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# Quantifying the Impact of Financial Development on Economic Development

WP 10-05

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# Quantifying the Impact of Financial Development on Economic Development

by

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**Abstract**

How important is financial development for economic development? A costly state verification model of financial intermediation is presented to address this question. The model is calibrated to match facts about the U.S. economy, such as intermediation spreads and the firm-size distribution for the years 1974 and 2004. It is then used to study the international data, using cross-country interest-rate spreads and per-capita GDP. The analysis suggests a country like Uganda could increase its output by 140 to 180 percent if it could adopt the world's best practice in the financial sector. Still, this amounts to only 34 to 40 percent of the gap between Uganda's potential and actual output.

*Keywords*: costly state verification, economic development, financial intermediation, firm-size distribution, interest-rate spreads, cross-country output differences, cross-country TFP differences

*JEL Nos*: E13, O11, O16

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# 1 Introduction

How important is financial development for economic development? Ever since Raymond W. Goldsmith's (1969) classic book, economists have been developing theories and searching for empirical evidence connecting financial and economic development. Goldsmith emphasized the role that intermediaries play in steering funds to the highest valued users in the economy. First, intermediaries collect and analyze information before they invest in businesses. Based upon this information, they determine whether or not to commit savers' funds. If they proceed, then they must decide how much to invest and on what terms. Second, after allocating funds intermediaries must monitor firms to ensure that savers' best interests are protected. Increases in the efficiency of financial intermediation, due to improved information production, are likely to reduce the spread between the internal rate of return on investment in firms and the rate of return on savings received by savers. The spread between these returns reflects the costs of intermediation. This wedge will include the costs of gathering ex-ante information about investment projects, the ex-post information costs of policing investments, and the costs of misappropriation of savers's funds by management, unions, etc., that arise in a world with imperfect information. An improvement in financial intermediation will not necessarily affect the rate of return earned by savers. Aggregate savings may adjust in equilibrium so that this return always equals savers' rate of time preference.

Figure 1, left panel, plots the intermediation wedge for the U.S. economy over time. (All data definitions are presented in the Appendix.) The United States is a developed economy with a sophisticated financial system. The wedge falls only slightly. At the same time, it is hard to detect an upward trend in the capital-to-output ratio. Contrast this with Taiwan, shown in the right panel. Here, there is a dramatic drop in the interest-rate spread. As the cost of capital falls one would expect to see a rise in investment. Indeed, the capital-to-output ratio for Taiwan shows significant increase. The observation that there is only a small drop in the U.S. interest-rate spread does not imply that there has not been any technological advance in the U.S. financial sector. Rather, it may reflect the fact that efficiency in the U.S. financial sector has grown in tandem with the rest of the economy, while for Taiwan it has outpaced it. For without technological advance in the financial sector, banks would face a losing battle with the rising labor costs that are inevitable in a growing economy. The intermediation spread would then have to rise to cover costs. More on this later.

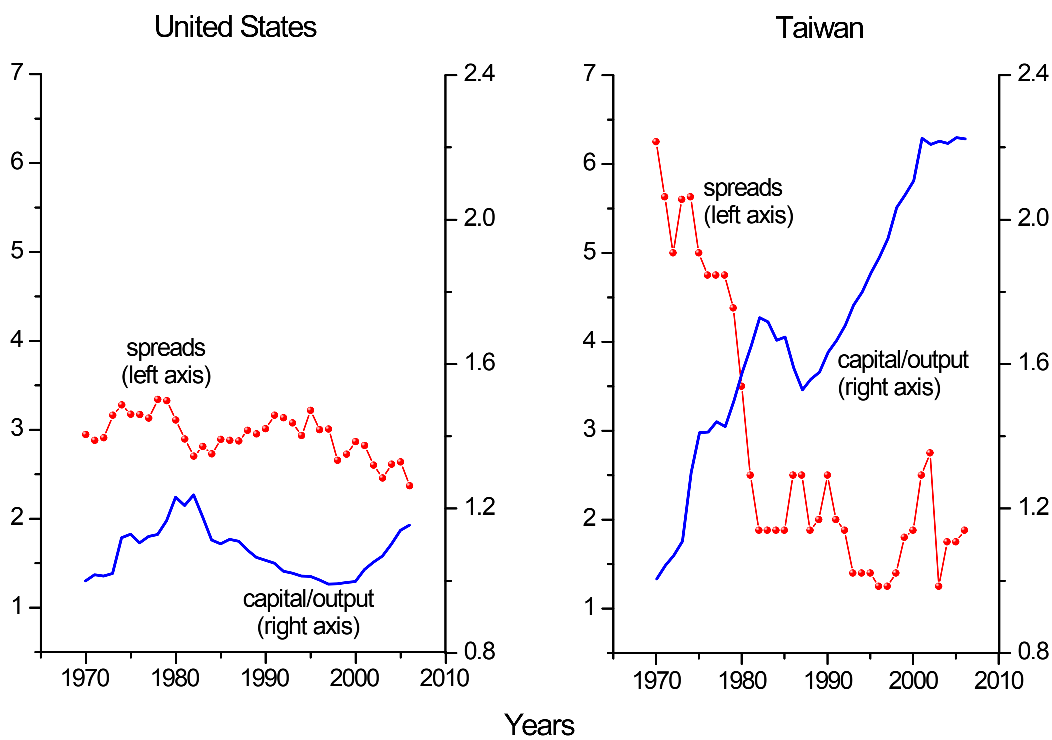


Figure 1: Interest-rate spreads and capital-to-output ratios for the United States and Taiwan, 1970-2005.

Now, in Goldsmithian fashion, consider the scatter plots presented for a sample of countries in Figures 2 and 3. Take Figure 2 first. The left panel shows that countries with lower interest-rate spreads tend to have higher capital-to-output ratios. The right panel illustrates that a higher capital-to-output ratio is associated with a greater level of GDP. Dub this the capital-deepening effect of financial intermediation. Next, turn to the left panel in Figure 3. Observe that lower interest-rate spreads are also linked with higher levels of total factor productivity, TFP. This would happen when better intermediation tends to redirect funds to the more efficient firms. The right panel displays how higher levels of TFP are connected with larger GDP. Call this the reallocation effect arising from financial intermediation. The capital deepening and reallocation effects from improved intermediation will play an important role in what follows. While the above facts are stylized, to be sure, it will be noted that empirical researchers have used increasingly sophisticated methods to tease out the relationship between financial intermediation and growth. This literature is surveyed masterfully by Levine (2005). The upshot is that financial development has a causal effect on economic development; specifically, financial development leads to higher rates of growth in income and productivity.

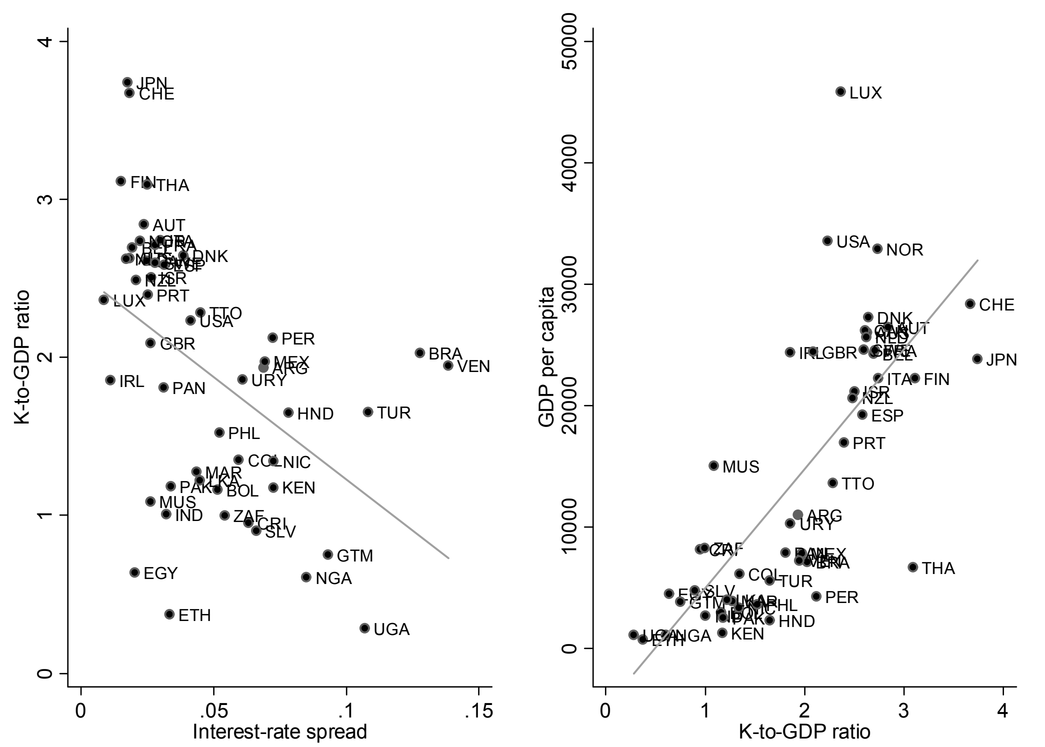


Figure 2: The cross-country relationship between interest-rate spreads, capital-to-output ratios and GDP.

The impact that financial development has on economic development is investigated here, quantitatively, using a costly state verification model that is developed, theoretically,

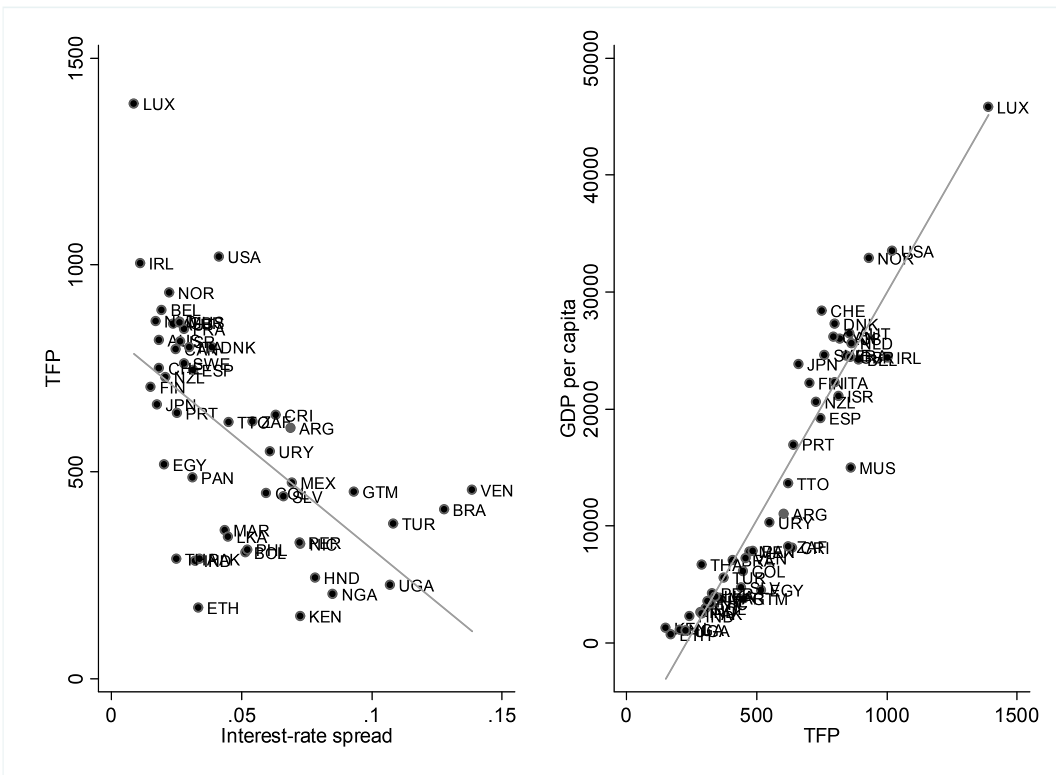


Figure 3: The cross-country relationship between interest-rate spreads, TFP and GDP

in Greenwood et al. (forthcoming). The source of inspiration for the framework is classic work by Diamond (1984), Townsend (1979), and Williamson (1986). It has two novel twists, however. First, the efficiency of monitoring the use of funds by firms depends upon both the amount of resources devoted to this activity and the state of technology in the financial sector. Second, firms have ex-ante differences in the structure of returns that they offer. A financial theory of firm size emerges. At any point in time, firms offering high expected returns are underfunded (relative to a world without informational frictions), while others yielding low expected ones are overfunded. This results from diminishing returns in information production. As the efficiency of the financial sector rises (relative to the rest of the economy) funds are redirected away from less productive firms in the economy toward the more productive ones. Furthermore, as the interest-rate spread declines, and the cost of borrowing falls, there will be capital deepening in the economy.

The model is calibrated to match some stylized facts for the U.S. economy, specifically the firm-size distributions and interest-rate spreads for the years 1974 and 2004. It does an excellent job replicating these facts. The improvement in financial sector productivity required to duplicate these facts also appears to be reasonable. It does this with little change in capital-to-output ratio. In the model, improvements in financial intermediation account for 30 percent of U.S. growth. The framework also is capable of mimicking the dramatic decline in the Taiwanese interest-rate spread. At the same time, it predicts a significant rise in capital-to-output ratio. It is estimated that dramatic improvements in Taiwan's financial sector accounted for 50 percent of growth.

The calibrated model is then taken to the cross-country data. It also does a reasonable job predicting the differences in cross-country capital-to-output ratios. Similarly, it does a good job matching the empirical relationship between financial development and average firm size. Financial intermediation turns out to be important quantitatively. For example, in the baseline model Uganda would increase its GDP by 140 percent if it could somehow adopt Luxembourg's financial system. World output would rise by 65 percent if all countries adopted Luxembourg's financial practice. Still, the bulk (or 64 percent) of cross-country variation in GDP cannot be accounted for by variation in financial systems.

There are other recent investigations of the relationship between finance and development that use quantitative models. The frameworks used, and the questions addressed, differ from the current analysis. For example, Townsend and Ueda (2006) estimate a version of the Greenwood and Jovanovic (1990) model to examine the Thai financial reform. Their analysis stresses the role that financial intermediaries play in producing ex-ante information about the state of the economy at the aggregate level. Financial intermediaries offer savers higher and safer returns. They find that Thai welfare increased about 15 percent due to financial liberalization. Buera et al. (2009) focus on the importance of borrowing constraints in distorting the allocation of entrepreneurial talent in the economy. This helps explain TFP differentials across nations.[1] Limited investor protection is emphasized by Castro et al. (2009). They build a two-sector model to explain the positive cross-country correlation between investment and GDP. They note that the capital-goods sector is risky. This makes capital goods expensive to produce in poor countries with limited investor production, because of the high costs of finance. An implication of their framework is that the correlation between investment and GDP is weaker when measured at domestic vis à vis international prices. This is true in the data.

## 2 The Economy

The analysis focuses on two types of agents; to wit, firms and financial intermediaries. Firms produce output using capital and labor. Their production processes are subject to idiosyncratic productivity shocks. The realized value of the productivity shock is a firm's private information. All funding for capital must be raised from financial intermediaries. This is done *before* the technology shock is observed. *After* seeing its shock, a firm hires labor on a spot market. When financing its capital a firm enters into a financial contract

[1] Erosa and Cabrillana (2008) also investigate the interplay between financial market frictions and the allocation of managerial talent for explaining cross-country productivity differences, albeit with more of a theoretical emphasis.

with the intermediary. This contract specifies the state-contingent payment that a firm must make to an intermediary upon completing production. Hidden in the background are consumer/workers. They supply a fixed amount of labor to the economy. They also deposit funds with an intermediary that earn a fixed rate of return. Given the focus here on comparative steady states, an analysis of the consumer/worker can be safely suppressed. The behavior of firms and intermediaries will now be described in more detail.

# 3 Firms

Firms hire capital, $k$, and labor, $l$, to produce output, $o$, in line with the constant-returns-to-scale production function

$$o = x\theta k^{\alpha} l^{1-\alpha}.$$

The productivity level of a firm's production process is represented by $x\theta$. It is the product of two components: an aggregate one, $x$, and an idiosyncratic one, $\theta$. The idiosyncratic level of productivity is a random. Specifically, the realized value of $\theta$ is drawn from the two-point set $\tau = \{\theta_1, \theta_2\}$, with $\theta_1 < \theta_2$. The set $\tau$ differs across firms. Call this the firm's type. Let $\Pr(\theta = \theta_1) = \pi_1$ and $\Pr(\theta = \theta_2) = \pi_2 = 1 - \pi_1$. The probabilities for the low and high states (1 and 2, respectively) are the same across firms. The realized value of $\theta \in \tau$ is a firm's private information. For now take the aggregate level of productivity, $x$, to be some known constant.

Suppose that a type-$\tau$ firm has raised $k$ units of capital. It then draws the productivity shock $\theta_i$. It must now decide how much labor, $l_i$, to hire at the wage rate $w$. In other words, the firm will solve the maximization problem shown below.

$$R(\theta_i, w)k \equiv \max_{l_i}\{x\theta_i k^{\alpha} l_i^{1-\alpha} - wl_i\}. \qquad \text{P(1)}$$

Denote the amount of labor that a type-$\tau$ firm will hire in state $i$ by $l_i(\tau) = l_i(\theta_1, \theta_2)$. Substituting the implied solution for $l_i$ into the maximand and solving yields the unit return function, $R(\theta_i, w)$, or

$$r_i(\tau) \equiv R(\theta_i, w) = \alpha(1-\alpha)^{(1-\alpha)/\alpha} w^{-(1-\alpha)/\alpha} (x\theta_i)^{1/\alpha} > 0. \qquad (1)$$

Think about $r_i(\tau) = R(\theta_i, w)$ as giving the gross rate of return on a unit of capital invested in a type-$\tau$ firm, given that state $\theta_i$ occurs.

# 4 Financial Intermediaries

Intermediation is competitive. Intermediaries raise funds from consumers and lend them to firms. Even though an intermediary knows a firm's type, $\tau$, it cannot observe the state of a firm's business either costlessly or perfectly.[2] That is, the intermediary cannot costlessly observe $\theta$, $o$ and $l$. Suppose a firm's true productivity in a period is $\theta_i$. It reports to the intermediary that its productivity is $\theta_j$, which may differ from $\theta_i$. The intermediary can audit this report. It seems reasonable to presume that the odds of detecting fraud are increasing the amount of labor devoted to verifying the claim, $l_{mj}$, decreasing in the size of the loan, $k$—because there will be more activity to monitor—and rising in the productivity of the monitoring technology, $z$. Let $P_{ij}(l_{mj}, k, z)$ denote the probability that the firm is caught cheating conditional on the following: (1) the true realization of productivity is $\theta_i$; (2) the firm makes a report of $\theta_j$; (3) the intermediary allocates $l_{mj}$ units of labor to monitor the claim; (4) the size of loan is $k$ (which represents the scale of the project); (5) the level of productivity in the monitoring activity is $z$. The function $P_{ij}(l_{mj}, k, z)$ is increasing in $l_{mj}$ and $z$, and decreasing in $k$. Additionally, let $P_{ij}(l_{mj}, k, z) = 0$ if the firm truthfully reports

[2] Recall that the intermediary knows the firm's type, $\tau$. One could think about this as representing the activity, industry or sector that a firm operates within. For instance, Castro et al. (2009, Figure 3) present data suggesting that the capital-goods sector is riskier than the consumption-goods one. It would be possible to have a screening stage where the intermediary verifies the initial type of a firm. The easiest way to do this would be to have them pay a cost that varies with loan size to discover $\tau$. If the firm's type can't be undercovered perfectly, as in the classic work of Boyd and Prescott (1986), then it may be possible to design the contract to reveal it.

that its type is $\theta_i$ (i.e., when $j = i$). A convenient formulation for $P_{ij}(l_{mj}, k, z)$ is[3]

$$P_{ij}(l_{mj}, k, z) = \begin{cases} 1 - \frac{1}{\epsilon (z/k)^{\psi} (l_{mj})^{\gamma}} < 1, \text{ with } 0 < \psi, \gamma < 1, \\ \qquad\qquad\qquad\qquad \text{for a report } \theta_j \neq \theta_i, \\ 0, \qquad\qquad\qquad\quad \text{for a report } \theta_j = \theta_i. \end{cases} \tag{2}$$

The intermediary makes a firm a loan of size $k$. In exchange for the loan the firm will make some specified state-contingent payment to the intermediary. The rents that accrue to a firm will depend upon the true state of its technology, $\theta_i$, the state that it reports, $\theta_j$, plus the outcome of any monitoring that is done. Clearly, a firm will have no incentive to misreport when the bad state, $\theta_1$, occurs. Likewise, the intermediary will never monitor a good report, $\theta_j = \theta_2$. It will just audit bad ones, $\theta_j = \theta_1$. If it finds malfeasance, then the intermediary should exert maximal punishment, which amounts to seizing everything or $r_2 k$. If it doesn't, then it should take all of the bad state returns, or $r_1 k$. These latter two features help to create, in a least-cost manner, an incentive for the firm to tell the truth. The above features are embedded into the contracting problem presented below. A more formal, step-by-step analysis is presented in Greenwood et al. (forthcoming).

Turn now to the contracting problem. Intermediation is competitive. Therefore, an intermediary must choose the details of the financial contract to maximize the expected rents for a firm. Competition implies that all intermediaries will earn zero profits on their lending activity. Suppose that intermediaries can raise funds from savers at the interest rate $\widehat{r}$. If the depreciation rate on physical capital is $\delta$, then the cost of supplying capital is $\widetilde{r} = \widehat{r} + \delta$. The intermediary's optimization problem can be expressed as[4]

$$v \equiv \max_{k, l_{m1}} \{\pi_2 [1 - P_{21}(l_{m1}, k, z)][r_2(\tau) - r_1(\tau)]k\}, \tag{P(2)}$$

[3] To guarantee that $P_{ij}(l_j^m, k, z) \geq 0$, this specification requires that some minimal level of labor must be devoted to monitoring; i.e., $l_j^m > \epsilon^{1/\gamma} (k/z)^{\psi/\gamma}$. Note that this minimal labor requirement for monitoring can be made arbitrarily small by picking a large enough value for $\varepsilon$. The choice of $\varepsilon$ can be thought of as normalization relative to the level of productivity in the production of monitoring services—see Greenwood et al. (forthcoming) for more detail.

[4] This is the dual of the problem presented in Greenwood et al. (forthcoming).

subject to

$$[\pi_1 r_1(\tau) + \pi_1 r_2(\tau)]k - \pi_2[1 - P_{21}(l_{m1}, k, z)][r_2(\tau) - r_1(\tau)]k - \pi_1 w l_{m1} = \widetilde{r}k. \tag{3}$$

The objective function P(2) gives the expected rents for a firm. These rents accrue from the fact that the firm has private information about its state. Suppose that the firm lies about being in the good state. When it doesn't get caught it can pocket the amount $[r_2(\tau) - r_1(\tau)]k$. The odds of not getting caught are $1 - P_{21}(l_{m1}, k, z)$. The good state occurs with probability $\pi_2$. An incentive compatible contract offers the firm the same amount from telling the truth that it can get from lying.[5] Equation (3) is the intermediary's zero-profit condition. The expected return from the project is $[\pi_1 r_1(\tau) + \pi_1 r_2(\tau)]k$. Out of this the intermediary must give the firm $\pi_2[1 - P_{21}(l_{m1}, k, z)][r_2(\tau) - r_1(\tau)]k$. The expected cost of monitoring low-state returns is $\pi_1 w l_{m1}$. Represent the amount of labor required to monitor a type-$\tau$ firm in state 1 by $l_{m1}(\tau) = l_{m1}(\theta_1, \theta_2)$. The contract presumes that the intermediary is committed to monitoring all reports of a bad state. Last, for some types of firms a loan may entail a loss. The intermediary will not lend to these firms.

# 5 Stationary Equilibrium

The focus of the analysis is on stationary equilibria. Firms differ by type, $\tau = (\theta_1, \theta_2)$ with $\theta_1 < \theta_2$. Denote the space of types by $\mathcal{T} \subseteq R_+^2$. Suppose that firms are distributed over

[5] Let $p_2$ represent the payment that a firm makes to the intermediary in the good state. The incentive constraint for the contract will read

$$[1 - P_{21}(l_1^m, k, z)][r_2(\tau) - r_1(\tau)]k \leq r_2(\tau)k - p_2.$$

The left-hand side represents what the firm will get by lying, while the right-hand side shows what it will receive when it tells the truth. The latter must dominate, in a weak sense, the former. (Recall that upon the declaration of a bad state the firm must turn over $r_1(\tau)k$ to the intermediary. So, it will make nothing when it truthfully reports a bad state. If the firm gets caught cheating, then it must make the payment $r_2(\tau)k$, so it will also earn zero rents here.) The incentive constraint will bind. Thus, P(2) maximizes the firm's expected rents, $\pi_2[r_2(\tau)k - p_2]$, subject to the zero-profit constraint. As in Townsend (1979), it can be shown that the revelation principle holds, so the focus here on incentive compatible contracts is without loss of generality.

productivities in accordance with the distribution function

$$F(x, y) = \Pr(\theta_1 \leq x, \theta_2 \leq y).$$

For all firms fix the odds of drawing state $i$ at $\Pr(\theta = \theta_1) = \pi_i$. This distribution $F$ can then be thought of as specifying the mean, $\pi_1\theta_1 + \pi_2\theta_2$, and variance, $\pi_1\pi_2(\theta_1 - \theta_2)^2$, of project returns across firms. So, which firms will receive funding in equilibrium?

To answer this question, focus on the zero-profit condition for intermediaries (3). Now, consider a firm of type $\tau$. Clearly, if $\pi_1 r_1(\tau)k + \pi_1 r_2(\tau)k < 0$, then the intermediary will incur a loss on any loan of size $k > 0$. Likewise, if $\pi_1 r_1 k + \pi_1 r_2 k > 0$, then it will be possible to make non-negative profits, albeit the loan may have to be very small. Therefore, a necessary and sufficient condition to obtain funding is that $\tau$ lies in the set $\mathcal{A}(w) \subseteq \mathcal{T}$ defined by

$$\mathcal{A}(w) \equiv \{\tau : \pi_1 r_1(\tau) + \pi_2 r_2(\tau) - \widetilde{r} > 0\}. \tag{4}$$

This set shrinks with the wage, $w$, because $r_i(\tau)$ is decreasing in $w$; as wages rise a firm becomes less profitable.

Firms with $\tau \in \mathcal{A}(w)$ will demand $l_i(\theta_1, \theta_2)$ units of labor in state $i$. Should one of these firms declare that it is in state 1, then the intermediary will send $l_{m1}(\theta_1, \theta_2)$ units of labor over to audit it. Recall that labor is in fixed supply. Suppose that there is one unit in aggregate. The labor-market-clearing condition will then appear as

$$\int_{\mathcal{A}(w)} [\pi_1 l_1(\theta_1, \theta_2) + \pi_2 l_2(\theta_1, \theta_2) + \pi_1 l_{m1}(\theta_1, \theta_2)] dF(\theta_1, \theta_2) = 1. \tag{5}$$

It is now time to take stock of the situation thus far by presenting a definition of the equilibrium under study.

**Definition 1** *Set the steady-state cost of capital at $\widetilde{r}$. A stationary competitive equilibrium is described by a set of labor allocations, $l_i$ and $l_{m1}$, a set of active firms, $\mathcal{A}(w)$, together with a loan size, $k$, and a value, $v$, for each firm, and finally a wage rate, $w$, such that:*

1. *The loan, $k$, offered by the intermediary maximizes the value of a firm, $v$, in line with P(2), given the prices $\widetilde{r}$ and $w$. The intermediary hires labor for monitoring in the amount $l_{m1}$, as also specified by P(2).*

*2. A firm is offered a loan if and only if it lies in the active set, $\mathcal{A}(w)$, as defined by (4).*

*3. Firms hire labor $l_i$, so as to maximize its profits in accordance with P(1), given wages, $w$, and the size of the loan, $k$, offered by the intermediary.*

*4. The wage rate, $w$, is determined so that the labor market clears, in accordance with (5).*

# 6 Discussion

The analysis focuses on the role that intermediaries play in producing information. Before an investment opportunity is funded, intermediaries assess its risk and return. In the current setting, this amounts to knowing a project's type, $\tau$. This can be costlessly discovered in the model here. It would be easy to add a variable cost for a loan that is a function of $z$. Doing so would have little benefit, however. Intermediaries need to put systems in place to monitor cash flows, or face the prospect of lower-than-promised returns. In yesteryear, banks required borrowers to keep their funds in an account with them. This way transactions could be monitored. Now, even a privately funded firm needs to be monitored, unless the scale is so small that the owner can operate it himself. Managers and workers tend to siphon off funds from the providers of capital, whether they are banks, bondholders, private owners, share holders, or venture capitalists. At the micro level, this is what a shirking worker in a fast food restaurant is doing. And, there is computer surveillance software available for \$200 a month, called HyperActive Bob, designed to catch such a person.[6]

Efficiency of monitoring, $z$, is likely to depend on the state of technology in the financial sector, both in terms of human and physical capital. Better information technologies allow for greater quantities of financial information to be collected, exchanged, processed and analyzed. Indeed, the most IT-intensive industry in the United States is Depository and Nondepository Financial Institutions. Computer equipment and software services accounted for 10 percent of value added over the period 1995 to 2000, as opposed to 5 percent in Industrial Machinery and Equipment, or 2.6 percent in Radio and Television Broadcasting.

[6] "Machines that can see." *The Economist*, March 5th 2009.

Berger (2003) discusses the importance of IT in accounting for productivity gains in the U.S. banking sector. This is reflected in the growth of ATM machines, Internet banking, electronic payment technologies, and information exchanges that permit the use of economic models to undertake credit scoring for small businesses, develop investment strategies, create new exotic financial products, etc. Similarly, a more talented work force allows for higher-quality information workers: accountants, financial analysts, and lawyers. Last, the efficiency of monitoring will depend on the legal environment, which specifies what information can, must, or must not be produced. This is separate from regulating the terms of payments, especially in bankruptcy (here $p_1$ or $p_{12}$) as analyzed in Castro et al. (2004).

Before proceeding on to the quantitative analysis, some mechanics of the above framework will now be inspected in a heuristic manner. For a more formal analysis see Greenwood et al. (forthcoming). The presence of diminishing returns to information production leads to a financial theory of firm size, as will be discussed. In fact, they can be thought of as providing a microfoundation for the Lucas (1978) span of control model. The framework also specifies a link between the state of financial development and the state of economic development.

(1) A firm's production is governed by constant returns to scale. In the absence of financial market frictions, no rents would be earned on production. Additionally, in a frictionless world only firms offering the highest expected return would be funded. In this situation, $\max_{\tau}[\pi_1 r_1(\tau) + \pi_2 r_2(\tau)] = \widetilde{r}$—cf (4). With financial market frictions, $\pi_1 r_1(\tau) + \pi_2 r_2(\tau) > \widetilde{r}$ for all funded projects $\tau \in \mathcal{A}(w)$, a fact easily gleaned from (3). Thus, deserving projects—those $\tau \in \mathcal{B}(w) \equiv \{x : \max_{x \in \mathcal{T}}[\pi_1 r_1(x) + \pi_2 r_2(x)]\}$—will be underfunded, while undeserving projects—$\tau \notin \mathcal{B}(w)$—are simultaneously overfunded. Funded firms will earn rents, $v$, as given by P(2).

(2) What determines the size of a firm's loan? By eyeballing the left-hand side of (3), which details the intermediary's profits, it looks likely that the firm's loan will be increasing in the project's expected return, $\pi_1 r_1(\tau) + \pi_1 r_2(\tau)$, ceteris paribus. This is true. Recall that the odds of detecting fraud, $P_{21}(l_{m1}, k, z)$, decrease in loan size, $k$. Therefore, more labor must be allocated to monitoring the project in response to an increase in loan size. Since

there are diminishing returns to information production, the size of the loan, $k$, is uniquely determined as a function of expected return. Similarly, it appears that a firm's loan will decrease in the project's risk, as measured by $r_2(\tau) - r_1(\tau)$. This is also true. When the spread between the high and low states widens, there is more of an incentive for the firm to misreport its returns. Recall that the gain from lying is given by the objective function in P(2). To counter this the intermediary must devote more labor to monitoring. The diminishing returns to information production imply that loan size is uniquely specified as a function of risk.

(3) Imagine that aggregate productivity, $x$, grows over time at the constant rate $g^{1/\alpha}$. Will there be balanced growth? Conjecture that along a balanced growth path the $k$'s, $o$'s, and $w$, will all grow at rate $g$. Also guess that $\mathcal{A}(w)$ and the $l_i$'s, $l_1^m$'s, and $r_i(\tau)$'s will remain constant. It is easy to see from the isoelastic forms of P(1) and (1) that the conjectured solution for balanced growth solution will be satisfied for the $l_i$'s, $l_1^m$'s, and $r_i(\tau)$'s. Since the $r_i(\tau)$'s remain constant so does the active set, $\mathcal{A}(w)$, that is spelled out in (4). Since the $l_i$'s and $l_1^m$'s remain fixed, if the labor-market clearing condition (5) holds at one point along the balanced path it will hold at all others. So, the hypothesized solution for $w$ is consistent with this. What about $k$? The solution guessed for $k$ is consistent with P(2), if $P_{12}$ does not change along a balanced growth path. From (2) it is clear that the odds of getting caught cheating, $P_{21}$, will change over time, however, unless $z$ grows at precisely the rate $g$. If this happens, then balanced growth occurs.

(4) Consider the case where $x$ grows at a different rate than $z$. Specifically, for illustrative purposes, take the extreme situation where $z$ rises while $x$ remains fixed. Thus, there is only financial innovation in the economy. By inspecting (2) the odds of detecting fraud will rise, other things equal. The rents that firms can make will drop, a fact that is evident from the objective function in P(2). This makes it feasible for financial intermediaries to offer firms larger loans, ceteris paribus, as can be gleaned from (3). The implied increase in the economy's aggregate capital stock will then drive up wages. Thus, inefficient firms will have their funding cut, as (4) makes clear. Therefore, financial innovation operates to weed out

unproductive firms. The active set of firms, $\mathcal{A}(w)$, thus shrinks. Average firm size in the economy is the total stock of labor (one) divided by the number of firms (or the measure of the active set). Therefore, average firm size increases. If $z$ increases without bound, then the economy will enter into a frictionless world where only firms offering the highest expected return, $\max_{\tau}[\pi_1 r_1(\tau) + \pi_2 r_2(\tau)]$, are funded. These firms will earn no rents; i.e., $\max_{\tau}[\pi_1 r_1(\tau) + \pi_2 r_2(\tau)] = \widetilde{r}$.

# 7 The United States and Taiwan

## 7.1 Fitting the Model to the U.S. Economy

The quantitative analysis will now begin. To simulate the model, values must be assigned to its parameters. This will be done by calibrating the framework to match some stylized facts. Some parameters are standard. They are given conventional values. Capital's share of income, $\alpha$, is chosen to be 0.35, a very standard number.[7] Likewise, the depreciation rate, $\delta$, is set to 0.06, another very common figure.[8] The chosen value for return on savings through an intermediary is $\widetilde{r} = 0.03$.[9]

Nothing is known about the appropriate choice for parameters governing the intermediary's monitoring technology $\psi$ and $\gamma$. Similarly, little is known about the distribution of returns facing firms. Let $\mu_{\theta_1}$ be the mean *across firms* for the logarithm of low shock, $\theta_1$; i.e., $\mu_{\theta_1} \equiv \int \ln(\theta_1) dF(\theta_1, \theta_2)$. Analogously, $\mu_{\theta_2} \equiv \int \ln(\theta_2) dF(\theta_1, \theta_2)$. Likewise, $\sigma^2_{\theta_j}$ will denote the variance over firms for the low shock; i.e., $\sigma^2_{\theta_j} \equiv \int [\ln(\theta_j) - \mu_{\theta_j}]^2 dF$, for $j = 1, 2$. In a similar vein, $\rho$ will represent the correlation between the low and high shocks, $\ln(\theta_1)$ and $\ln(\theta_2)$, in the type distribution for firms. Assume that these means and variances of firm-level

[7] Conesa and Krueger (2006) and Domeij and Heathcote (2004) use a capital share of 0.36, close to the number imposed here.

[8] The same number is used, for instance, by Chari et al. (1997).

[9] For the period 1800 to 1990, Siegel (1992) estimates the real return on bonds, with a maturity ranging from 2 to 20 years, to be between 3.36 percent (geometric mean) and 3.71 percent (arithmetic mean). He also estimates the real return on 90 day commercial paper to be between 2.95 percent (geometric mean) and 3.13 percent (arithmetic mean).

ln(TFP) are distributed according to a bivariate truncated normal, $N(\mu_{\theta_1}, \mu_{\theta_2}, \sigma^2_{\theta_1}, \sigma^2_{\theta_2}, \rho)$. Normalize $\mu_{\theta_1}$ to be 1. Of course, values for the parameters determining the productivities of the technologies used in the production and financial sectors, $x$ and $z$, are also needed.

Let $\text{T}_{\text{ARGETS}_j}$ represent the $j$-th component of a $n$-vector of observations that the model should match. Similarly, $M(\text{PARAM})$ denotes the model's prediction for this vector. The calibration procedure will minimize the distance between the vectors TARGETS and $M\,(\text{PARAM})$. The key, then, is to choose targets that will be tightly connected to the model's parameters. The technological parameters, $x$ and $z$, are very important for determining the efficiencies of the production and financial sectors. In particular, the model provides a mapping between the aggregate level of output (per person), $\mathbf{o}$, and the interest-rate spread, $\mathbf{s}$, on the one hand, and the state of technology in its production and financial sectors, $x$ and $z$, on the other. Represent this mapping by $(\mathbf{o}, \mathbf{s}) = O(x, z; p)$, where $p = (\epsilon, \psi, \gamma, \mu_{\theta_2}, \sigma^2_{\theta_1}, \sigma^2_{\theta_2}, \rho)$, represents the remaining 7 parameters in PARAM (where $\mu_{\theta_1}$ is normalized to one and hence is omitted). Now, while the states of the technologies in these sectors are unobservable directly, this mapping can be used to make an inference about $(x, z)$, given an observation on $(\mathbf{o}, \mathbf{s})$, by using the relationship

$$(x, z) = O^{-1}(\mathbf{o}, \mathbf{s}; p). \tag{6}$$

Given the importance of these two parameters, this condition will be used as a constraint in the minimization of the distance between TARGETS and $M\,(\text{PARAM})$. Equation (6) will also play an important role in the cross-country analysis.

The distribution of returns across firms will be integrally related to the distribution of employment across them. Firms with high returns will have high employment, other things equal. Figure 4 illustrates a firm's employment, $l$, as a function of its capital stock, $k$, and the realized value of the technological shock, $\theta$. A firm that receives a bigger loan, $k$, will hire more labor, $l$, other things equal. Recall that the size of the loan is determined before the technology shock is realized. Given the size of its loan, a firm will hire more labor the higher is the realized state of its technology shock. Given this relationship, the size distributions of firms for the years 1974 and 2004 are chosen as data targets to determine the remaining 8 parameters. Seven points on the distribution for each year are picked. As it is well known, the size distribution of firms is highly skewed to the right; that is, there are many small firms, employing a relatively small amount of labor in total, and a few large ones, hiring a lot. For instance, in 1974, the smallest 60 percent of establishments employed only 7.5 percent of the total number of workers, while the largest 5 percent of establishments hired about 60 percent of workers. Using only one target for the size distribution would be insufficient to capture this fact. It is important that the largest 12 percent of establishments employ 75 percent of the workers, but it is equally important that the truncated distribution inside of the largest 12 percent of establishments is also very skewed—remember that the largest 5 percent of establishments employed about 60 percent of workers. Therefore, it is useful to consider the share of employment in the smallest 60, 75, 87, 95, 98, 99.3, and 99.7 percent of establishments. Thus, there are 7 targets for each of the two years. Denote the $j$th percentile target for the year $t$ by $e_{j,t}^{US}$ and let $M_j\left(x_t^{US}, z_t^{US}, p\right)$ give the model's prediction for this statistic (all for $j = 60, 75, 87, 95, 98, 99.3, 99.7$ and $t = 1974, 2004$).

The mathematical transliteration of the above calibration procedure is

$$\min_p \left\{ \sum_j \frac{w_j}{2} [e_{j,74}^{US} - M_j\left(x_{74}^{US}, z_{74}^{US}, p\right)]^2 + \sum_j \frac{w_j}{2} [e_{j,04}^{US} - M_j\left(x_{04}^{US}, z_{04}^{US}, p\right)]^2 \right\}, \qquad \text{P(3)}$$

subject to

$$(x_{74}^{US}, z_{74}^{US}) = O^{-1}(\mathbf{o}_{74}^{US}, \mathbf{s}_{74}^{US}; p), \qquad (7)$$

and

$$(x_{04}^{US}, z_{04}^{US}) = O^{-1}(\mathbf{o}_{04}^{US}, \mathbf{s}_{04}^{US}; p). \qquad (8)$$

Thus, following this strategy, 18 targets (including the $\mathbf{o}^{US}$'s and $\mathbf{s}^{US}$'s) are used to calibrate 11 parameters (including the $x^{US}$'s and $z^{US}$'s).

The upshot of the above fitting procedure is now discussed. First, there exists a set of technology parameters for the production and financial sectors, $(x_{74}^{US}, z_{74}^{US}, x_{04}^{US}, z_{04}^{US})$, so that the model can match exactly interest-rate spreads and per-capita GDP for the years 1974 and 2004. Second, the model does a very good job matching the 1974 and 2004 firm-size distributions—see the upper two panels. Across time the size distribution shifts slightly to

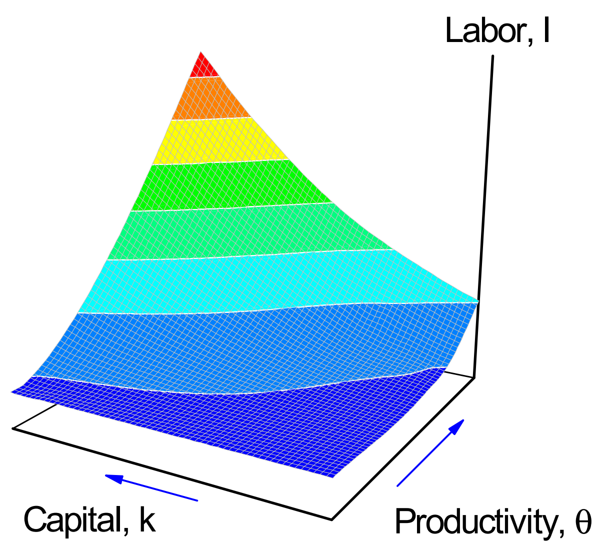


Figure 4: Employment, $l$, as a function of capital, $k$, and the realized value of the technological shock, $\theta$–model

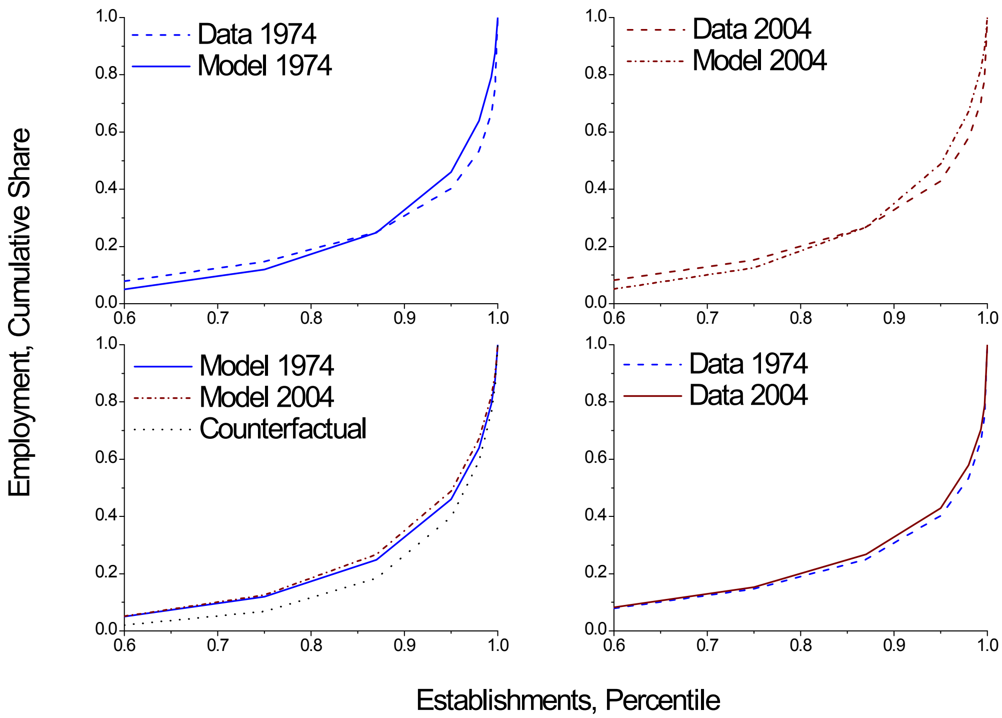


Figure 5: Firm-size distribution, 1974 and 2004–data and model

the left, as the lower right panel of Figure 5 makes clear. The largest firms account for a little less of employment. Last, the parameters obtained from the fitting procedure are presented in Table 1.

Table 1: Parameter Values

| *Parameter* | *Definition* | *Basis* |
|---|---|---|
| $\alpha = 0.35$ | Capital's share of income | Conesa and Krueger (2006) |
| $\delta = 0.06$ | Depreciation rate | Chari, Kehoe and McGrattan (1997) |
| $\widetilde{r} = 0.03$ | Return to Savers | Siegel (1992) |
| $\epsilon = 32.57$ | Pr of detection, constant | Normalization |
| $\psi = 0.95$ | Pr of detection, exponent | Calibrated to fit targets |
| $\gamma = 0.40$ | Monitoring cost function | Calibrated to fit targets |
| $\mu_{\theta_1} = 1.0$ | Mean of $\ln(\theta_1)$ | Normalization |
| $\mu_{\theta_2} = 3.05$ | Mean of $\ln(\theta_2)$ | Calibrated to fit targets |
| $\sigma^2_{\theta_1} = 0.53$ | Variance of $\ln(\theta_1)$ | Calibrated to fit targets |
| $\sigma^2_{\theta_2} = 0.61$ | Variance of $\ln(\theta_2)$ | Calibrated to fit targets |
| $\rho = -0.87$ | Correlation $\ln(\theta_1)$ and $\ln(\theta_2)$ | Calibrated to fit targets |
| $x_{1974} = 0.14, z_{1974} = 11.5$ | TFP's | Calibrated to fit targets |
| $x_{2004} = 0.20, z_{2004} = 28.2$ | " | " |

## 7.2 The United States, Balanced Growth

It would not be unreasonable to argue, for the purposes of the current analysis, that the U.S. economy is characterized by a situation of balanced growth. First, there is only a small shift in the U.S. firm-size distribution between 1974 and 2004, as was shown in Figure 5 (bottom right panel). Second, the economy's interest-rate spread shows only a modest decline—recall Figure 1. Third, the capital-to-output ratio displays a small increase—again Figure 1.

Finance is important in the model. This can be gauged by undertaking the following counterfactual question: By how much would GDP have risen between 1974 and 2004 if there had been no technological progress in the financial sector? As can be seen from the third panel of Table 2, output would have risen from \$22,352 to \$33,656 or by about 1.4 percent a year (when continuously compounded). This compares with the increase of 2.0 percent (\$22,352 to \$41,208) that occurs when $z$ rises to its 2004 level. Thus, about 30 percent of the increase in growth is due to innovation in the financial sector. Likewise, the model predicts that about 12 percent of TFP growth was due to improvement in financial intermediation. The financial system actually becomes a drag on development when $z$ is not allowed to increase. Wages rise as the rest of the economy develops. This makes monitoring more expensive. Therefore, less will be done. As a consequence, interest rates rise and the economy's capital-to-output ratio drops. Without an improvement in the financial system, the firm-size distribution actually moves over time in a direction (rightward) that is opposite to that shown in the data (leftward), as can be seen by comparing the lower two panels of Figure 5. When there is no technological progress in the financial sector there will be a larger number of small inefficient firms around. Therefore, the smallest firms in the economy (or the left tail) will now account for a smaller fraction for the work force—see the lower left panel.

Now, monitoring and the provision of financial services are abstract goods, so it is difficult to know what a reasonable change in $z$ should be. One could think about measuring productivity in the financial sector, as is often done, by $\mathbf{k}/\mathbf{l}_m$, where $\mathbf{k}$ is the aggregate amount of credit extended by financial sector and $\mathbf{l}_m$ is the aggregate labor that it employs. By this traditional measure, productivity in the financial sector rose by 2.59 percent annually between 1974 and 2004. Berger (2003, Table 5) estimates that productivity in the commercial banking sector increased by 2.2 percent a year over this same period (which includes the troublesome productivity slowdown) and by 3.2 percent from 1982 to 2000.

Table 2: The U.S. Economy

| | Data | Model |
|---|---|---|
| *1974* | | |
| Spread, **s** | 3.07% | 3.07% |
| GDP (per capita), **o** | $22,352 | $22,352 |
| capital-to-output ratio (indexed), **k**/**o** | 1.00 | 1.00 |
| TFP | | 6.63 |
| *2004* | | |
| Spread, **s** | 2.62% | 2.62% |
| GDP (per capita), **o** | $41,208 | $41,208 |
| capital-to-output ratio (indexed), **k**/**o** | 1.02 | 1.10 |
| TFP | | 9.54 |
| *2004 Counterfactual,* $z_{2004}^{US} = z_{1974}^{US}$ | | |
| Spread, **s** | 2.62 | 3.87 |
| GDP (per capita), **o** | $41,208 | $33,656 |
| capital-to-output ratio (indexed), **k**/**o** | 1.02 | 0.86 |
| TFP | | 9.12 |
| | | |
| Yearly growth in financial productivity | | 2.59% |

## 7.3 Taiwan, Unbalanced Growth

Return to Taiwan, as shown in Figure 1. In Taiwan there was a large drop in the interest-rate spread between 1974 and 2004. This was accompanied by a significant increase in the economy's capital-to-output ratio. This is clearly a situation of unbalanced growth. Recall that model provides a mapping between the state of technologies in the production and financial sectors on the one hand, $x$ and $z$, and output and interest-rate spreads, **o** and **s**, on the other. This mapping can be inverted to infer $x$ and $z$ using observations on **o** and **s** using (6), given a vector of parameter values, $p$. Take the parameter vector $p$ that was calibrated/estimated for the U.S. economy and use the Taiwanese data on per-capita GDPs and interest-rate spreads for the years 1974 and 2004, $(\mathbf{o}^T_{1974}, \mathbf{s}^T_{1974}, \mathbf{o}^T_{2004}, \mathbf{s}^T_{2004})$, to get the imputed Taiwanese technology vector $(x^T_{1974}, z^T_{1974}, x^T_{2004}, z^T_{2004})$. The results of the fitting exercise for Taiwan are shown below.

So, how important was financial development for Taiwan's economic development? To answer this question, compute the model's solution for 2004 assuming that there had been no financial development; i.e., set $z^T_{2004} = z^T_{1974}$. Almost 50 percent of Taiwan's 6.1 percent annual rate of growth between 1974 and 2004 can be attributed to financial development. It also accounts for 20 percent of the growth in Taiwanese TFP. Taiwan had almost a 10 percent annual increase in the productivity of its financial sector, as is conventionally measured.

Table 3: The Taiwan Economy

| | *Data* | *Model* |
|---|---|---|
| *1974* | | |
| Productivity, industrial | | $x_{1974}$ =0.0383 |
| Productivity, financial | | $z_{1974}$ =0.4214 |
| Spread, **s** | 5.41% | 5.41% |
| GDP (per capita), **o** | $2,211 | $2,211 |
| capital-to-output(indexed), **k/o** | 1.00 | 1.00 |
| TFP | | 1.68 |
| *2004* | | |
| Productivity, industrial | | $x_{2004}$ =0.0897 |
| Productivity, financial | | $z_{2004}$ =16.267 |
| Spread, **s** | 1.96% | 1.96% |
| GDP (per capita), **o** | $13,924 | $13,924 |
| capital-to-output(indexed), **k/o** | 1.847 | 1.905 |
| TFP | | 4.46 |
| *2004 Counterfactual,* $z^T_{2004} = z^T_{1974}$ | | |
| Spread, **s** | 1.96% | 9.66% |
| GDP (per capita), **o** | $13,924 | $5,676 |
| capital-to-output(indexed), **k/o** | 1.847 | 0.630 |
| TFP | | 3.66 |
| Yearly growth in financial productivity | | 9.89% |

# 8 Cross-Country Analysis

Move on now to some cross-country analysis. In particular, a sample of 45 countries, the intersection of all the nations in the Penn World Tables and the Beck, Demirguc-Kunt and Levine (2000, 2001) dataset, will be studied. For each country $j$, a technology vector $(x^j, z^j)$ will be backed out using data on output and interest-rate spreads $(\mathbf{o}^j, \mathbf{s}^j)$, given the procedure implied by (6) while setting $p$ to the calibrated parameter vector for the U.S. economy. Erosa (2001) uses interest-rate spreads to quantify the effects of financial intermediation on occupational choice. It is not a foregone conclusion that this can always be done; i.e., that a set of technology parameters can be found such that (6) always holds.[10] The results are reported in Table 9 in the Appendix. By construction the model explains all the variation in output and interest-rate spreads across countries.[11] Still, one could ask how well the measure of the state of technology in the financial sector that is backed out using the model correlates with independent measures of financial intermediation. Here, take the ratio of private credit by deposit banks and other financial institutions to GDP as a measure of financial intermediation, as reported by Beck et al. (2000, 2001). (Other measures produce similar results but reduce the sample size too much.) Additionally, one could examine how well the model explains cross-country differences in capital-to-output ratios.

Table 4 reports the findings. The correlation between the imputed state of technology in the financial sector and the independent Beck et al. (2000, 2001) measure of financial intermediation is quite high—see Table 4 and Figure 6. Thus, it appears reasonable to use

[10] Theoretically speaking, there is a maximum interest-rate spread that the model can match. When the financial sector becomes too inefficient, it no longer pays to monitor loans. As $z$ falls (relative to $x$) the aggregate volume of lending declines. The wage rate will decline along with the economy's capital stock. As this happens, the $r_1$'s rise–see (1). Take the firms with the highest value of $r_1$ and denote this by $\overline{r}_1$. By definition, $\overline{r}_1 = r_1(\overline{\tau})$, where $\overline{\tau} = \arg\max_{\tau \in \mathcal{T}}\{r_1(\tau)\}$. Eventually, $\overline{r}_1$ will hit $\widetilde{r}$. At this point, a Williamson (1986)-style credit-rationing equilibrium emerges. In the credit-rationing equilibrium, $\overline{r}_1 = \widetilde{r}$. Here type-$\overline{\tau}$ firms will pay the fixed interest rate $\overline{r}_1$. They will not be monitored. Because $r_2 > \widetilde{r}$ for these firms, they would demand as big a loan as possible. Thus, their credit must be rationed. The interest-rate spread on these loans will be zero. Note that $\overline{r}_1$ can never exceed $\widetilde{r}$, because infinite profit opportunities would then emerge in the economy. Thus, the interest rate spread is a $\cap$-shaped function of $z$. (The interest-rate spread also approaches zero as $z \to \infty$, or when economy asymptotes to the frictionless competitive equilibrium. As $z \to 0$ the fraction of loans that are not monitored will eventually approach one, implying that the interest-rate spread will drop to zero.) The peak of the $\cap$ function is the maximum permissible interest-rate spread allowed by the model.

[11] The model predicts a positive association between a country's rate of investment and its GDP. Castro et al. (2009, Figure 1) show that this is true. As was mentioned, it is stronger when investment spending is measured at international prices, as opposed to domestic ones. This puzzle could be resolved here by adopting aspects of Castro et al.'s (2009) two-sector analysis.

the constructed values of $z$ for investigating the relationship between output and financial development. Now, the backed-out measure for the efficiency of the financial sector correlates well with a country's adoption of information technologies, as is shown in Figure 6 (upper left panel). It also is strongly associated with a country's human capital (upper right) and the maturity of its legal system (lower right). These three factors should make intermediation more efficient, for the reasons discussed in Section 6. Indeed, Figure 6 (lower left panel) also illustrates how the ratio of overhead cost to assets, a measure of efficiency, declines with constructed $\ln(z)$.

As can be seen, the capital-to-output ratios predicted by the model are positively associated with those in the data. The correlation is reasonably large. That these two correlations aren't perfect, should be expected. There are other factors, such as the big differences in public policies discussed in Parente and Prescott (2000), which may explain a large part of the cross-country differences in capital-to-output ratios. Differences in monetary policies across nations may influence cross-country interest-rate spreads. Additionally, there is noise in these numbers given the manner of their construction—see the Appendix.

TABLE 4: CROSS-COUNTRY EVIDENCE

| | $\mathbf{k/o}$ | $\ln z$ with Beck et al (2000, 2001) | $\mathbf{k/l}_m$ with Beck et al (2000, 2001) |
|---|---|---|---|
| *Corr(model, data)* | 0.62 | 0.81 | 0.82 |

Interestingly, Sri Lanka and the United States both have an interest-rate spread of about 4.2 percent. The model predicts the United States' $z$ is about 250 percent higher (when ln differenced or continuously compounded) than Sri Lanka's—the former's $\ln(z)$ is 2.28, compared with 0.013 for the latter; again, see Table 9 in the Appendix. But, recall that the units for $\ln(z)$ are meaningless, since monitoring is abstract good. If one measures productivity in the financial sector by the amount of credit extended relative to the amount of labor employed in the financial sector, as was discussed earlier, then the analysis suggests that intermediation in the United States is about 214 percent (continuously compounded) more efficient than in Sri Lanka. Why? The United States has a much higher level of income

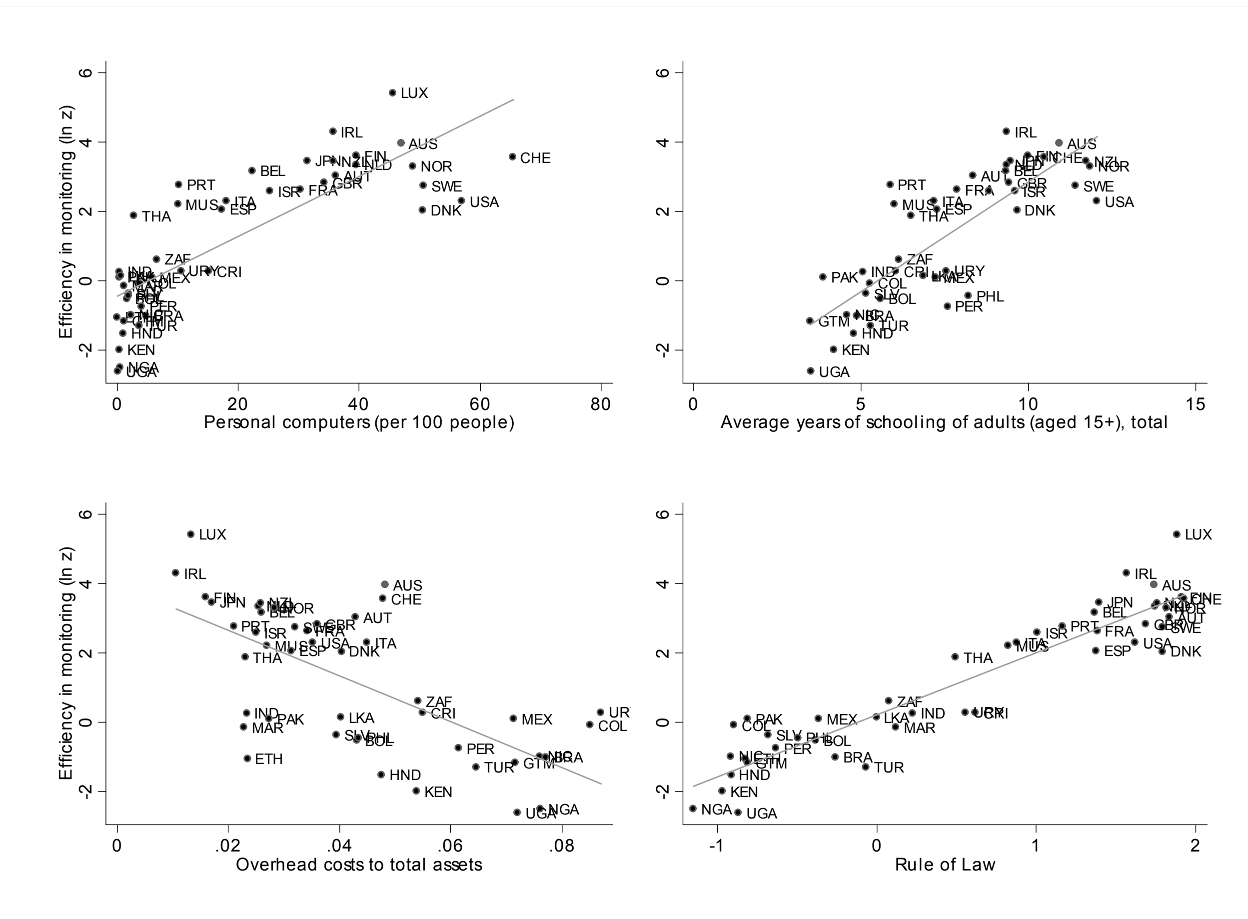


Figure 6: The relationship between imputed $\ln(z)$ on the one hand, and measures of information technology, human capital, overhead costs to assets and the rule of law, on the other

per worker and hence TFP than does Sri Lanka ($33,524 versus $3,967). Therefore, given the higher wages, monitoring will be more expensive in the United States. To give the same interest-rate spread, efficiency in the U.S.'s financial sector must be higher. Before proceeding on to a discussion of the importance of financial development for economic development, note that the findings in the next section do not change much if the model is matched up with overhead costs, perhaps a more direct measure (see Figure 6), instead of the Beck et al. (2000, 2001) interest-rate spreads.

## 8.1 The Importance of Financial Development for Economic Development

It is now possible to gauge how important efficiency in the financial sector is for economic development, at least in the model. To this end, let the best industrial and financial practices in the world be denoted by $\overline{x} \equiv \max\{x_i\}$ and $\overline{z} \equiv \max\{z_i\}$, respectively. Represent country $i$'s output, as a function of the efficiency in its industrial and financial sectors, by $\mathbf{o}_i = \mathbf{O}(x_i, z_i)$—this is really just the first component of the mapping $O(x, z, p)$. If country $i$ could somehow adopt the best financial practice in the world it would produce $\mathbf{O}(x_i, \overline{z})$. Similarly, if country $i$ used the best practice in both sectors it would attain the output level $\mathbf{O}(\overline{x}, \overline{z})$. The shortfall in output from the inability to attain best practice is $\mathbf{O}(\overline{x}, \overline{z}) - \mathbf{O}(x_i, z_i)$. The United States turns out to have the highest value for $x$, and Luxembourg for $z$.

The percentage gain in output for country $i$ by moving to best financial practice is given by $100 \times [\ln \mathbf{O}(x_i, \overline{z}) - \ln \mathbf{O}(x_i, z_i)]$. The results for this experiment are plotted in Figure 7. As can be seen, the gains are quite sizeable. On average, a country could increase its GDP by 31 percent, and TFP by 10 percent. The country with the worst financial system, Uganda, would experience a 140 percent rise in output. Its TFP would increase by 30 percent. While sizeable, these gains in GDP are small relative to the increase that is needed to move a country onto the frontier for income, $\mathbf{O}(\overline{x}, \overline{z})$. The percentage of the gap that is closed by a movement to best financial practice is measured by $100 \times [\mathbf{O}(x_i, \overline{z}) - \mathbf{O}(x_i, z_i)]/[\mathbf{O}(\overline{x}, \overline{z}) - \mathbf{O}(x_i, z_i)] \equiv 100 \times \mathbf{G}(x_i, z_i)$. Figure 7 plots the reduction in this gap for the countries in the sample. The average reduction in this gap is only 17 percent. For most countries the shortfall in output is accounted for by a low level of total factor productivity in the non-financial sector.

Therefore, the importance of financial intermediation for economic development depends on how you look at it. World output would rise by 65 percent by moving all countries to the best financial practice—see Table 5. This is a sizeable gain. Still, it would only close 36 percent of the gap between actual and potential world output. Dispersion in cross-country output would fall by about 19 percentage points from 77 percent to 58 percent. Financial development explains about 27 percent of cross-country dispersion in output by this metric.

TABLE 5: WORLD-WIDE MOVE TO BEST FINANCIAL PRACTICE, $\overline{z}$

| | |
|---|---|
| Increase in world output (per worker) | 65% |
| Reduction in gap between actual and potential world output | 35.6% |
| Increase in world TFP | 17.4% |
| Fall in dispersion of ln(output) across countries | 27.2% ( $\simeq$ 111.4% - 84.2%) |
| Fall in (pop-wghtd) mean of (cap-wghtd) distortion | 20.8% ($\simeq$ 23.4% - 2.6%) |
| Fall in (pop-wghtd) mean dispersion of (cap-wghtd) distortion | 13.5% ($\simeq$ 14.6% - 1.1%) |

Restuccia and Rogerson (2008) started a literature about the importance of idiosyncratic distortions that create heterogeneity in the prices faced by individual producers. Although they do not identify the sources of those distortions, they show they can generate differences in TFP in the range of 30 to 50 percent. Guner et al. (2008) analyze the impact that size-dependent policies, such as the restrictions on retailing in Japan favoring small stores, can have in an economy. Here, the presence of informational frictions causes the expected marginal product of capital, $\pi_1 r_1 + \pi_2 r_2$, to deviate from its user cost, $\widetilde{r}$. The distortion is modelled endogenously. Define the induced distortion in investment by $d = \pi_1 r_1 + \pi_2 r_2 - \widetilde{r}$. For a country such as Uganda these deviations are fairly large. Figure 8 plots the distribution of the distortion across plants for Luxembourg and Uganda. As can be seen, both mean level of the distortion and its dispersion are much larger in Uganda than they are in Luxembourg.

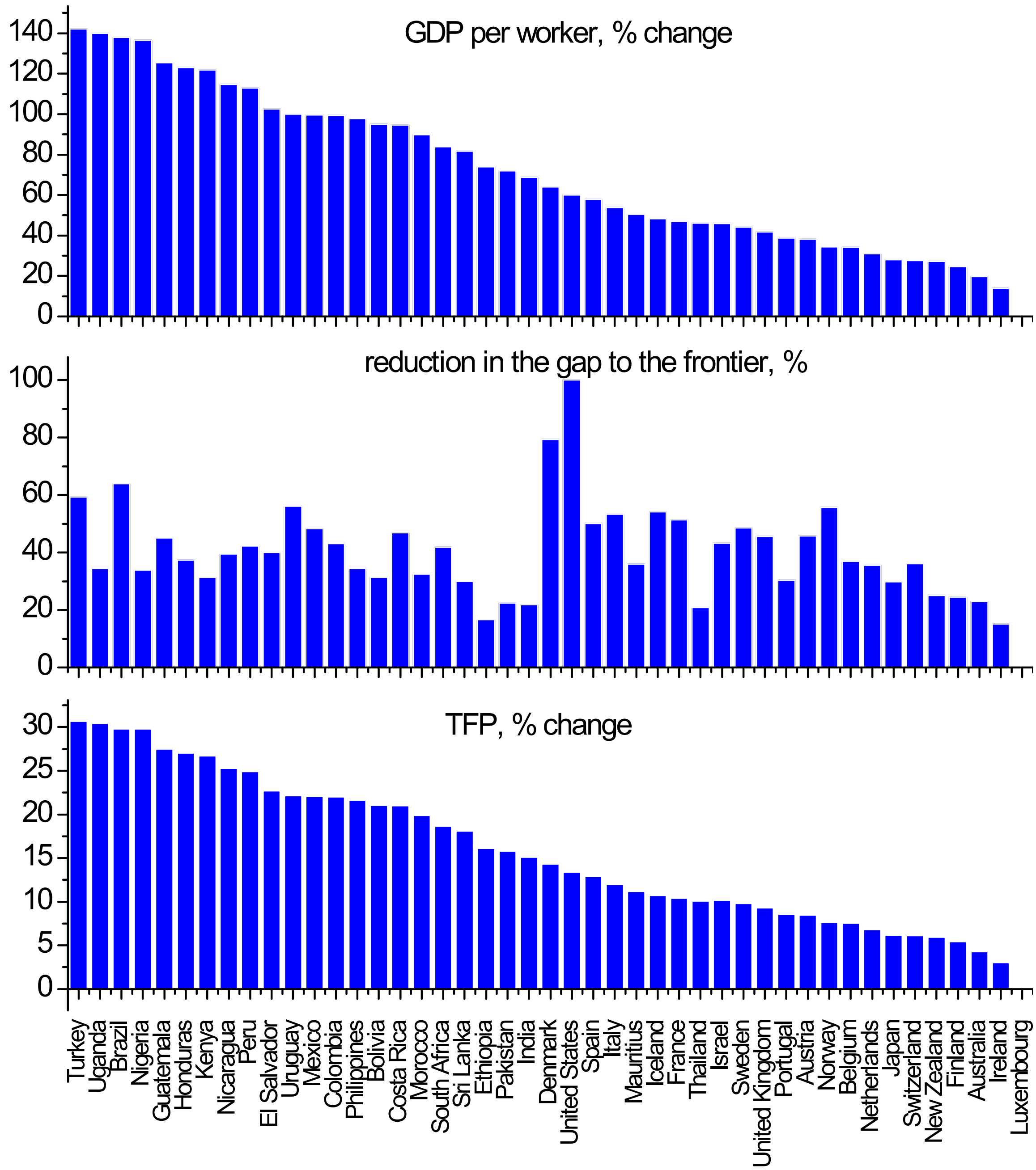


Figure 7: Cross-country results: The impact of a move to financial best practice on GDP, the output gap and TFP

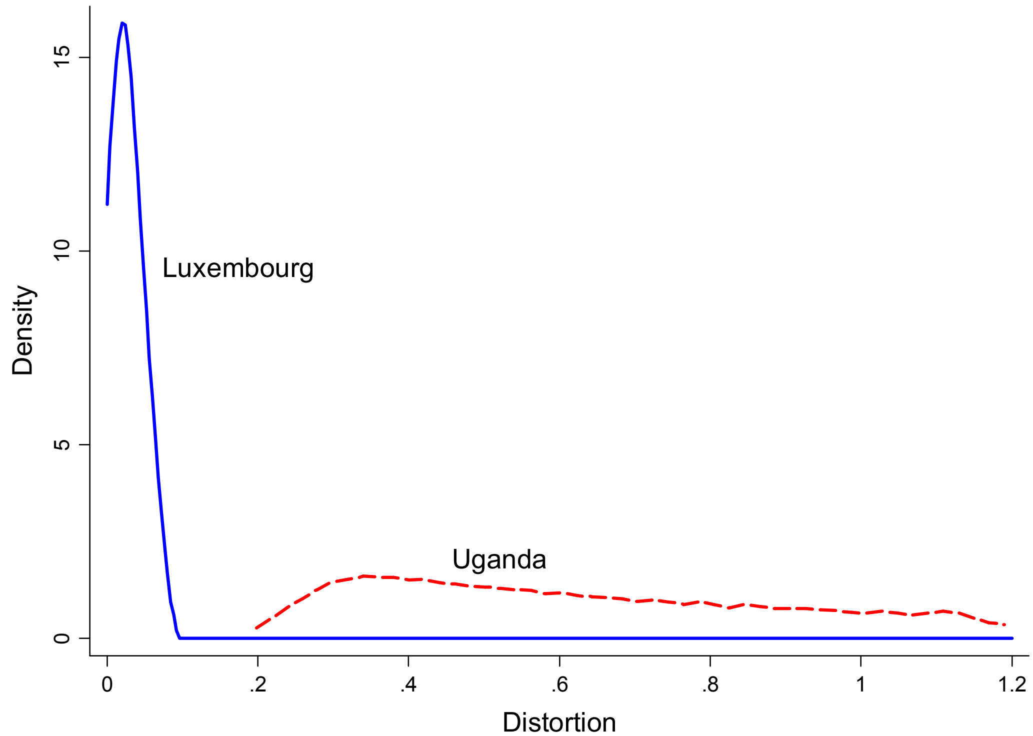


Figure 8: The distribution of distortions across establishments for the Luxembourg and Uganda–the model

The (capital-weighted) mean level of this distortion is 49.8 percent (4.6 percent) for Uganda (Luxembourg). It varies across plants a lot, as indicated by a coefficient of variation of 32.7 percent (1.94 percent). If Uganda adopted Luxembourgian financial practices the average size of this distortion would drop to 1.4 percent. Its standard deviation across plants collapses from 9 percent to just 0.3 percent. The elimination of this distortion results in capital deepening among the active plants. Average TFP would rise by 26 percent in the model, as inefficient plants are culled. For the world at large, the average size of the distortion is 23.4 percent, with an average coefficient of variation of 14.6 percent. The mean distortion drops to 2.6 percent with a world-wide movement to best financial practice. The average standard deviation across plants falls from 14.6 percent to a mere 1.1 percent.

Finally, the model predicts that larger firms should be found in countries with more developed financial systems. It is hard to come up with a comparable dataset for many countries. Beck et al. (2006) argue that the best available alternative is to use the size of the largest 100 companies. They find that there exists a positive relationship between the development of a country's financial system and firm size, after controlling for the size of the economy, income per capita and several firm and industry characteristics. As an example, their estimation implies that if Turkey had the same level of development in the financial sector as Korea (a country with a more developed financial system), the average size of the largest firms in Turkey would more than double.

On this, imagine running a regression of the following form for both the data and the model:

$$\ln(size) = constant + \eta \times spread + \iota \times controls.$$

Firm size in the data is measured by average annual sales per firm (in \$U.S.) for the top 100 firms, as taken from Beck et al. (2006). For the analogue in the model, simply use a country's GDP divided by the measure of active set $\mathcal{A}$ to obtain output per firm. Once again the data for interest-rate spreads are obtained from Beck et al. (2000, 2001). Controls are added for a country's GDP and population in the regression for the data, while for the model they are just added for GDP.[12] The same list of countries is used for both the data and model.

The upshot of the analysis is shown in Table 6. A negative relationship is found in the cross-country data between the interest-rate spread and average firm size. The model also produces a negative relationship between these variables. The similarity between the size of interest-rate spread coefficient, $\eta$, for the data and model is reassuring. Additionally, the data estimate of $\eta = -0.16$ implies that if a country with an interest-rate spread of 10 percentage points (which is among the worst 5 percent of nations in terms of financial

[12] The idea here is that larger countries, as measured by income or population, would tend to have larger firms. In a frictionless world firms could locate anywhere, so there would be no need for such a connection to hold. Nontraded goods, productivity differences across countries, restrictions on trade, transportations costs, etc., would all lead to a positive association between average firm size on the one hand and income or population on the other.

development) could reduce its spread to just 1 percentage point (which would place it in the upper 5 percent of countries), then the average size of its top 100 firms would increase by 144 percent. This is roughly in accord with the Beck et al. (2006) finding discussed above, given that Turkey had one of the worst financial systems while Korea had one of the best.

Table 6: Cross-Country Firm-Size Regressions

| | *Data* | *Model* |
|---|---|---|
| Interest-rate spread coefficient, $\eta$ | -0.16 | -0.19 |
| Standard error for $\eta$ | 0.07 | 0.03 |
| Number of country observations | 29 | 29 |
| $R^2$ | 0.51 | 0.93 |

# 9 Robustness Analysis

## 9.1 Intangible Investments and Capital's Share of Income

Suppose part of investment spending is undertaken in the form of intangible capital. As a result, measured investment may lie below true investment. This will lead to measured income, GDP, falling short of true output, **o**. This injects an upward (a downward) bias in the measurement of labor's (capital's) share of income. Specifically, in context of the standard neoclassical model, with a Cobb-Douglas production function, measured labor's share of income, LSI, will appear as

$$\text{LSI} = \frac{\mathbf{o}}{\text{GDP}} \times (1-\alpha) > (1-\alpha).$$

Corrado et al. (2007) estimate the amount of intangible investment that was excluded from measured GDP from 1950 to 2003. They show that when output is adjusted to include these unrecognized intangibles, true output, **o**, is 12 percent higher than measured output, GDP, for the period 2000-2003. As a consequence, it is easy to calculate that

$$\alpha = 1 - \frac{\text{GDP}}{\mathbf{o}} \times \text{LSI} = 1 - \frac{1}{1.12}(1-0.33) = 0.41.$$

How does this larger estimate for capital's share of income affect the analysis?

The calibration procedure described by P(3) is redone for the case where $\alpha = 0.41$. The results are in accord with those obtained earlier. The model again fits the U.S. data well. In particular, it matches the firm-size distributions for 1974 and 2004 extremely well. With no financial innovation, U.S. GDP would have risen by about 1.77 percent a year, compared with its actual rise of 2.0 percent. Hence, financial development accounts for about 40 percent of the growth in GDP. For Taiwan about 60 percent of growth is due to financial development.

Financial intermediation is now more important for economic development. World output would increase by 88 percent, as opposed to the 65 percent found earlier, if all countries moved to the best financial practice. There is also a bigger impact on TFP. As a result, suboptimal financial practices now make up a larger fraction of the output gap. A more detailed breakdown of the results is displayed in the Appendix, Figure 9.

Table 7: World-Wide move to best financial practice, $\overline{z}$

$\alpha = 0.41$ (intangible capital)

| | |
|---|---|
| Increase in world output (per worker) | 88.2% |
| Reduction in gap between actual and potential world output | 43.5% |
| Increase in world TFP | 33.1% |
| Fall in dispersion of ln(output) across countries | 34.4% ( $\simeq$ 111.4% - 77.0%) |

## 9.2 Varying the Degree of Substitutability between Capital and Labor

Let output be produced according to a CES production function of the form

$$o = [\alpha k^{\lambda} + (1-\alpha)(x\theta l)^{\lambda}]^{\frac{1}{\lambda}}, \text{ with } \lambda \leq 1.$$

This production function will have implications for how labor's share of income, LSI, will vary across countries. To see this, think about the one-sector growth model. Here labor's share of income can be written as LSI$= (w/l)/(w/l + rk) = 1/[1 + (r/w)(k/l)]$. Therefore, labor's share will rise whenever $(r/w)(k/l)$ falls. With the above production function, $\xi = 1/(1-\lambda)$ represents the elasticity of substitution between capital and labor. Hence, in response to a shock in some exogenous variable, $z$, it will happen that $d\ln(r/w)/dz = -(1/\xi)d\ln(k/l)/dz$. If the shock induces capital deepening $[d\ln(k/l)/dz > 0]$ then labor's share will rise or fall depending on whether the elasticity of substitution is smaller or bigger than one.[13] In the cross-country data, labor's share either rises slightly or remains constant with per-capita income. This suggests that for the quantitative analysis, $\lambda$ should be restricted so that $1/(1-\lambda) < 1$, which implies $\lambda < 0$; i.e., capital and labor are less substitutable than Cobb-Douglas.

Let $\lambda = -0.38$, roughly in line with Pessoa et al. (2005). The calibration procedure described above is redone for this value for $\lambda$. The CES framework does not fit the U.S. firm-size distributions for 1974 and 2004 nearly as well as the Cobb-Douglas case. In fact, if one allowed for $\lambda \leq 0$ to be freely chosen in the calibration procedure, then a value close to zero (Cobb-Douglas) would be picked. For the U.S. economy, the CES specification predicts a rise in labor's share from 69.5 to 70.2 percent as the economy grows. The model with a CES production function has a difficult time matching the observed large variation in cross-country interest-rate spreads. Specifically, it cannot match the very high interest-rate spreads observed for some countries.[14] All in all, both the U.S. and cross-country data prefer the Cobb-Douglas specification. With a CES production structure world output would increase by 32 percent, if all countries move to best financial practice. This is lower than the Cobb-Douglas case for two reasons. First, the model cannot match the high interest-rate spreads for some nations. This limited the gain that these countries could realize by a move to best financial practice. Second, the potential for capital deepening is more limited the higher the degree of complementarity between capital, which is reproducible, and labor, which is fixed, in production.

[13] That is, $r/w$ will decrease by more (less) than $k/l$ rises when the elasticity of substitution is smaller (greater) than one.

[14] See footnote 10.

## 10 Conclusions

So, how important is financial development for economic development? To address this question, a costly state verification model is taken to both U.S. and cross-country data. The model has two unique features. First, financial intermediaries choose how much resources to devote to monitoring their loan activity. The odds of detecting malfeasance are a function of this. They also depend upon the technology used in financial sector. Second, each firm faces a distribution of returns. Furthermore, there is an economy-wide distribution across firms over these firm-specific distributions. These two features lead to a financial theory of firm size. The framework is calibrated to fit the U.S. firm-size distributions for 1974 and 2004, as well as the observed intermediation spreads on loans.

The analysis suggests that financial intermediation is important for economic development. In particular, about 30 percent of U.S. growth can be attributed to technological improvement in financial intermediation. Since there was little change in the U.S. interest-rate spread, it appears that technological progress in the financial sector was in balance with technological advance in the rest of the economy. Roughly 50 percent of Taiwanese growth could be attributed to financial innovation. Given the dramatic decline in the Taiwanese interest-rate spread, technological progress in the financial sector may have outpaced that elsewhere.

The model's predictions for the efficiency of financial intermediation in a cross-section of 45 countries matches up well with independent measures. It does a reasonable job mimicking cross-country capital-output ratios. The average measured distortion in the world between the expected marginal product of capital and its user cost falls somewhere between 17 and 21 percentage points. The average coefficient of variation in the distortion within a country is 28 to 29 percent. World output could increase somwhere between 65 and 88 percent if all countries adopted the best financial practice in the world. Adopting this practice leads to funds being redirected away from inefficient firms toward more productive ones. This reallocation effect is reflected by a rise in world TFP by 17 to 33 percent. Still, this only accounts for 36 to 45 percent of the gap between actual and potential world output. This happens because the bulk of the differences in cross-country GDP are explained by the huge differences in the productivity of the non-financial sector.

# 11 Data Appendix

- *Figure 1*: For the United States, the spread is computed along the lines of Mehra et al. (2009). Specifically, the spread is defined to be "Intermediation Services associated with household borrowing and lending" divided by "Total Amount Intermediated" (see definitions of these below). The "Intermediation Services associated with household borrowing and lending" is computed as "Interest Paid" minus "Interest Received" minus "Services Furnished by financial intermediaries without payment Interest Paid." These numbers are taken from the National Income and Product Accounts [NIPA, Tables 7.11 (lines 4 and 28) and 2.4.5 (lines 89 and 108)]. The "Total Amount Intermediated" is taken from the Flow of Funds account (2000, Table B.100b.e.) This number is Assets (line 1) minus Tangible Assets (line 2). For Taiwan, the spread is obtained from Lu (2008). The initial capital-to-output ratio in each country was normalized to one (to control for different definitions of the capital stock).

- *Figure 2, Figure 3* and *Section 8:* The cross-country data for the interest-rate spreads are taken from the Financial Structure Dataset, assembled by Beck et al. (2000, 2001) and revised in January 2009. It is defined as the accounting value of banks' net interest as a share of their interest-bearing (total earning) assets averaged over 1997 to 2003. The numbers for the financial development measure are obtained from the same dataset. They represent demand, time and saving deposits in deposit money banks as a share of GDP, and are also averaged over 1997 to 2003. The other numbers derive from the Penn World Tables (PWT), Version 6.2—see Heston et al. (2002). The capital stock for a country, $k$, is computed for the period 1955-2003 sample period. The starting value is computed using the formula $k = i/(g+\delta)$, where $i$ is gross investment (rgdpl*pop*ki in the PWT's notation), $g$ is the growth rate in investment, and $\delta$ is rate of depreciation. The depreciation is taken to be 0.06. For the starting value, $i$ and $g$ are the average over the first five years available for each country (in general 1950 to 1954). From there on, a time series is constructed for each country using $k_t = k_{t-1}(1-\delta) + i_t$. Again, the numbers used correspond to the average over 1997 to 2003. A country's total factor productivity, $TFP$, was computed using the formula $TFP = (y/l)/(k/l)^{\alpha}$, where $y$ is GDP, $l$ is aggregate labor, and $\alpha$ is capital's share of income. A value of 0.35 was picked for $\alpha$.

- *Figure 5 (Firm size)*: The data are for establishments. They come from County Business Patterns (CBP), which is released by the U.S. Census Bureau annually. Due to a significant shift in the methodology employment by the Census from 1974 on, data are only used for this time period. The horizontal axis orders establishments (from the smallest to highest) by the percentile that they lie in for employment. The vertical axis shows the cumulative contribution of this size of establishment to the employment in the U.S. economy. Some data are shown below.

Table 8: U.S. Establishment-Size Distribution Data, 1974 & 2004

| | Establishments with number of workers between: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Series | 1-4 | 5-9 | 10-19 | 20-49 | 50-99 | 100-249 | 250-499 | 500-999 | 1000 + |
| Year 1974 | | | | | | | | | |
| Establishments (# in 1,000's) | 2,411 | 739 | 463 | 309 | 103 | 55.9 | 17.5 | 7.61 | 4.39 |
| Employees (# in 1,000's) | 4,591 | 5,222 | 6,582 | 9,714 | 7,223 | 8,615 | 6,112 | 5,286 | 10,153 |
| Establishments | 59% | 18% | 11% | 7.5% | 2.5% | 1.4% | 0.5% | 0.2% | 0.1% |
| Employees | 7.2% | 8.2% | 10% | 15% | 11% | 14% | 9.6% | 8.3% | 16% |
| Year 2004 | | | | | | | | | |
| Establishments (# in 1,000's) | 4,019 | 1,406 | 933 | 637 | 218 | 122 | 31.3 | 11.5 | 6.83 |
| Employees (# in 1,000's) | 6,791 | 9,311 | 12,598 | 19,251 | 15,037 | 18,314 | 10,662 | 7,815 | 15,295 |
| Establishments | 54% | 19% | 13% | 8.6% | 3.0% | 1.7% | 0.4% | 0.2% | 0.1% |
| Employees | 5.9% | 8.1% | 11% | 17% | 13% | 16% | 9.3% | 6.8% | 13% |

Source: County Business Patterns (CBP).

- *Figure 6 (relationship between* $\ln z$ *and some other variables)*: Data for the "rule of law" are taken from the World Bank's "Aggregate Governance Indicators, 1996-2008"—see Kaufmann et al. (2009). Data on personal computers are obtained from the World Bank publication *Information and Communications for Development 2009: Extending Reach and Increasing Impact.* The numbers for the financial development measure and the ratio of overhead costs to assets are available in the revised version of the Beck et al (2000) dataset mentioned above. Last, average years of education is based on Barro and Lee (2001).

Table 9: Cross-Country numbers, data and model

| *Country* | *Data* | | | *Model* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Benchmark | | | Counterfactual | | | | | | |
| | K/Y | Spread | GDPpc | x | ln(z) | K/Y | GDPpc | Spread | ΔGDP | ΔGap | ΔTFP | Δd |
| Uganda | 0.28 | 0.101 | 1043 | 0.03 | -2.62 | 0.59 | 4228 | 0.003 | 1.40 | 0.34 | 0.30 | 0.48 |
| Ethiopia | 0.37 | 0.031 | 705 | 0.01 | -1.05 | 1.42 | 1478 | 0.002 | 0.74 | 0.17 | 0.16 | 0.15 |
| Nigeria | 0.61 | 0.096 | 1086 | 0.03 | -2.50 | 0.62 | 4256 | 0.003 | 1.37 | 0.34 | 0.30 | 0.46 |
| Guatemala | 0.75 | 0.091 | 3786 | 0.07 | -1.17 | 0.65 | 13264 | 0.005 | 1.25 | 0.45 | 0.27 | 0.42 |
| El Sal. | 0.90 | 0.064 | 4706 | 0.07 | -0.38 | 0.86 | 13140 | 0.005 | 1.03 | 0.40 | 0.23 | 0.29 |
| Costa Rica | 0.95 | 0.060 | 8093 | 0.09 | 0.26 | 0.90 | 20859 | 0.006 | 0.95 | 0.47 | 0.21 | 0.27 |
| S. Africa | 1.00 | 0.049 | 8207 | 0.09 | 0.60 | 1.04 | 18997 | 0.006 | 0.84 | 0.42 | 0.19 | 0.21 |
| India | 1.01 | 0.032 | 2630 | 0.04 | 0.25 | 1.42 | 5235 | 0.003 | 0.69 | 0.22 | 0.15 | 0.14 |
| Mauritius | 1.09 | 0.028 | 14986 | 0.11 | 2.19 | 1.52 | 24821 | 0.007 | 0.50 | 0.36 | 0.11 | 0.11 |
| Bolivia | 1.16 | 0.052 | 2929 | 0.05 | -0.53 | 1.00 | 7579 | 0.004 | 0.95 | 0.31 | 0.21 | 0.24 |
| Kenya | 1.18 | 0.076 | 1258 | 0.03 | -1.99 | 0.75 | 4251 | 0.003 | 1.22 | 0.31 | 0.27 | 0.36 |
| Pakistan | 1.18 | 0.033 | 2479 | 0.03 | 0.09 | 1.37 | 5089 | 0.003 | 0.72 | 0.22 | 0.16 | 0.15 |
| Sri Lanka | 1.22 | 0.043 | 3967 | 0.05 | 0.13 | 1.16 | 8980 | 0.004 | 0.82 | 0.30 | 0.18 | 0.19 |
| Morocco | 1.28 | 0.049 | 3835 | 0.05 | -0.16 | 1.05 | 9421 | 0.004 | 0.90 | 0.32 | 0.20 | 0.22 |
| Nicaragua | 1.34 | 0.075 | 3337 | 0.06 | -0.99 | 0.76 | 10514 | 0.004 | 1.15 | 0.39 | 0.25 | 0.35 |
| Colombia | 1.35 | 0.062 | 6092 | 0.08 | -0.09 | 0.88 | 16455 | 0.006 | 0.99 | 0.43 | 0.22 | 0.28 |
| Philipp. | 1.52 | 0.056 | 3565 | 0.05 | -0.45 | 0.95 | 9475 | 0.004 | 0.98 | 0.34 | 0.22 | 0.26 |
| Honduras | 1.65 | 0.082 | 2273 | 0.05 | -1.52 | 0.70 | 7780 | 0.004 | 1.23 | 0.37 | 0.27 | 0.39 |
| Turkey | 1.65 | 0.127 | 5559 | 0.10 | -1.30 | 0.49 | 23021 | 0.007 | 1.42 | 0.59 | 0.31 | 0.59 |
| Ireland | 1.85 | 0.012 | 24344 | 0.11 | 4.28 | 2.33 | 27968 | 0.007 | 0.14 | 0.15 | 0.03 | 0.02 |
| Uruguay | 1.86 | 0.069 | 10269 | 0.11 | 0.27 | 0.81 | 27904 | 0.007 | 1.00 | 0.56 | 0.22 | 0.30 |
| Mexico | 1.97 | 0.065 | 7776 | 0.09 | 0.09 | 0.85 | 21049 | 0.006 | 1.00 | 0.48 | 0.22 | 0.29 |
| Brazil | 2.03 | 0.123 | 7067 | 0.11 | -1.02 | 0.50 | 28070 | 0.007 | 1.38 | 0.64 | 0.30 | 0.57 |

(Table 9, continued)

| *Country* | *Data* | | | *Model* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Benchmark | | | Counterfactual | | | | | |
| | K/Y | Spread | GDPpc | x | ln(z) | K/Y | GDPpc | Spread | ΔGDP | ΔGap | ΔTFP | Δd |
| U.K. | 2.09 | 0.026 | 24400 | 0.14 | 2.82 | 1.59 | 37075 | 0.008 | 0.42 | 0.46 | 0.09 | 0.09 |
| Peru | 2.12 | 0.075 | 4220 | 0.07 | -0.75 | 0.76 | 13052 | 0.005 | 1.13 | 0.42 | 0.25 | 0.34 |
| U.S. | 2.23 | 0.042 | 33524 | 0.20 | 2.28 | 1.17 | 61061 | 0.011 | 0.60 | 1.00 | 0.13 | 0.16 |
| Luxem. | 2.36 | 0.009 | 45830 | 0.16 | 5.40 | 2.56 | 45830 | 0.009 | 0.00 | 0.00 | 0.00 | 0.00 |
| Portugal | 2.40 | 0.022 | 16936 | 0.11 | 2.76 | 1.74 | 24977 | 0.007 | 0.39 | 0.30 | 0.09 | 0.08 |
| N. Zealand | 2.49 | 0.017 | 20605 | 0.11 | 3.43 | 1.99 | 27036 | 0.007 | 0.27 | 0.25 | 0.06 | 0.05 |
| Israel | 2.50 | 0.028 | 21106 | 0.13 | 2.57 | 1.54 | 33398 | 0.008 | 0.46 | 0.43 | 0.10 | 0.10 |
| Iceland | 2.57 | 0.030 | 25071 | 0.15 | 2.57 | 1.45 | 40607 | 0.009 | 0.48 | 0.54 | 0.11 | 0.11 |
| Spain | 2.58 | 0.035 | 19215 | 0.13 | 2.05 | 1.32 | 34266 | 0.008 | 0.58 | 0.50 | 0.13 | 0.13 |
| Sweden | 2.60 | 0.028 | 24582 | 0.14 | 2.72 | 1.54 | 38230 | 0.009 | 0.44 | 0.49 | 0.10 | 0.10 |
| Nether. | 2.62 | 0.020 | 25600 | 0.13 | 3.34 | 1.83 | 34881 | 0.008 | 0.31 | 0.36 | 0.07 | 0.06 |
| Australia | 2.63 | 0.015 | 25993 | 0.13 | 3.95 | 2.13 | 31620 | 0.008 | 0.20 | 0.23 | 0.04 | 0.04 |
| Denmark | 2.64 | 0.043 | 27246 | 0.18 | 2.03 | 1.15 | 51658 | 0.010 | 0.64 | 0.79 | 0.14 | 0.17 |
| Belgium | 2.69 | 0.022 | 24228 | 0.13 | 3.16 | 1.77 | 34089 | 0.008 | 0.34 | 0.37 | 0.08 | 0.07 |
| France | 2.71 | 0.029 | 24537 | 0.15 | 2.61 | 1.48 | 39189 | 0.009 | 0.47 | 0.51 | 0.10 | 0.10 |
| Norway | 2.73 | 0.024 | 32896 | 0.17 | 3.29 | 1.67 | 46414 | 0.009 | 0.34 | 0.56 | 0.08 | 0.07 |
| Italy | 2.74 | 0.033 | 22234 | 0.14 | 2.29 | 1.37 | 38087 | 0.008 | 0.54 | 0.53 | 0.12 | 0.12 |
| Austria | 2.84 | 0.025 | 26433 | 0.15 | 3.01 | 1.65 | 38748 | 0.009 | 0.38 | 0.46 | 0.08 | 0.08 |
| Thailand | 3.09 | 0.022 | 6659 | 0.06 | 1.86 | 1.76 | 10562 | 0.004 | 0.46 | 0.21 | 0.10 | 0.09 |
| Finland | 3.11 | 0.016 | 22207 | 0.12 | 3.59 | 2.04 | 28434 | 0.007 | 0.25 | 0.24 | 0.05 | 0.05 |
| Switzer. | 3.67 | 0.019 | 28363 | 0.14 | 3.54 | 1.88 | 37403 | 0.008 | 0.28 | 0.36 | 0.06 | 0.05 |
| Japan | 3.74 | 0.018 | 23818 | 0.12 | 3.45 | 1.92 | 31533 | 0.008 | 0.28 | 0.30 | 0.06 | 0.05 |

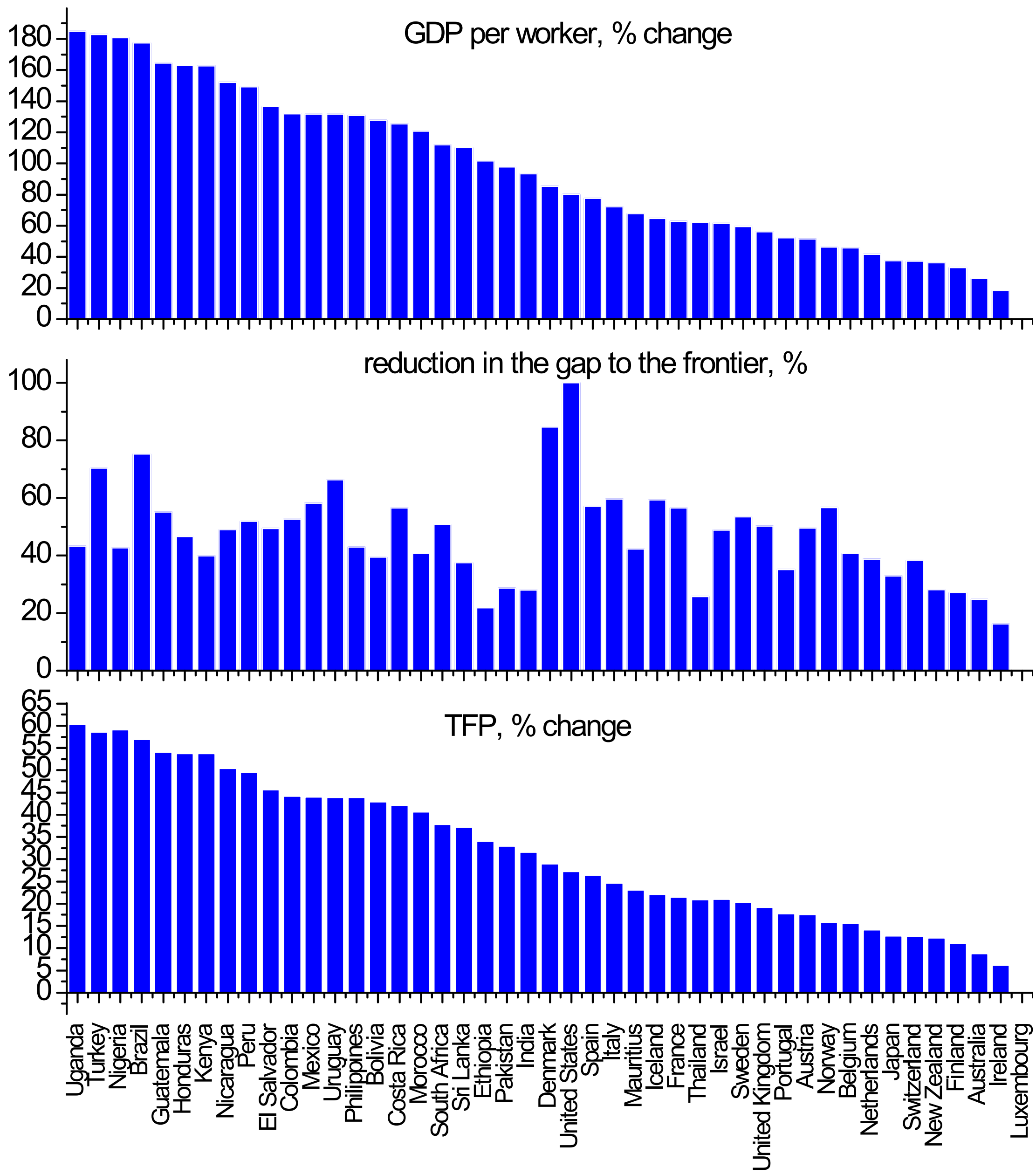


Figure 9: Cross-country results with intangible capital, $\alpha = 0.41$

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