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Productivity in Economies with Financial Frictions: Facts and a Theory

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Productivity and Interest Rates in Economies with Financial Frictions: Facts and a Theory

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Abstract

We document and account for two facts regarding the relation between international interest rates and total factor productivity (TFP) in a sample of developing countries. First, there is a negative correlation between both variables at quarterly frequency. Second, the share of agricultural labor and interest rates are positively correlated, whereas the share of agricultural labor and TFP are negatively correlated. Manufacturing labor shows opposite correlations. These relationships are particularly strong in the aftermath of financial crises. We then construct a model in which the presence of costly intermediation can produce such relationships. We show that, after increases in interest rates, a requirement to intermediate factors of production in high productivity sectors, like manufacturing, causes resources to leave these sectors. Resources end up in low productivity sectors, like agriculture, where intermediation is cheaper. This lowers aggregate productivity. We show that the channel we identify is quantitatively important in the case of Korea after the 1997 financial crisis.

Keywords: Small open economy, financial intermediation, total factor productivity
JEL codes: E44; F41; F32

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1 Introduction

Interest rates and total factor productivity (TFP) in developing countries are inversely correlated. The relationship is particulary strong during recent financial crises. As Meza and Quintin (2006) show, the fall in productivity is a significant source of the fall in output in crises. Yet, the connection between interest rates and productivity remains largely unexplored. Economists who study extreme events in developing countries have widely ignored this observation. The falls in productivity after crises are large enough that, when noted, they are often attributed to measurement error, instead of meriting an explanation in their own right.

In this paper we attack the underlying gap in the literature. We begin by documenting two facts regarding the relation between international interest rates and total factor productivity (TFP) in a sample of developing countries. First, there is a negative correlation between both variables at quarterly frequency. Second, we show that the share of labor in agriculture is positively correlated with interest rates and negatively correlated with TFP. The manufacturing labor share shows the opposite correlations. These correlations are especially pronounced in the aftermath of crises, where interest rates and the agricultural labor share rise sharply and TFP experiences large drops. This is consistent with previous work in Benjamin and Meza (2006), where we show that the large fall in TFP in Korea in 1997 is primarily due to a reallocation of resources across sectors, from manufacturing to agriculture.

We demonstrate that sectoral differences in intermediating factors of production can account for the negative correlation between total factor productivity and interest rates. We consider an environment where intermediation costs are higher in manufacturing. In an environment with such differences, increases in interest rates cause manufacturing sectors to contract and agricultural sectors to expand. This pattern is consistent with the data. We show further that the effects demonstrated are significant. For the Korean crisis of 1997 they can account for a substantial portion of the fall in productivity.

1.1 Literature Review

To our knowledge, there is no paper that tries to account for the negative correlation between international interest rates and TFP. There are only a few papers that model endogenous changes in "measured" TFP around major episodes in developing countries. Most that do consider falls in TFP the result of incorrectly measured capital or labor. Indicative of these is Gertler, Gilchrist, and Natalucci (2003), who attribute the size of the fall in TFP in Korea in 1998 to a fall in capital utilization. Gertler, Gilchrist, and Natalucci (2003) do not explicitly measure capacity utilization. However, Meza and Quintin (2006) show that TFP, measured using data and adjusted for capital utilization with a model similar to Gertler, Gilchrist, and Natalucci (2003), falls approximately two thirds as much as unadjusted TFP. In other words, the size of the fall in TFP remains large.

Our paper is related to research on developing countries and capital returns. Neumeyer and Perri (2005) document a negative correlation between output and international interest rates in a sample of developing countries. They show, using a version of the simplest small open economy model, that country risk can account for most of the empirical regularities of Argentina during their sample period. We establish an empirical relationship between interest rates and productivity, and construct a model in which changes in interest rates lead to changes in TFP.

On the theoretical side, our paper owes a substantial debt to Imrohoroglu and Kumar (2004). We model financial intermediation in the same way they do. They are focused on the heterogeneity of costs across countries and how capital flows across them. We consider a small open economy model. Because of this, we are able to derive a relationship between intermediation and outcomes with homogenous costs over time. This allows us to talk about changes in productivity within a country, even if intermediation costs themselves do not change over the relevant time period. We are also able to extend their mechanism to a model with a competitive labor market, which allows for productivity to depend on labor movements.

We begin with a presentation of facts about interest rates and productivity. We then present the basic model and derive the basic analytic result. After that, we introduce labor supply in the model. Finally we conclude with the numerical results.

2 Evidence

In this section we document three facts. First, the real interest rate for international borrowing and TFP are negatively correlated for a sample of developing countries that have experienced crises. This is the main fact we are after in this paper. Second, we establish that TFP and the share of labor in the agricultural and manufacturing sectors are correlated both generally and specifically, in the aftermath of recent financial crises. Finally, we demonstrate that the costs of intermediating capital are significantly higher in the manufacturing sector than in the agricultural sector for Korea.

The fact at the center of this paper is the correlation between TFP and real interest rates. We demonstrate that for four of the five countries discussed in Neumeyer and Perri (2005) a negative relationship exists and is strong. We take most of the relevant data from Neumeyer and Perri (2005), where data sources are fully discussed. The countries we choose are Korea, Mexico, Philippines, Brazil and Argentina. All five countries experienced major financial crises within the time period. For Korea, we have national accounts data from 1980 to 2001. This data captures the crisis that occurred in 1997. For Mexico, the data is between 1980 and 2001. Mexico faced the Tequila Crisis in 1994. The Philippines data covers 1982 to 2001 and includes the crisis in 1997. Data for Brazil goes from 1991 to 2001 and includes the crisis in 1999. In Argentina the data from 1980 to 2001 includes the crisis in 2001.

To construct real interest rates, we use the nominal rates reported in Neumeyer and Perri (2005) net of inflation, which we measure with the United States GDP deflator.[1] To measure TFP, we follow Meza and Quintin (2006). They adjust TFP by variations in capital utilization, using the model of Greenwood, Hercowitz, and Huffman (1988). In that model the depreciation rate is a function of the rate of capital utilization. We assume that in the long run the depreciation rate is 5% on a yearly basis. Labor data in Argentina is not reported quarterly, but instead reported twice per year. Thus, we measure TFP in Argentina on a yearly basis. In the case of Argentina, we used data reported in Kehoe (2003).

We present this data in two ways. First we report data on the real interest rates and deviations from trend for TFP.[2] This is Figure 1. From Figure 1, we highlight the pronounced negative contemporaneous correlation for Argentina, Korea and Mexico. We also report the correlation coefficients between TFP's and lagged interest rates in Figure 2. For Argentina, Korea and Mexico the coefficient is negative for contemporaneous interest rates and every lagged value of the interest rate. For the Philippines, lagged interest rates show similar negative correlations, while contemporaneous interest rates show a small positive correlation.[3]

[Figure 1 about here]

[Figure 2 about here]

The relationship between TFP and interest rates is very strong in the immediate aftermath of a crisis. This particular aspect of the relationship is detailed in Meza and Quintin (2006) who

[1] We follow the procedure used in Meza and Quintin (2006).

[2] We use the Hodrick-Prescott filter to compute deviations from trend. We first calculate logarithms of the TFP series and then use the filter.

[3] The negative relationship between TFP and contemporaneous or lagged interest rates does not exist for Brazil. We posit an explanation. The aggregate labor data for Brazil reported in Neumeyer and Perri (2005) was constructed using urban employment and average hours worked in manufacturing. In the data, a large fall in aggregate labor would contribute to making the TFP fall smaller, as more of the changes in output would be attributed to labor. This is important because we present a model where labor in the manufacturing sector falls more than aggregate labor supply, after an increase in interest rates.

use slightly differing data than what we present. We highlight five specific crises and point on the relationship between interest rates and TFP in these crises. The vertical bars in Figure 1 refer to a year in which a financial crisis took place. In four of the five countries we see sharp increases in interest rates and sharp falls in TFP.

The second empirical observation we demonstrate is the negative correlation between agricultural employment shares and TFP. In Benjamin and Meza (2006) we have shown that the primary reason for the fall in TFP during the Korean crisis is a shift in resources from manufacturing to agriculture.

Our data source is the International Labour Organization. To construct labor shares by sector, we use yearly data. Our basic unit of analysis are employment shares in agriculture and manufacturing.[4] We exclude Mexico from our sample because available data does not include 1994, the year in which the Tequila Crisis took place. We begin by examining the behavior of the labor shares around a crisis. In Figure 3, for each country we report 3 variables: the share of employment in agriculture relative to total employment, the respective share for manufacturing, and the share of agriculture relative to the sum of agriculture and manufacturing. This last variable is most relevant for the predictions of the model we discuss in the next section. We mark a crisis year with a vertical bar. For the four countries in our sample, except the Philippines, the employment share in agriculture increases either on the year of or the year after after the respective financial crisis. The opposite happens to the manufacturing share. In the case of the share of agriculture relative to the sum of agriculture and manufacturing, this variable increases in the four countries.

That we are constrained to using yearly data may account for the fact that the shares move either on the year of the crisis or the year after. For example, in the case of Korea, the crisis occurred in the last quarter of 1997. At the same time, we can see that labor shares react in 1998. The case of the Philippines is similar in terms of timing. In the case of Argentina, the crisis hit in mid-2001, and the shares react during that year. In Brazil, the crisis took place at the beginning of 1999, and the shares react during that year.[5]

[Figure 3 about here]

[4] We do not construct hours worked because some countries in our sample lack data on hours worked in agriculture, or have no data for years of financial crisis. Since fluctuations in the labor input (aggregate hours worked) are due, mostly, to changes in the extensive margin, not changes in hours per worker, such additional detail would not likely change the results.

[5] Given that we have few observations, we decided not to detrend this data. If the time series were longer, we would expect to observe a reduction in the agricultural employment share. In the case of Argentina we display data for 1996-2001 only. Data before 1996 corresponds only to the Greater Buenos Aires region.

To provide further evidence, we also report correlation coefficients in Table 1. Interest rates and the share of agricultural employment relative to the sum of agricultural and manufacturing employment are positively correlated in all countries. Additionally, for every country except Brazil, the relative size of the agricultural sector is negatively correlated with TFP.[6]

[Insert Table 1 here]

The third fact we want to establish is that the cost of intermediating capital is larger in the manufacturing sector than in the agricultural sector in the case of Korea before the 1997 crisis. We posit that this observation is due to the standardized nature of agriculture. Lending in agriculture tends to be secured by assets that are easy to sell and keep their value if seized. On the other hand, manufacturing firms must be frequently and costly reorganized to preserve value. Agricultural borrowers aim at a homogenized set of products, like seeds and fertilizer. Manufacturers borrow from a wider range. These attributes should make agriculture partially easier to intermediate.

Our measurement is limited to Korea for whom we have both a detailed input-output matrix and financial data on loans by industry. The source for the Korean input-output matrix is the National Statistical Office of Korea. The source of financial data is the Bank of Korea. We use data for 1995. Our measure of the intermediation cost per industry is equal to the ratio of financial services provided by the finance industry to a certain industry, relative to loans received by that industry. Data on loans includes bank and non-bank financial intermediaries. We present two possible denominators, as reported by the Bank of Korea. For both of the possible choices, intermediation costs are higher in the manufacturing sector. Data is presented in Table 2.[7]

[Insert Table 2 here]

3 The Model

We have established the relationship between aggregate TFP and interest rates in a sample of developing countries. We now show that the presence of costly financial intermediation can account for this relationship. Changes in interest rates affect the implicit costs of using intermediation. The model has two sectors, one agricultural and one manufacturing. We assume,

[6] This last fact should come as little surprise since TFP is not correlated with contemporaneous interest rates in Brazil.

[7] Erosa (2001) measures intermediation costs across countries using input-output matrices. In our case, we measure intermediation cost across industries within a country.

as shown in the data, that intermediation costs are more important in manufacturing than agriculture. As interest rates rise, intermediation becomes more important and entrepreneurs take on less productive projects to avoid intermediation. After interest rates rise, resources leave manufacturing to enter agriculture.

We consider an economy with three kinds of agents. The agents are a consumer, a continuum of entrepreneurs and a financial intermediary (a bank). Of these, the most interesting decisions are made by entrepreneurs and the bank. We begin by describing entrepreneurs. Entrepreneurs live for one period only and are risk neutral. They choose to undertake production in one of the two sectors. In their chosen sector, entrepreneurs produce goods from sector-specific capital and labor.

Each sector has its own technology. Let us begin with agriculture. Agriculture uses a simple, standardized technology. Its production is observable and deterministic. All entrepreneurs in agriculture have equal productivity. Because of these factors, intermediating capital is costless in agriculture. The agricultural good is produced using its own capital, k_a, with a technology $Y(k_a) = Ak_a^{\alpha}$, where $0 < \alpha < 1$ and $A > 0$.

Manufacturing is more complex. This is because of the presence of risk and of entrepreneur-specific human capital. Production is risky in that output can be either high or low and the entrepreneur can be either a success or a failure. We label the two outcomes in manufacturing, Y_h and Y_l, respectively. Formally

$$Y^m = \begin{cases} Y_h(k_m) = A_h k_m^{\alpha} & \text{if successful,} \\ Y_l(k_m) = A_l k_m^{\alpha} & \text{if the project fails.} \end{cases}$$

where $A_h > A > A_l \geq 0$.

Entrepreneurs differ in their skill level in running a manufacturing firm. An entrepreneur's skill level is private information. Each entrepreneur has a type, θ, such that with probability $\pi(\theta)$ the high outcome occurs. These probabilities are independent across type, of which there is a continuum of types of measure one. Entrepreneurs are ordered such that π is an increasing, measurable function, so high types are more likely to be successful manufacturers than low types. There is a density $f(\theta)$ associated with the distribution of types. For simplicity, we assume f is uniform, so $f(\theta) = \theta$.

There is idiosyncratic risk in manufacturing, but no aggregate risk. Consumers who own the capital are risk averse. Because of this, the allocation of capital to entrepreneurs is undertaken through a bank who can diversify the idiosyncratic risk away from the consumers. Entering any given period, the bank has acquired a supply of capital from the consumer. It intermediates this capital so it can be used in production. Some of this capital is delivered to entrepreneurs. The rest is sent abroad.

The bank decides what choices to make through negotiations. The bank holds negotiations with the full continuum of entrepreneurs to allocate capital and pick interest rates. Negotiations are specifically over "contracts," which we define as a set of type specific capital deliveries and interest rates. Negotiated capital is delivered directly to the entrepreneur, who if successful makes interest payments. The interest rates that are negotiated are only relevant to successful entrepreneurs. Unsuccessful entrepreneurs have all of their output seized by the bank. Formally, a contracts is: $(k_m(\theta), k_a(\theta), r^m(\theta), r^a(\theta)) \in \Re^4_+$.

After contracts are agreed upon, the entrepreneur chooses which sector to enter and which pair of promised capital and interest rates to accept. A failure to earn the high return leads to bankruptcy and the entire output seized by the bank.

Finally, entrepreneurs in the manufacturing sector must borrow additionally to pay for the cost of intermediating capital, which we denote by e. Thus, each period an entrepreneur in manufacturing borrows $e + k_m$ from the bank. Both capital and the intermediation costs depreciate completely at the end of the period.

In equilibrium, all types of entrepreneurs are offered the same contract. Pooling across entrepreneurs occurs because the uniformity of the bankruptcy policy does not offer any attempts at screening. Consequently there is no means to prevent low types from imitating higher types who would otherwise be offered more favorable terms.

We study negotiations that lead to the same outcome as an informationally constrained, efficient mechanism. The equilibrium contract maximizes total surplus subject to incentive constraints on the choice of sector by entrepreneurs and a resource constraint. For entrepreneurs that choose agriculture the incentive constraint requires higher expected profits in the agricultural sector than the manufacturing sector. Let $\mathcal{A}$ be the set of types that choose agriculture. The incentive constraint is explicitly written as:

$$Y(k_a) - r^a k_a \geq \pi(\theta) \left(Y_h(k_m) - r^m(e + k_m)\right) \quad \forall \theta \in \mathcal{A} \tag{1}$$

For entrepreneurs that choose manufacturing the sign is reversed as they require higher profits in manufacturing. In equilibrium, for most types, these constraints do not bind. Only one individual type possesses a constraint which holds in equilibrium with equality. We call the critical entrepreneur's type z. Types above the critical value choose manufacturing and types lower than the critical value choose agriculture. Formally the single incentive constraint we subject the negotiations to is:

$$Y(k_a) - r^a k_a = \pi(z)\left(Y_h(k_m) - r^m(e + k_m)\right). \tag{2}$$

To state the problem equilibrium contracts solve, we need a definition of total surplus. For a given critical value, z, we write the probability measure for firms that invest in manufacturing and are successful in its production as:

$$\Phi(z) = \frac{1 - z^2}{2}. \tag{3}$$

Those that enter manufacturing and receive a low return have a measure of:

$$\Psi(z) = 1 - z - \Phi(z) = \frac{1 - 2z - z^2}{2}.$$

Finally we define k_{ab} to be the capital sent abroad. Total surplus equals revenues from successes, failures, and capital abroad. Formally total surplus is:

$$F(z)Y(k_a) + \Phi(z)Y_h(k_m) + \Psi(z)Y_l(k_m) + r^w k_{ab}. \tag{4}$$

Note that we assume the goods produced in the two sectors are perfect substitutes. This allows us to talk about productivity differences without explicitly modeling the consumer's decisions.[8]

The resource constraint requires capital in each sector and abroad to equal capital the bank has to lend, k. It is written as:

$$k_{ab} + F(z)k_a + (1 - F(z))(e + k_m) = k. \tag{5}$$

The formal negotiations maximize expression (4) over k_a, k_m, k_{ab} and z, subject to equations (2) and (5).

We now solve for the outcome of the negotiations. The bank's capital, k, affects only outcomes of capital lent abroad, k_{ab}. Variables z, k_m, and k_a are important for studying productivity and are entirely determined by the above problem. They are characterized through a set of three first order conditions:

[8]This assumption is not necessary for productivity differences across sectors to exist in equilibrium. It is merely a simplifying assumption.

$$Y'(k_a) = r^a \tag{6}$$

$$\frac{\Phi(z)}{1-F(z)} Y_h'(k_m) + \frac{\Psi(z)}{1-F(z)} Y_l'(k_m) = r^w \tag{7}$$

$$Y(k_a) - r^w k_a = \pi(z) Y_h(k_m) + (1-\pi(z)) Y_l(k_m) - r^w(e + k_m). \tag{8}$$

The first condition describes the agricultural sector, which behaves in the same way as a small open economy model. The marginal product of capital in the sector equals the world interest rate. The second condition equates the marginal return on capital in the manufacturing sector to the return on capital abroad. The final condition, (8), determines the optimal division of entrepreneurs between sectors. Notice that, because of the negative sign on the final term, increasing z spares the entrepreneur some of her intermediation costs.

3.1 The Algebra of TFP

Our goal now is to derive aggregate TFP from the perspective of a statistician who would assume that all output is produced via a one sector deterministic model. This section is devoted to its construction.

The statistician's measure of TFP can be found as follows. If we begin by equating the marginal products from the two sectors, it becomes apparent from equation (6) and (7) that:

$$\frac{k_m}{k_a} = c(z),$$

where, in the uniform case we are working with:

$$c(z) = \left[\left(\frac{1+z}{2} \right) \frac{A_h}{A} + \left(\frac{1-z}{2} \right) \frac{A_l}{A} \right]^{\frac{1}{1-\alpha}}.$$

From here it is easy to substitute for the domestically held capital stock, which is:

$$k^* = (1-z)k_m + z k_a.$$

Combining the two equations yields:

$$k_a = \frac{1}{z + (1-z)c(z)} k^* = c_1 k^*, \tag{9}$$

and likewise

$$k_m = \frac{c(z)}{(zc(z) + (1-z))} k^* = c_2 k^*. \tag{10}$$

We can substitute the above expressions for k_a and k_m into our expression for domestically produced output. From there we can factor out $k^{*\alpha}$. Letting domestically produced output equal $TFP\ \ k^{*\alpha}$, we obtain the following expression for TFP:

$$TFP(z) = zAc_1^{\alpha} + \Phi(z)A_h c_2^{\alpha} + \Psi(z)A_l c_2^{\alpha}.$$

In the appendix, we show that the above expression changes inversely with z, when z changes due to a change in the interest rate. This leads to our main analytic result, which is that TFP and interest rates move in opposite directions. Formally our main result is:

Proposition 1. *TFP decreases as r^w increases.*

This result is shown in the appendix. It is an intuitive result. As interest rates rise, the costs of participating in the manufacturing sector rises for two reasons. First, the cost of borrowing for intermediation rises. Second, the intermediation costs become more important to firms which are borrowing smaller amounts of capital. This leads many manufacturing entrepreneurs to take up agriculture, thereby lowering aggregate productivity.

4 Extension of the Model: Labor

In this section, we introduce a competitive labor market into the model. Labor is an important addition because the movement of labor between sectors is more pronounced in the data than the movement of capital. As we show, the introduction of labor preserves the relationship between total factor productivity and interest rates. Labor adds realism, but it comes at the sacrifice of analytical results. Hence we present quantitative results which show the channel presented here can be significant.

Labor enters the production function in both sectors. The production functions change to be of the form $A_i k_i^{\alpha} l_i^{\mu}$. The coefficient on labor, μ, is the same in both sectors and is such that $\alpha + \mu < 1$. Again, all shares are identical in both sectors. Unlike capital, labor is hired competitively before output is realized. Different types of manufacturing entrepreneurs can hire different amounts of labor. We assume that the labor contract is hidden from the bank, so that the bank cannot infer the firm's type from it. Finally, labor must be hired from households at a competitive wage w. Households are indifferent as to the sector of production. Optimal contracts now solve:

$$\max_{k_m,k_a,k_{ab},z,l_a,l_m(\omega)} Azk_a^\alpha l_a^\mu - F(z)wl_a + \int_z^1 (\pi(\omega)A_h + (1-\pi(\omega))\,A_l)\,k_m^\alpha l_m(\omega)^\mu f(\omega)d\omega$$
$$- \int_z^1 wl_m(\omega)f(\omega d(\omega) - (1-F(z))(1+r^w)e + r^w k_{ab} \quad (11)$$

s.t.

$$k_{ab} + F(z)k_a + (1-F(z))\,(k_m) = k.$$

The intermediation cost e is a fixed cost. Hence our theory is consistent with any costs required to undertake business in the manufacturing sector, including intermediation costs and hiring costs. To allow for these potential interpretations, we subtract the intermediation costs directly from the realized output at the end of the period.

The model as it currently stands is not closed. In the previous model, the consumer's decisions did not affect productivity or any other important outcome of the negotiation. Here, the inclusion of a labor market requires the wage to be determined in equilibrium. Productivity depends on wages. Hence we need a maximization decision from the consumer to construct labor supply. We consider a consumer who supplies a deposit, k_t, to the bank in every period. She is endowed with an initial capital stock, k_0. She receives a payment r_t^b for each unit of capital supplied to the bank. We assume complete international capital markets and consider only perfectly foreseen changes in the interest rate.[9] A consumer can buy and sell bonds b_{t+1}, net debt with respect to the rest of the world, at the world interest rate. She is endowed with an initial stock of net debt, b_0. We denote her consumption in each period c_t. Finally, the consumer supplies labor in every period, which we denote by l_{st}, and receives wage w_t.

A consumer solves:

$$\max \sum_{t=0}^{\infty} \beta^t u(c_t, l_{st})$$

s.t.

$$c_t + b_{t+1} + k_{t+1} - (1+r_{t+1}^w)b_t \leq w_t l_{st} + r_t^b k_t \forall t.$$

Parameter $0 < \beta < 1$ represents the discount factor. We close the model with the requirement that labor supply equals labor demand (ignoring time subscripts):

[9]See Schmitt-Grohe and Uribe (2003) for a version of a small open economy model with complete markets and uncertainty.

$$l_s = F(z)l_a + \int_z^1 l(\omega)f(\omega)d(\omega).$$

With complete capital and bond markets, $c_t = \bar{c}$ in every period, where $\bar{c}$ is endogenous and constant. Hence, the relevant first order condition depends on the within period utility function. We assume this function is:

$$u(c, l) = \gamma \ln(c) + \ln(L - l_s).$$

The consumption-leisure condition is:

$$\frac{\gamma w}{\bar{c}} = \frac{1}{L - l_s}.$$

This condition closes the model.

4.1 Quantitative Results

We demonstrate the result in this section quantitatively. It is possible to construct a statistician's measure of TFP from the model's domestically produced output, Y_{dom} , domestic capital, k^*, and supplied labor l_s. To this end, we define total factor productivity to equal:

$$TFP = \frac{Y_{dom}}{k^{*\alpha} l_s^{\mu}}.$$

The rest of this section is devoted to quantitatively assessing the effect of a crisis on TFP. Our specific goal is to assess the relevance of this theory in the aftermath of the Korean financial crisis. We pick Korea because it has the one of the richest macroeconomic datasets for any country that experienced a recent crisis.

The model has relatively few parameters and most are standard to the calibration of macroeconomic models. The usual macroeconomic parameters include the coefficients in the production function and the sectorial TFP's. The parameters specific to our model are related to intermediation costs and the variance of output in the model's manufacturing sector.

Before we select parameters, we discuss how the less standard parameters affect outcomes. One of these is the intermediation cost, e. The larger the intermediation cost e, the stronger the key relationships are. If $e = 0$ then TFP and interest rates are unrelated.

Similarly, important to this analysis is the variance of expected productivity in manufacturing. In equilibrium, densities whose expected productivity lead to a substantial mass directly above the critical type, z, produce large effects. Densities which spread the mass out thinly produce small effects. For example, with a uniform density, the further apart A_l and A_h are, the smaller the key relationships are.

Now we are ready to select specific parameter values. To measure the change in TFP we need six observations from the data. Namely, we use measures of productivity in each sector, the aggregate capital and labor share, the intermediation cost and hours worked per capita.

We follow Quintin and Amaral (2005) in choosing the labor share as the residual of payments to entrepreneurs and capital in National Product Accounts. Specifically, we choose the share for rents of national income to entrepreneurs directly from their calculations, noting that it is a value computed from US data. Other researchers, such as Young (1995), have found income shares for Korea that are very similar to the ones in the US.

For the productivities in the manufacturing sector, we begin by setting A_l equal to zero.[10] Setting A_l equal to zero allows us to solve the labor allocation problem in the manufacturing sector analytically.[11]

Both A_h and A are taken from Benjamin and Meza (2006). We measured A_h using a Cobb-Douglas production function and data on capital, labor and GDP for the manufacturing sector in Korea in 1995. In the model we match this number to the unweighed average productivity of firms in the manufacturing sector. We measured A following a similar procedure for the agricultural sector in Korea.[12]

We choose $\frac{\gamma}{\bar{c}}$ to match a ratio of working time l_s to time available for work L equal to 33%. This value is close to the ratio in Korean data in 1995, which is 30%. We choose L arbitrarily to equal 40.

For quantitative purposes, we associate intermediation costs exclusively with the financial intermediation of capital. For intermediation costs, we make the model match the ratio of intermediation costs to loans in 1995. Since in the data our measure of intermediation costs in agriculture is positive, whereas in the model the cost is zero, we subtract the ratio of intermediation costs in agriculture from the manufacturing one. Note that loans in the model equal $e + k_m$. Thus, the model counterpart of our measure of intermediation costs is $e/(e + k_m)$. Setting this expression equal to the intermediation cost in the data determines a value for e.

We summarize the chosen values in Table 3.

[10] Imrohoroglu and Kumar (2004) make a similar assumption in their quantitative work.

[11] This assumption creates a large variance between the expected outcome of successful and unsuccessful firms. In the data, failures and successes are closer together. Aw, Ching, and Roberts (2003) report productivity differences of unsuccessful and successful manufacturing firms to be around 25%.

[12] We are using a constant returns to scale function to measure the productivities. Our model has decreasing returns in each technology.

[Table 3 about here]

The experiment we consider involves an interest rate shock identical to the one that hit the Korean economy at the end of 1997. The average international interest rate faced by Korea increased from 3.6% to 8% between the first three quarters of 1997 and 1997:IV-1998. Results are reported in Table 4.

[Table 4 about here]

The annual data on TFP for Korea reported in the empirical section shows that detrended TFP fell by 4.1% between 1997 and 1998. The fall in TFP in the model is 3.6%. Thus, the model can account for 88% of the fall. We take this result as suggestive that the channel we have identified in our simple model plays a significant role in the fall in TFP.

Qualitatively, the model also predicts the labor factor reallocation that occurred in the data and reported in the empirical section. We focus on the ratio of agricultural labor relative to the sum of agriculture and manufacturing labor. In the data, the labor share in agriculture increased by 4.4 percentage points, from 33.7% to 38.1%. In the model the share increases, also by four percentage points.

The largest gap between the data and the model are the sizes of the agricultural and manufacturing sector before the crisis. This is an artifact of the low value of agricultural productivity and the uniform density for manufacturing productivities. Together they posit that the vast majority of the agents in the economy are productive enough in the manufacturing sector that they can afford to pay the higher costs associated with that sector. A distribution where a substantial number of agents had a productivity advantage in agriculture (or were similarly productive in both sectors) would improve the performance of the model in this dimension.

5 Conclusion

In this paper we first document a relationship between real international interest rates and TFP. To our knowledge, this is the first paper that reports such correlation. TFP was measured taking into account variable capital utilization, thus eliminating a usual suspect for the fall in productivity. We also present evidence that both the fall in TFP and interest rates are correlated with a shift of labor from manufacturing to agriculture. This shift in labor produces changes in TFP, as labor moves from a high productivity sector, manufacturing, to a low productivity sector, agriculture.

We then present a simple model that accounts for the negative correlation between real interest rates and TFP. The model has a mechanism that makes resources move from a highly productive industry to one with lower productivity in the face of a rise in interest rates. The mechanism is relevant because it focuses on one of the salient features of developing economies, high intermediation costs. It is also tractable in that it lends itself to qualitative results. In order to test the predictions of our simple model, we focus on the Korean 1997 financial crises. We assign parameter values that are consistent with data from pre-crisis Korea. We then measure how much TFP would change given increases in the international interest rate. We find that our mechanism can account for a large amount of the fall in the data.

We consider our results as pointing to a promising explanation of changes in TFP in developing countries, in particular around important events such as financial crises: factor reallocation. However, our quantitative results are limited in that they are sensitive to modeling assumptions that we have made and from parameter values that are difficult to pin down. For example, the numerical results are aided by the decision to model intermediation as a fixed cost. If these costs were modeled as having a constant returns component in addition to the fixed costs, their influence on equilibrium outcomes would be smaller.

Even with a smaller quantitative impact, the presence of costly financial intermediation produces changes in aggregate productivity and resource allocation that are qualitatively similar to those that occur in developing countries in the midst of crises. Given the large shifts in resources from manufacturing to agriculture that have occurred after some crises, in particular Korea 1997 and Argentina 2001, avoiding expensive intermediation is a serious mechanism for understanding an important trend.

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6 Appendix: Proof

The proof consists of two lemmas. The first lemma does not deal with TFP directly. For this lemma, we show, that z is monotone increasing in r^w. Intuitively, the first lemma holds because an increase in the world interest rate increases the costs of borrowing the amount e. Furthermore, increased interest rates also reduce the scale of projects. Due to both of the above reasons, avoiding intermediation costs becomes more important and greater investment in the agricultural sector occurs. Mechanically, the first lemma is a traditional comparative static result on the incentive constraint for the marginal type z. Most of the work of demonstrating the lemma consists of substituting variables that are not z out of the particular incentive constraint. The lemma itself holds to more generality than we have previously used in defining the model. We show the lemma in its generality here. That is, we prove this lemma with a general density f and probability function π.

Lemma 1. *Suppose that* $\int_0^x f(x)\pi(x)dx$ *is differentiable for all* x *and that the density,* f*, and the cumulative distribution function,* F*, are also differentiable. Suppose also that the density,* f*, possesses an increasing monotone hazard ratio (*$\frac{F(x)}{f(x)}$ *increases as* x *increases). Then the investment threshold is monotone increasing in* r*.*

Proof. Recall that the investment threshold is characterized by (6-8).

Our first step is to look for expressions for k_a and k_m in terms of z.

From these equations, solve first for k_a :

$$k_a = \left(\frac{r^w}{\alpha A}\right)^{\frac{1}{1-\alpha}}.$$

Now we need to find k_m. We can do this both for general densities and for the specific uniform density. In general define $g(z) = \frac{\int_0^1 (A_h \pi(z) + A_l(1-\pi(z)))f(z)dz)}{1-F(z)}$.

In the uniform case this fraction is

$$\frac{(1+z)A_h}{2} + \frac{(1-z)A_l}{2}.$$

Because of our assumptions, this term is increasing for both general probability measures and the specific case of the uniform distribution. It also appears in the first order condition on manufacturing capital as is the de facto TFP term for that sector.

Finally, define $h(z) = \pi(z)A_h + (1-\pi(z))\,A_l$. In the uniform case this term is again linear. In all cases it corresponds to the TFP term for the marginal firm remaining in the manufacturing sector, z.

Rearranging the threshold equation yields:

$$Y(k_a) - r^w k_a + r^w e = \pi(z)Y_h(k_m) + (1-\pi(z))\,Y_l(k_m) - r^w k_m.$$

The next step is to add our redefined terms to the above expression and substitute out k_a and k_m. This gives us:

$$A^* r^{w\frac{\alpha}{\alpha-1}} + r^w e = h(z)\left(\frac{r^w}{\alpha g(z)}\right)^{\frac{\alpha}{\alpha-1}} - r^{w\frac{\alpha}{\alpha-1}}(\alpha g(z))^{\frac{1}{1-\alpha}}.$$

where A^* is a positive collection of parameters. Factoring out $r^{w\frac{\alpha}{\alpha-1}}$ leads to the following equation characterizing z:

$$A^* + r^{w\frac{1}{1-\alpha}} = c(\alpha)h(z)g(z)^{\frac{1}{1-\alpha}}\left(\alpha g(z)^{\alpha} - 1\right).$$

It is obvious that the LHS increases as r^w increases. What we require for the lemma to be true is that the RHS increases in z. It is not difficult to show that the RHS behaves as desired. Both $g(z)$ and $h(z)$ increase in z for general densities, because π is increasing and the assumption on the monotone hazard ratio. Hence it is sufficient for the parenthetical term on the RHS to be positive. However this follows since all other multiplicative terms (the LHS and the other terms on the RHS) are positive.

□

We have established a positive correlation between r^w and the measure of firms in the agricultural sector, indexed by z. The second lemma shows there is a negative correlation between the measure of firms in the agricultural sector and the level of TFP. For this lemma, the assumption of a uniform density is important as we rely on previous algebra. The proof makes the following argument. If TFP increased in z, entrepreneurs who choose low values of z could increase total surplus to the negotiators by raising the marginal type z and saving on the expenditures of intermediation costs.

Lemma 2. *Suppose z increases through a shock to r^w. Then TFP decreases.*

Proof. The result follows by contradiction. Fix two values of r^w. Associate with these values two values for TFP. Call them TFP_1 and TFP_2 and suppose $TFP_1 \geq TFP_2$ and that $z_1 > z_2$. It follows by the previous lemma that $r^1 > r^2$.

Let allocation 1 be the choice of k_a, k_m, k_{ab}, z and k^* when the interest rate equals r^1 and let allocation 2 be that choice for interest rate r^2. To fix notation, let numerical subscripts refer to the allocation the element belongs to. Also let x_1 refer to allocation 1 and x_2 refer to allocation 2.

We will construct a feasible and incentive compatible allocation that produces higher total surplus than x_2. Consider the following alternative allocation in the event the interest rate equals interest rate 2. Allocate k_{a3} and k_{m3} such that for z_1,

$$\frac{A}{z_1 A_h + (1 - z_1 A_l)} \left(\frac{k_{a3}}{k_{m3}}\right)^{(\alpha-1)} = 1 \text{ and}$$

$$z_1 k_{a3} + (1 - z_1) k_{m3} = k_2^* = k_3^*.$$

Also let $k_{ab3} = k_{ab2} + e(z_1 - z_2)$ and $z_3 = z_1$.

Let's refer to this allocation as allocation 3 or x_3 Note that allocation 3 clearly satisfies the resource constraint. Note further that there are interest rates r_3^a and r_3^m such that this allocation is incentive compatible. (There are an infinite number of pairs of such interest rates). Allocation 3 also produces a higher total surplus than allocation 2, because domestically produced output equals $TFP(z)k^{*\alpha}$ and by our previous algebra $TFP\,(z_3))$ equals $TFP(z_1)$. By our assumption $TFP(z_1) \geq TFP(z_2)$.

Hence x_3 is a superior allocation to x_2. But this contradicts the assumption that x_2, solved the negotiation problem when the interest rate was r^2.

$\square$

Table 1: Correlations with the Relative Share of Agricultural Labor

Country	Korea	Argentina	Philippines	Brazil
Correlation Between Agriculture and Interest Rates	0.72	0.77	0.44	0.88
Correlation Between Agriculture and TFP.	-0.79	-0.90	-0.19	0.34

Table 2: Intermediation Costs: Financial Services Used Relative to Loans

Measure of Loans	Intermediation Costs in Agriculture	Intermediation Costs in Manufacturing
Loans	0.028	0.062
Loans+Equipment Funds	0.048	0.074

Table 3: Parameter Values

Parameter	α	μ	A	A_h	A_l	e	$\frac{\gamma}{\bar{c}}$
Value	0.3	0.4	0.056	0.203	0	0.169	1.65

Table 4: Generated Values After an Increase in the Interest Rate

Observation	Change in TFP	Labor share in agriculture before	Labor share after
Model	3.6 %	2.6%	6.6 %
Data	4.1 %	33.7%	38.1%

Figure 1: TFP and Interest Rates

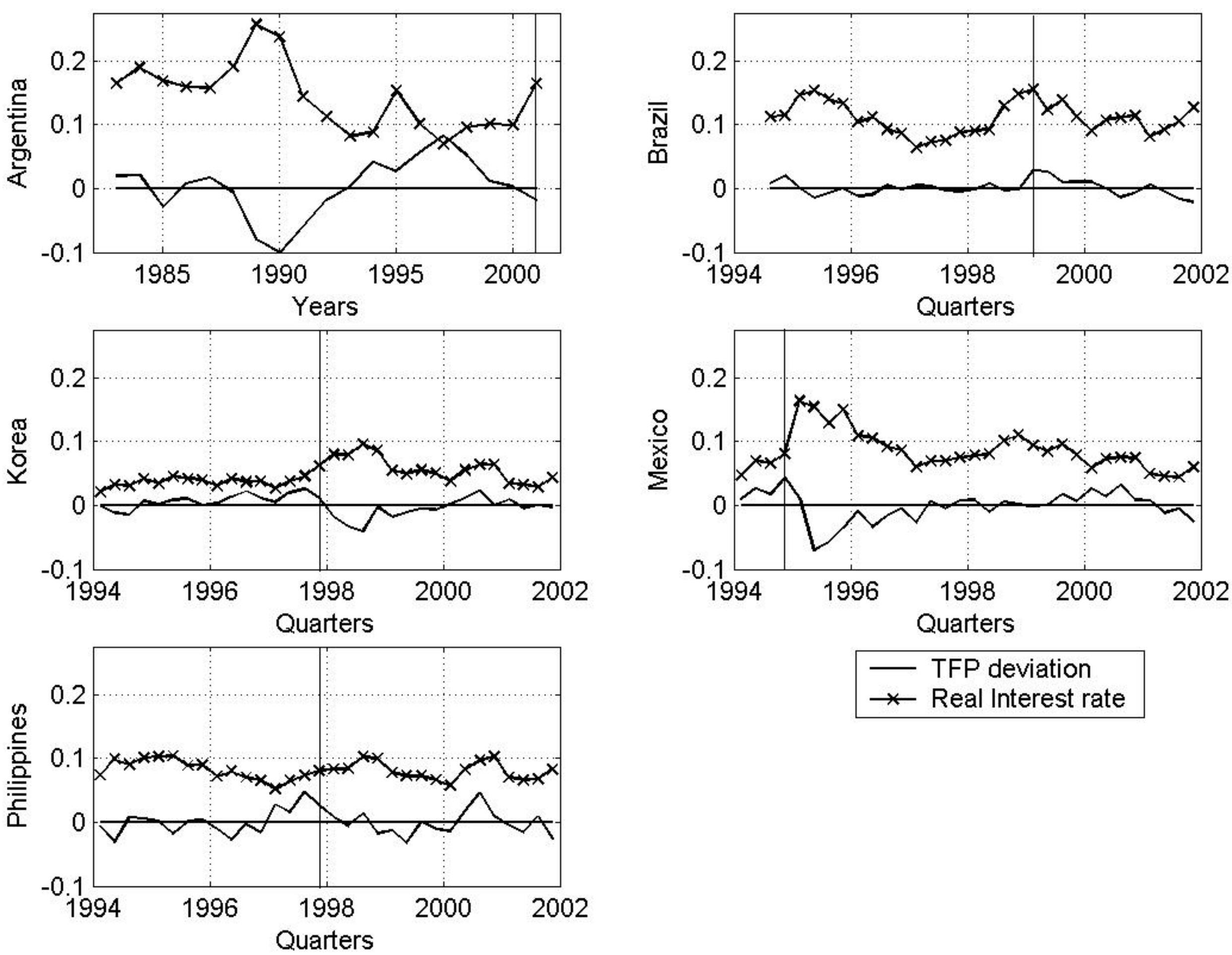

Figure 2: Correlations Between Interest Rates and Various Lags of TFP

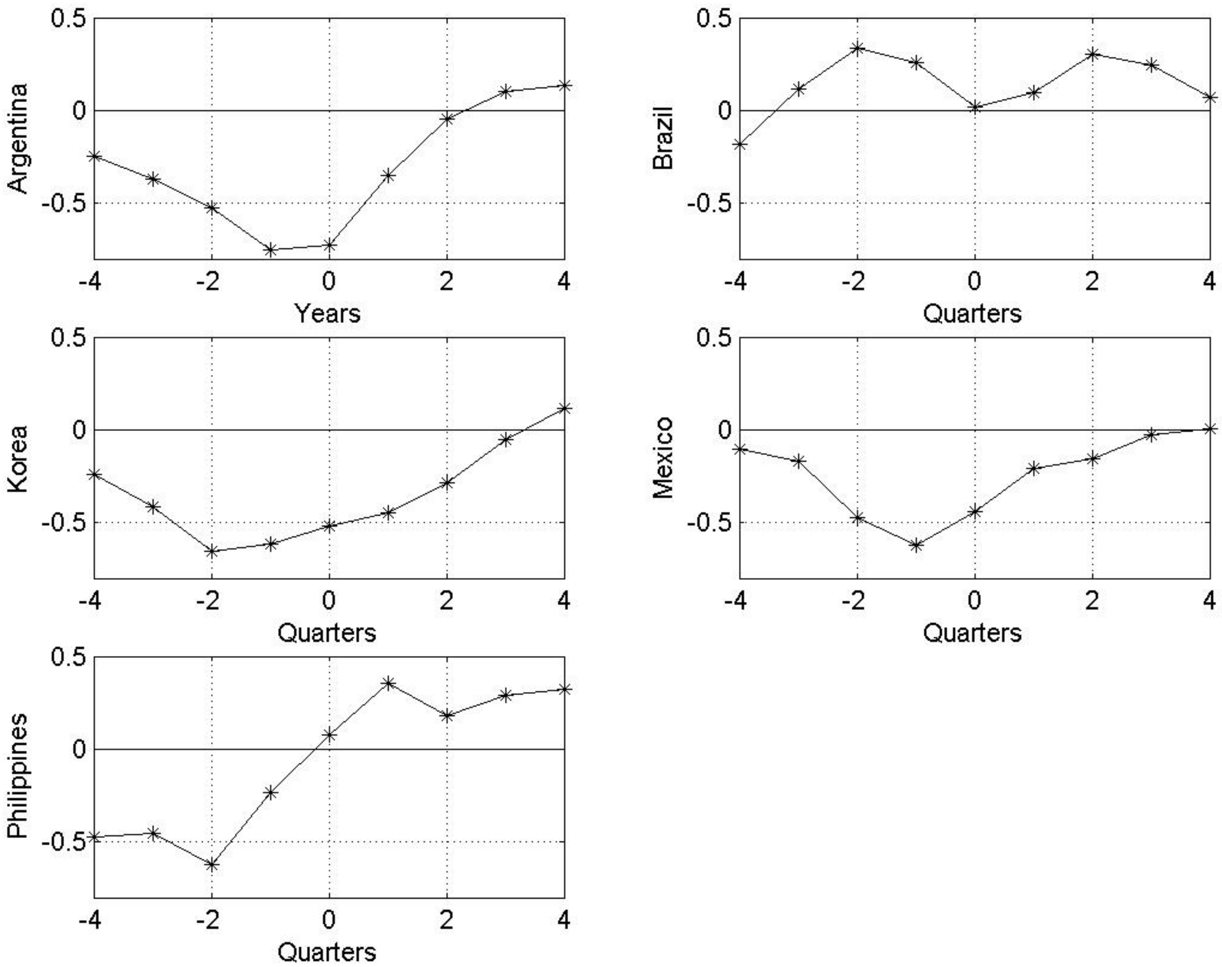

Figure 3: Labor Shares Around Crises