that expand/shrink is now roughly double that in the Colombian data, while the difference in returns to the variable factor is now 5 times larger than that in the Colombian data. It is for this reason that our Colombian calibration requires a much stronger precautionary savings motive in order to simulataneously match the dispersion in returns to factors as well as the lower debt positions of the Colombian plants.

D. Discussion

What accounts for the low TFP losses the model predicts, especially in Colombia were firms are severely constrained in their ability to borrow externally ($\lambda = 0.18$)? Two forces are at play, and we focus on each of these below.

Recall that the losses from misallocation depend on the dispersion in returns to capital and variable factors the model generates. The returns to capital in the model are equal to

$$(1-\alpha)\,\eta\frac{R}{K} = \tilde{r} + \delta$$

while the returns to variable factors are equal to

$$\alpha\eta\frac{R}{V} = 1 + \tilde{r}$$

Thus, although the dispersion in $\tilde{r}$ generates quite a bit of dispersion in the marginal product of capital (because $\tilde{r}$ and δ are of similar magnitude), it generates much less dispersion in the marginal product of the variable factor (because $\tilde{r}$ is relatively close to 0: even an external finance premium of 100% would only double the returns to the variable factor in the model). As a result the TFP losses are quite small given the small share of capital in the production function.

Why is the dispersion in the cost of external funds fairly small in the model? Why is a plant that starts small and receives a sequence of good productivity shocks able to quickly grow out of its borrowing constraint? Recall that plants finance their expenditure with two sources of funds: external finance (which is constrained), but also with internal finance (net worth). The plant's net-worth evolves according to

$$W_{t-1} = \left(A_{t-1}V_{t-1}^{\alpha}K_{t-1}^{1-\alpha}\right)^{\eta} + (1-\delta)\,K_{t-1} - B_{t-1}$$

and is strongly correlated with current productivity as long as A_t is persistent. Thus, a plant that becomes productive is quickly accumulating internal funds as higher productivity translates into higher revenue even for constrained firms. As a result highly productive plants do not stay constrained for long. This is illustrated in Figure 3 where we report the

impulse response to a large (2 standard deviations) productivity shock in the counterfactual experiment we conducted for Korea with $\lambda = .12$. Notice that the increase in productivity initially leads the plant to sell capital in order to finance increases in its dividends (the consumption-smoothing motive), as well as to allow it to hire more of the variable factors. Eventually however the higher productivity of the plant generates more revenue and the firm's effective cost of funds quickly decays to its pre-shock level.

This discussion suggests that the persistence of productivity shocks plays an important role in the plant's ability to quickly grow out of their borrowing constraints. Moll (2009) has recently argued that plant-level productivity is much less persistent in the data and estimates a serial correlation parameter ($\rho = 0.79$) for the dataset we use (Colombia) that is much smaller than what we find ($\rho = 0.98$). He argues that our results are very sensitive to the degree of serial autocorrelation of productivity shocks in the model.

The difference in the two sets of estimates reflect differences in methodology. Moll (2009) computes a Solow residual measure of plant productivity using value-added data (we use revenue) and estimates an AR(1) process for it (which may be subject to a small sample bias). Given the uncertainty regarding the value of ρ and the sensitivity of its estimate to differences in methodologies, we ask whether our results are indeed sensitive to the value of this paramater. We do so by recomputing our Colombian calibration and imposing a value for ρ equal to 0.79, Moll's estimate for Colombia. We find that the TFP losses when $\rho = 0.79$ are only double those in the original Colombian calibration (1.9 %), reflecting a counterfactually larger dispersion in returns to factors (e.g. 0.40 for capital vs. 0.30 in the data) and a less persistent process for plant-level revenue (the serial correlation is 0.89 in the model and 0.99 in the data). We thus conclude that our findings are not that sensitive to the exact value for ρ one employs. We conjecture that the difference between our results and those of Moll (2009) reflect our estimate of a lower span-of-control parameter for Colombia (0.87). Moll, in contrast, studies a model with constant returns to scale in which any amount of dispersion in plant-level returns to factors (in fact the mere co-existence of more than one plant) is very costly.

5. Additional Experiments

We next gauge the robustness of our results to several perturbations of the model, including allowing for plant-level turnover, shocks to net worth, and a lower elasticity of substitution between capital and the variable factor.

A. Exit and Entry

Given our focus on the amount of misallocation across existing plants (as opposed to distortions of the exit/entry margin), we assume a constant hazard of plant exit, θ. A plant that exits is replaced by a new plant whose productivity is equal to A_0, a parameter we calibrate, and whose net worth is equal to a fraction ϕ of the old plant's net worth. The owner's continuation value now reflects the possibility that the plant it owns is replaced by a new one:

$$\beta\left[(1-\theta)\int F\left(W',A'\right)dG\left(\varepsilon'\right)+\theta F\left(\phi W',A_0\right)\right]$$

We calibrate the three additional parameters, θ, ϕ and A_0, in order to match three additional moments of the Korean unbalanced panel of plants from 1991-1996: the fraction of young plants (ages 1-5 years), the median difference in revenue for plants that are young (1-5 years) vs. plants that are old (6 years and above), as well as the difference in returns to capital and the variable factor for young and old plants. Intuitively, A_0 governs the median gap between the size of newly entering and older plants, while ϕ governs the extent to which entering plants are constrained. The latter parameter is pinned down using information on the dispersion in returns to factors: the more constrained entering plants are, the larger their returns to capital and labor. Finally, a higher θ generates more plant turnover and thus a higher proportion of young plants in the sample. We use the latter statistic (as opposed to the actual degree of turnover in the data), because turnover in our sample may be spurious. For example, a plant may disappear from the sample simply because it falls below the cutoff of 5 workers, the truncation point of the survey we use.

In addition to these three additional moments of the data, we will calibrate the model to the entire panel of Korean plants (no longer restricting our focus to a balanced panel), using all moments we have discussed above and now reported in Table 6 (notice that these are very similar to those for the balanced panel in Table 1). Unfortunately, we do not have age information for Colombia so we restrict our analysis to the sample of Korean plants.

Table 6 shows the fit of the model. To conserve space, we only focus on the new moments that are specific to the economy with turnover. Notice that 1/2 of the plants in the sample are younger than 5 years, both in the model and in the data, and that these plants are, on average 0.55 log-points smaller than the older plants. The returns to capital are 15% greater for younger plants in the data (11% in the model) while those to the variable factor are 1.4% in the data (2.3% in the model). Thus age generates little dispersion in returns to

factors.

Achieving this fit requires an exit hazard of $\theta = 0.131$, an initial productivity of $\ln(A_0) = 0.15$, that entering plants start with $\phi = 0.5$ of the net worth of the exiting plants, a rate of time-preferences equal to $\beta(1+r) = 1$ and a borrowing constraint equal to $\lambda = 0.58$. The initial productivity of 0.15 is equal to the median productivity across plants in the population (also 0.15, greater than 0 because of the small fraction of spikes in productivity), hence entering plants are smaller only because of the borrowing constraints, not because of lower initial efficiency. Also, the rate of time-preference is now greater because of the assumption that the plant owner loses a fraction of its net-worth with positive probability upon exit: the latter possibility prevents the owner from relying solely on internal finance and allows the model to match the debt-to-sales ratio in the data even with $\beta(1+r) = 1$.

Also notice, in Table 6, that the model does a very good job at accounting for the additional features of the data that were not directly used for calibration. The model accounts for the concentration of revenue in the largest plants (for example, the largest 10% of the plants account for 83% of the revenue in the data, 86% in the model), as well as the growth rates of the young plants (4.3% in the data and 4.9% in the model). Cooley and Quadrini (2001) show how the growth-rate vs. age relationship varies with the severity of financing frictions. That our model matches the speed at which young firms grow is, to us, evidence that our identification of the strength of financing frictions using variation in returns to factors is quite robust.

Does exit and entry increase the degree of misallocation predicted by the model? We find that a somewhat greater fraction of plants are constrained now (52% vs. 46% earlier), the median effective cost of funds for constrained plants is 8% (6%) earlier, and the interquartile range of $\tilde{r}$ is 0.11% (0.09% earlier). Although somewhater greater, these financing frictions do not increase aggregate TFP losses much: eliminating the borrowing constraint would raise TFP by 1.90% (1.69% earlier). We thus conclude that our results are robust to allowing for plant-level turnover.

B. Shocks to net worth

Our identification strategy for uncovering the size of borrowing constraints relies on the assumption that productivity shocks are the main source of establishment-level dynamics. This is very much in the spirit of Hopenhayn (1992) and the recent work that quantifies the role of finance in generating misallocation. Nevertheless, suppose that shocks to the borrowing

constraint or the plant's net worth are an important source of movements in plant-level sales. In this case, firms that are subject to a negative shock to their ability to borrow will have to contract the amount of resources they hire, and will thus simultaneously increase a drop in sales and an increase in returns to factors. Thus shocks to the plant's ability to borrow drive a negative correlation between returns to factors and growth rates, the opposite of the effect driven by productivity shocks.

We next ask whether this additional countervailing effect is indeed quantitatively important. We assume shocks to the return's to a given plant's net worth, so that the law of motion for net worth is equal to

$$W' = \left[\left(AV^{\alpha}K^{1-\alpha}\right)^{\eta} + (1-\delta)\,K - B\right]\Phi$$

where the returns to net worth are log-normally distributed: $\log \Phi \sim N\left(0, \sigma_{\Phi}^{2}\right)$.

We set $\sigma_{\Phi}^{2} = 0.5$ which is arguably very large: more than 30% of the plants experience more than a 50% increase or decrease in their equity holdings and hence their ability to borrow in any given period. We then shut down productivity shocks: changes in net worth are the sole source of variation in plant-level revenue. We find that in this experiment returns to factors are indeed negatively correlated with growth rates. Plants that expand now have returns to capital 7% smaller than firms that contract and the differences in returns to the variable factor are 1.2%. This parametrization fails however to generate much dispersion in the size or growth rate of revenue. For example, the standard deviation of changes in revenue is equal to 0.13 (0.46 in the data). Even more extreme, the unconditional variance of revenue is 0.016 (2.50) in the data. Absent variation in productivity, the model also generates very little TFP losses from misallocation, only 0.2%. We hence argue that shocks to the borrowing constraint alone account for little of the size distribution of plants in the data.

C. Lower elasticity of substitution

We have argued above that one of the reasons the model predicts small TFP losses from misallocation is the fact that capital is the only factor that is fairly sensitive to variations in the effective cost of external funds, but its share is too small for distortions along this margin to produce large effects on misallocation. We now ask whether our results are sensitive to the unitary elasticity of substitution between capital and the variable factor that we have

assumed.

We assume now that output is produced according to a more general CES production function:

$$R = \left(A \left[\alpha V^{\frac{\theta-1}{\theta}} + (1-\alpha) K^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \right)^{\eta},$$

where θ is the elasticity of substitution between the two factors.

In Table 7 we report results from two experiments, for $\theta = 0.5$ and 1.5. We leave all parameters, except for α, unchanged as the moments we target are insensitive to the value of θ. The share parameter, α, is chosen so as to match the ratio of capital to revenue as in the original analysis. In addition to the moments that relate to the returns to factors, we also report how the ratio of capital to the variable factor varies across plants that expand/shrink. We argue below that the latter statistics is informative about the value of θ.

To see this, note that the ratio of capital to the variable factor in the model satisfies

$$\frac{K}{V} = \left(\frac{1-\alpha}{\alpha} \frac{1+\tilde{r}}{\tilde{r}+\delta} \right)^{\theta}$$

Thus, because $\delta < 1$, we have that an increase in the cost of borrowing, $\tilde{r}$, reduces the ratio of capital to the variable factor. Hence the model predicts that firms that expand have a relatively smaller capital-variable factor ratio than firms that contract. This difference in capital-variable factor ratio depends however on the elasticity of substitution: the lower θ is, the smaller the difference. In the limit, with a Leontieff production function the ratio of capital to the variable factor is independent of the cost of external finance, $\tilde{r}$.

Table 7 reports the TFP losses from misallocation for these additional experiments. We find that indeed, lower substitutability between factors raises the losses from misallocation. The effects are quantitatively small however: the TFP losses range from 1.6% when $\theta = 1.5$ to 1.77% when $\theta = 0.5$. The reason the effect is small is that a smaller elasticity induces a smaller dispersion in the capital to variable factor ratio. Also notice that a value of $\theta = 1.5$ is most consistent with the -0.30 difference in the capital to variable factor ratio among plants that expand/shrink in the data (this gap is equal to -0.20 when $\theta = 1$ and -0.10 when $\theta = 0.5$). Thus, if anything, our use of a Cobb-Douglas production function overstates the role of this mechanism.

6. Korean Financial Crisis

The 1997-1998 Korean financial crisis provides an important case study against which to evaluate our model's predictions. The crisis started in January of 1997 with the bankruptcy of Hanbo steel, one of the largest chaebols, followed by the failure of another steel producer (Samni group), as well as a number of other chaebols and business groups (including Kia motors, the third largest automakers in July 1997)[18].

The crisis was accompanied by a 5% increase in the country risk premium, a 9% rise in corporate bond spreads and a 70% exchange rate devaluation[19]. The latter played an important role since much of the corporate debt was denominated in dollars: Gilchrist and Sim (2007) find that these balance sheet effects account for 50-80% of the drop in investment spending by Korean firms in the aftermath of the crisis. Finally, utilization-adjusted TFP dropped 3.3% relative to trend, according to calculations by Benjamin and Meza (2009). Our goal in this section is to study our model's predictions for the response of TFP in the Manufacturing sector after the crisis.

Figure 4 reports how the cross-sectional variance of returns to capital and the variable factor evolves in Korea from 1993 to 1998. We compute returns for the balanced sample of plants that survive all years and first demean using each plant's time-series average returns (for the 91-96 period) before computing, for each year, the cross-sectional variance. The cross-sectional variance of returns to the two factors increases considerably during the crisis, by 0.14 (a 55% increase) for capital and 0.006 (a 25% increase) for the variable factor.

We model the crisis as a one-time decrease in all the plant's net worth by 70%. This drop in net worth is chosen so that the model accounts for the 9% increase in the cost of external funds ($\tilde{r}$ in the model) observed in the data for Korean corporate bonds spreads following the crisis. In response to this shock, the amount of misallocation in the model economy increases as well: the variance of returns to capital increases by 0.09 (recall 0.14 in the data) and the variance of returns to the variable factor increases by 0.006 (0.006 in the data). Hence our model accounts remarkably well for the increased dispersion in returns to factors in the data.

Figure 5 reports the response of TFP to the financial crisis in the model. We find that TFP drops by 2% (relative to trend) in the aftermath of the crisis, and the drop is fairly

[18]See Adelman and Nak (1998) for a detailed description of the crisis.
[19]Gertler, Gilchrist, Nataluci (2003).

persistent (1% below trend 3 years after the crisis). The model thus accounts for 60% of the drop in TFP in Korea reported by Benjamin and Meza (2009). Thus, a financial crisis of large proportions produces, both in the model and in the data, a fairly small drop in TFP.

7. Conclusions

We document, using micro-level data for Colombia and Korea, modest variation in returns to factors of production across plants that expand/contract or across young/old plants. We show that a model of firm dynamics driven solely by shocks to establishment-level efficiency, interprets this data as evidence that financial frictions have a minor role in distorting resource allocation across productive units. Accordingly, the model we study predicts TFP losses in the neighborhood of 1-2%. These numbers are much smaller than those reported in earlier work that focuses mostly on aggregate-level information to pin down the size of financing frictions.

We emphasize that ours is not an impossibility result: we do not argue that financing frictions on capital accumulation *cannot* generate large aggregate efficiency losses. Indeed, we show how the model's predictions can vary quite a bit if one ignores micro-level information and focuses solely on a country's external finance to GDP ratio.

Our focus was, due to data limitations, on a very narrow question: to what extent can finance frictions distort resource allocations among *existing plants.* We focus on this question because we only observe data on returns to factors for plants that are currently operating. Hence our analysis is silent on whether misallocation plays an important role on the extensive margin, by preventing talented individuals from joining entrepreneurship, or by distorting the allocation of resources across sectors, as in the work of Buera and Shin (2008) and Buera, Kaboski and Shin (2009).

Our results are not evidence that financing frictions are unimportant. In fact, we find that roughly half of the plants in our sample are financially constrained and face an average premium on external finance of roughly 5%. Rather, the model's failure to generate TFP losses stems from the ability of productive establishments to quickly accumulate internal funds. In the model, a highly productive firm is one that also generates a lot of revenue. This revenue is used, in turn, to accumulate equity and the productive establishment quicky overcomes the borrowing constraint. Our calibration predicts that this incentive to accumulate internal funds is greater for plants in Colombia, the relatively poor country, thus explaining why the losses from misallocation are small in Colombia despite a very low debt-to-GDP

ratio.

Finally, we do not interpret our results as evidence against an importank link between finance and TFP. Our analysis indicates that financing frictions cause fairly small distortions in the allocation of factors across plants that differ in the efficiency with which they currently operate. Nevertheless, to the extent to which these frictions distort the adoption[20] of newer and better technologies, their effect on TFP is potentially much greater. An extension of our analysis along these lines remains an exciting topic for future research.

[20]We thank Simon Gilchrist for suggesting an extension of our model along these lines.

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Table 1: Plant-level Facts: Balanced Panel

		Korea	Colombia
1.	aggregate K/R	0.34	0.33
2.	aggregate V/R	0.72	0.80
3.	$\Delta \ln(R)$	0.06	0.05
4.	I/K	0.20	0.12
5.	corr. $\ln(R_{it}), \ln(R_{it-1})$	0.96	0.99
6.	s.d. $\Delta \ln(R_{it})$	0.46	0.29
7.	$\ln\left(\frac{R_{it}}{K_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{K_{it}}\right)^{-}$	0.27	0.30
8.	$\ln\left(\frac{R_{it}}{V_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{V_{it}}\right)^{-}$	0.03	0.03
9.	95 % to s.d. $\Delta \ln(R)$	1.73	1.59
10.	99 % to s.d. $\Delta \ln(R)$	3.17	2.81
11.	Debt-to-Sales	0.50	0.10
12.	var $\ln R$	2.50	2.96
13.	Fraction revenue top 10% plants	0.85	0.72
14.	Fraction revenue top 20% plants	0.92	0.86

Table 2: Moments in Model and Data

		Korea		Colombia	
		Data	Model	Data	Model
	Used in Calibration				
1.	aggregate K/R	0.34	0.34	0.33	0.33
2.	aggregate V/R	0.72	0.72	0.80	0.80
3.	$\Delta \ln(R)$	0.06	0.06	0.05	0.05
4.	I/K	0.20	0.20	0.12	0.12
5.	corr. $\ln(R_{it}), \ln(R_{it-1})$	0.96	0.96	0.99	0.99
6.	s.d. $\Delta \ln(R_{it})$	0.46	0.46	0.29	0.29
7.	$\ln\left(\frac{R_{it}}{K_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{K_{it}}\right)^{-}$	0.27	0.25	0.30	0.28
8.	$\ln\left(\frac{R_{it}}{V_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{V_{it}}\right)^{-}$	0.03	0.05	0.03	0.04
9.	95 % to s.d. $\Delta \ln(R)$	1.73	1.72	1.59	1.65
10.	99 % to s.d. $\Delta \ln(R)$	3.17	3.27	2.81	2.78
11.	Debt-to-Sales	0.50	0.50	0.10	0.10
	Additional moments				
12.	var $\ln R$	2.50	2.57	2.96	3.05
13.	Fraction revenue top 10% plants	0.85	0.72	0.72	0.69
14.	Fraction revenue top 20% plants	0.92	0.84	0.86	0.82

Table 3: Parameter values

		Korea	Colombia
α	Variable factor share	0.925	0.960
η	Span of control	0.824	0.870
δ	Depreciation rate	0.137	0.070
g	Productivity growth	0.053	0.046
ρ	Persistence productivity	0.929	0.978
σ_ε	s.d. shocks to productivity	0.095	0.050
p	prob. large product. shock	0.041	0.047
B	size large product. shock	4.75	2.50
λ	Borrowing constraint	0.605	0.180
$\beta(1+r)$	Discount factor	0.897	0.985

Table 4: Size of financing frictions and TFP losses from misallocation

	Korea	Colombia
Fraction borrow	0.72	0.42
Fraction constrained	0.46	0.42
median $\tilde{r}$ if constrained	0.06	0.06
iqr $\tilde{r}$ if constrained	0.09	0.07
90 % $\tilde{r}$ if constrained	0.19	0.16
median plant size	0.84	0.80
TFP losses, %,	1.69	0.99

Table 5: Effect of varying λ only. Korean calibration.

	$\lambda = 0.61$	$\lambda = 0.12$	Korea	Colombia
$\ln\left(\frac{R_{it}}{K_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{K_{it}}\right)^{-}$	0.25	0.56	0.27	0.30
$\ln\left(\frac{R_{it}}{K_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{K_{it}}\right)^{-}$	0.05	0.15	0.03	0.03
Debt-to-Sales	0.50	0.10	0.50	0.10
Fraction borrow	0.72	0.73		
Fraction constrained	0.46	0.73		
median $\tilde{r}$ if constrained	0.06	0.15		
iqr $\tilde{r}$ if constrained	0.09	0.20		
90 % $\tilde{r}$ if constrained	0.19	0.42		
median plant size	0.84	0.53		
TFP losses, %,	1.69	7.92		

Table 6: Economy with plant turnover

	Korea, all plants	Model
Used in calibration		
aggregate K/R	0.33	0.34
aggregate V/R	0.73	0.72
$\Delta \ln(R)$	0.07	0.07
corr. $\ln(R_{it}), \ln(R_{it-1})$	0.94	0.94
s.d. $\Delta \ln(R_{it})$	0.49	0.52
$\ln\left(\frac{R_{it}}{K_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{K_{it}}\right)^{-}$	0.27	0.25
$\ln\left(\frac{R_{it}}{V_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{V_{it}}\right)^{-}$	0.024	0.05
95% to s.d. $\Delta \ln(R)$	1.75	1.77
99% to s.d. $\Delta \ln(R)$	3.17	3.10
Debt-to-Sales	0.50	0.50
Fraction young	0.51	0.51
$\Delta \ln(R)$ young	-0.55	-0.54
$\Delta \ln(R/K)$ young	0.15	0.11
$\Delta \ln(R/V)$ young	0.014	0.023
Additional moments		
Δ R growth young	0.043	0.049
Fraction revenue top 10% plants	0.83	0.86
Fraction revenue top 20% plants	0.90	0.91

Table 7: Role of elasticity of substitution between factors

	Data	$\theta = 0.5$	$\theta = 1$	$\theta = 1.5$
$\ln\left(\frac{R_{it}}{K_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{K_{it}}\right)^{-}$	0.273	0.165	0.25	0.34
$\ln\left(\frac{R_{it}}{V_{it}}\right)^{+} - \ln\left(\frac{R_{it}}{V_{it}}\right)^{-}$	0.025	0.062	0.052	0.044
$\ln\left(\frac{K_{it}}{V_{it}}\right)^{+} - \ln\left(\frac{K_{it}}{V_{it}}\right)^{-}$	-0.30	-0.10	-0.20	-0.30
TFP losses, %		1.77	1.69	1.60

Figure 1: Decision Rules for Capital

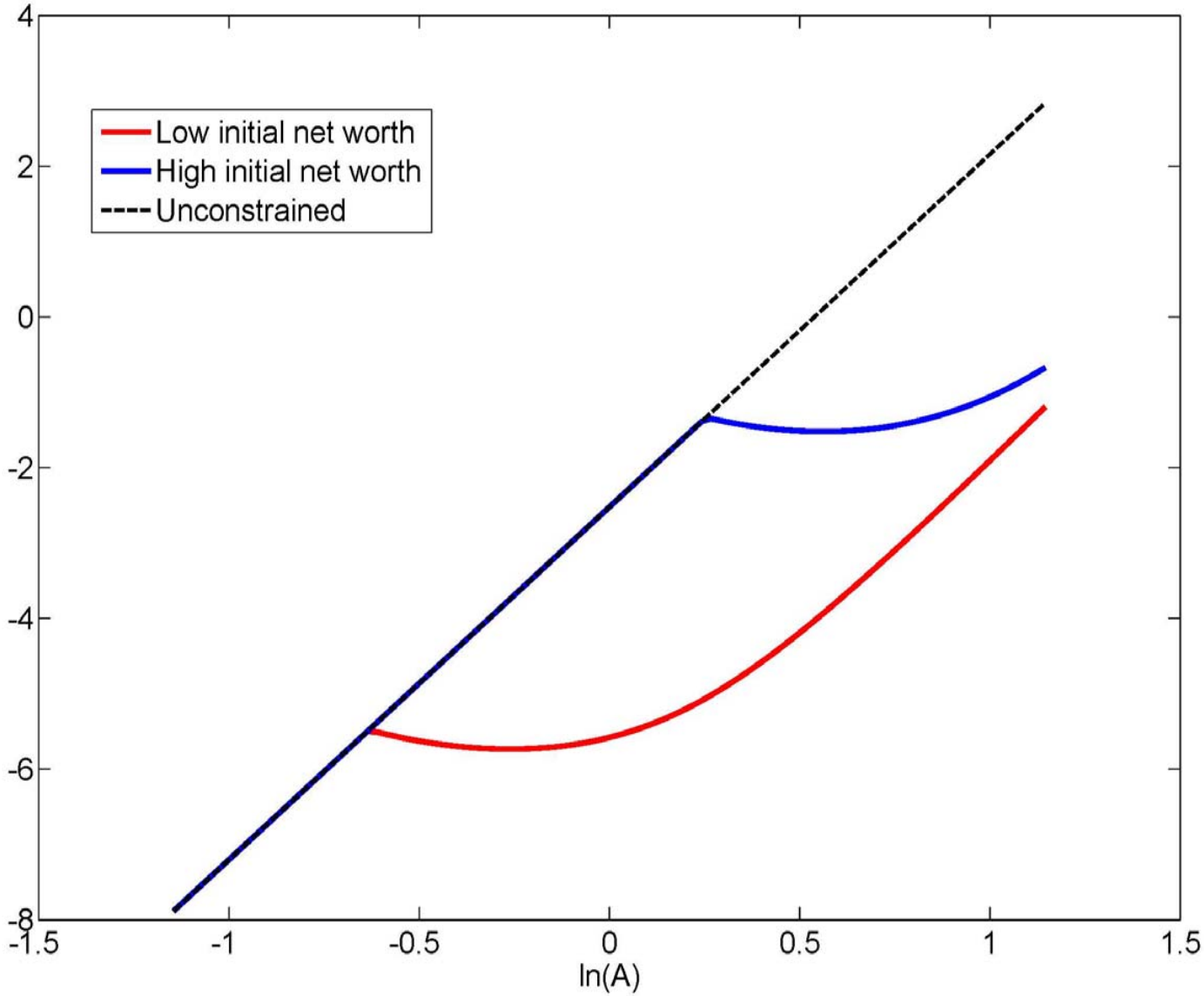

Figure 2: Returns to K vs. λ

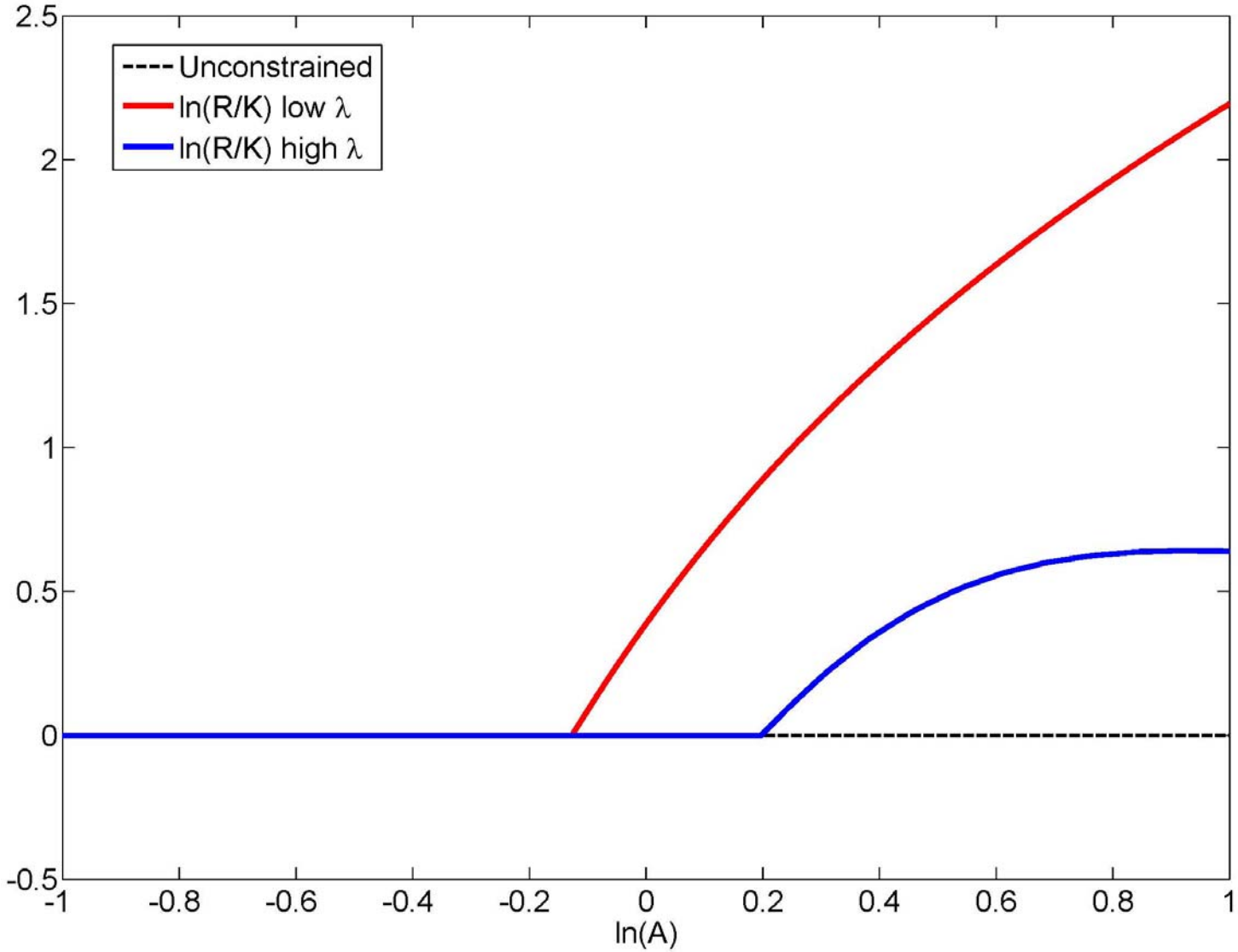

Figure 3: Impulse response to 2 s.d. A shock.

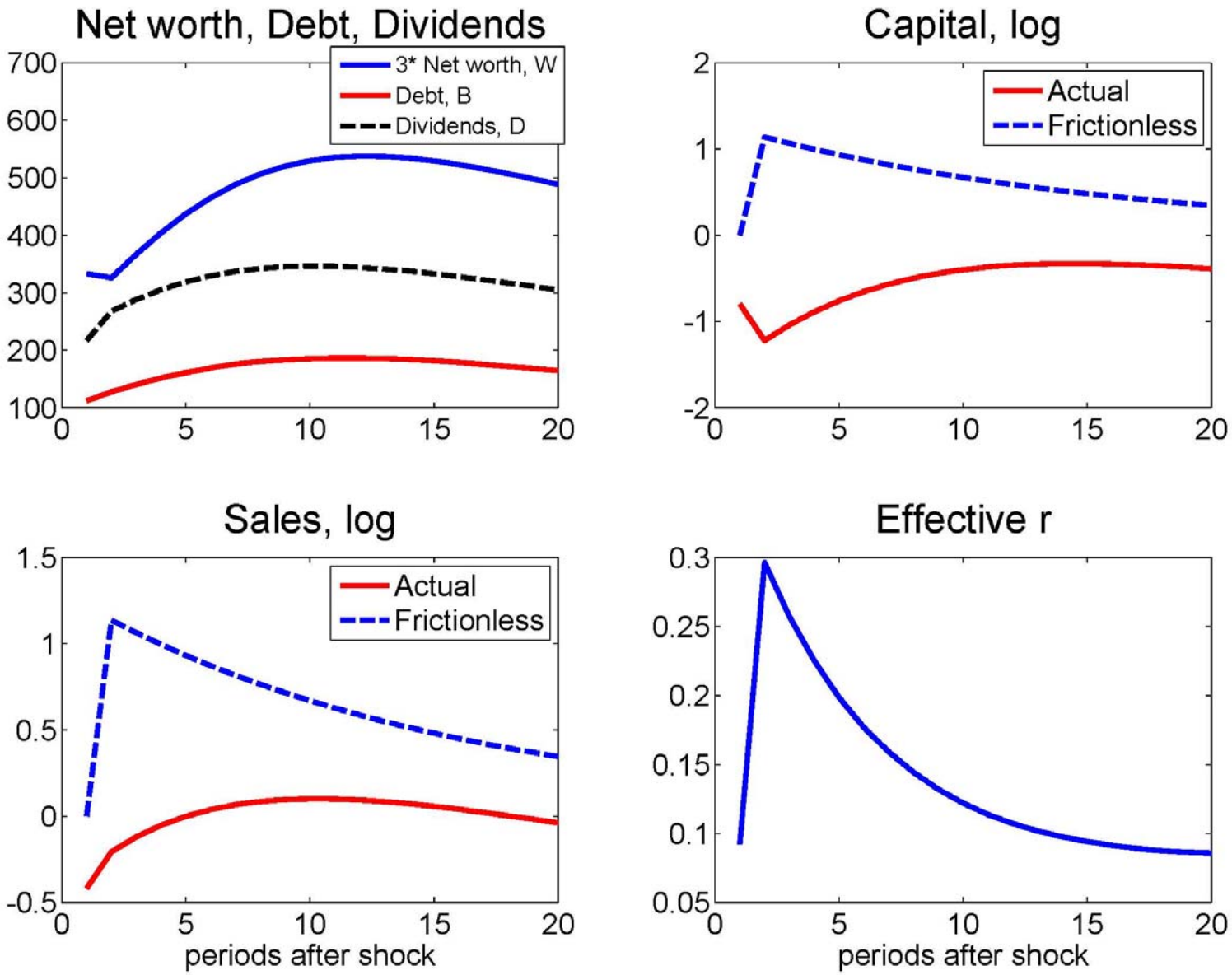

Figure 4: Dispersion returns during Korean crisis

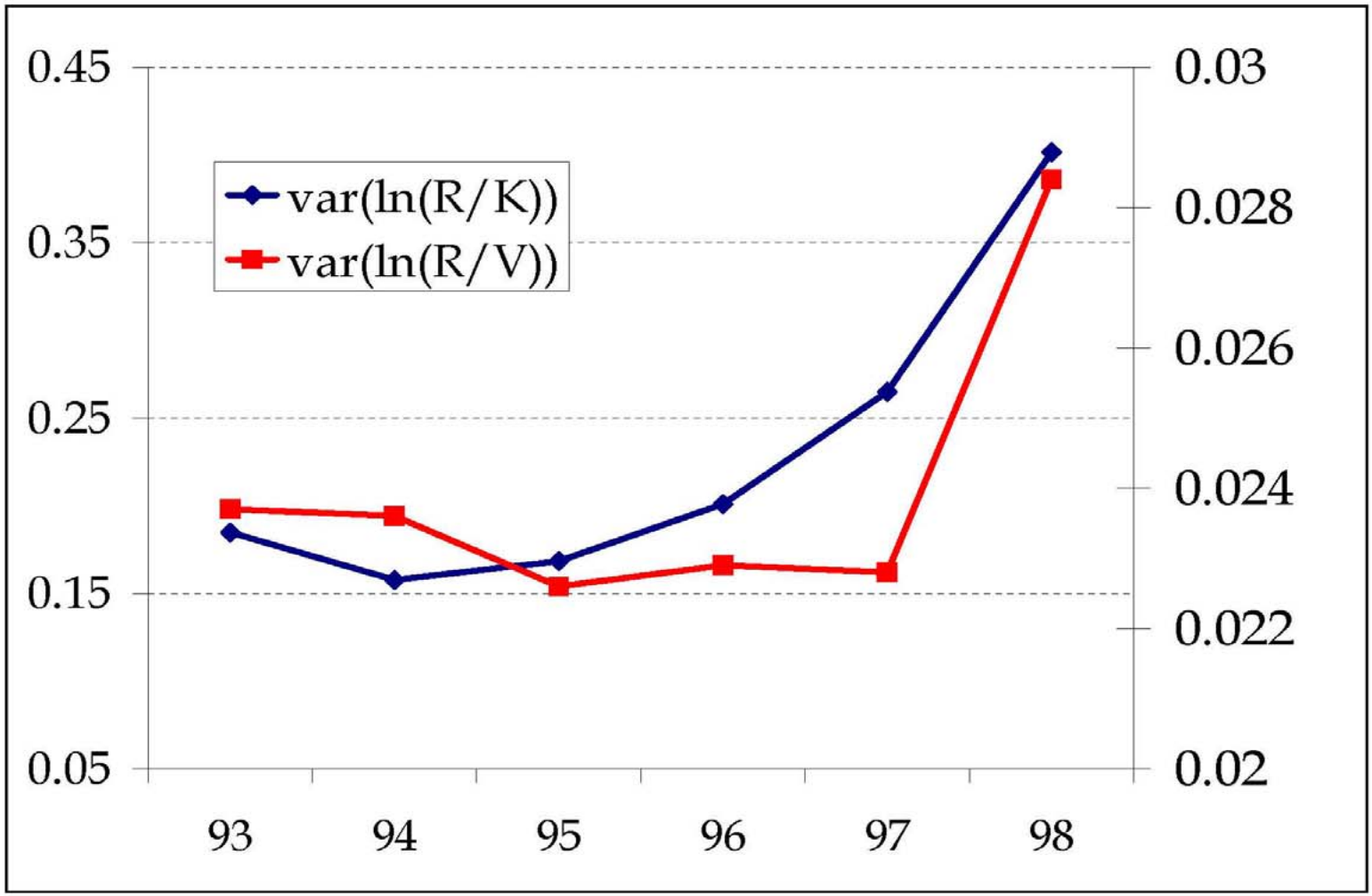

Figure 5: Response of TFP to financial crisis in model economy