

Costly Intermediation and the Poverty of Nations¹

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Abstract

Distortions in private investment due to credit frictions, and in public investment due to corruption and bureaucratic inefficiencies, have both been suggested as important factors in accounting for the cross-country per capita income distribution. We introduce two modifications to the standard one-sector neoclassical growth model to incorporate these distortions. The model is calibrated using data from 79 countries to examine the quantitative implication of these margins. We find that financial frictions account for less than 2% of the cross-country variation in relative income. Even accounting for mismeasurement, financial frictions can typically explain less than 5% of the income gap between the five richest and the five poorest countries in the world. Distortions in the public investment process, on the other hand, seem more promising. There is both more variation in the measured value of the public capital distortion and it can account for more than 25% of the income gap between the richest and poorest countries in our sample.

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1 Introduction

The evidence on cross-country per capita income from the last forty years suggests that, contrary to the prediction of the simple version of the neoclassical growth model, income levels have not converged. A large related literature has noted the importance of credit market frictions, financial development, and distortions in the provision of public capital in explaining patterns of growth and development in the modern era as well as historically. The primary aim of this paper is to incorporate these distortions into a microfounded model so as to generate sustained differences in per capita income across nations, and then evaluate the quantitative potential of these margins in explaining the world income distribution.

We introduce two key modifications to the standard neoclassical model. First, private investment is subject to agency costs due to informational asymmetries in the credit market. This distorts households' consumption-savings decision, inducing cross-country dispersions in steady-state incomes. Second, productive public capital in our model requires intermediation by public agents, a service for which they have to be compensated. This leakage of tax revenues directly reduces steady-state output. We calibrate these distortions using cross-country data and generate predictions for income differences across countries. To the best of our knowledge, this is the first paper to provide a quantification of these two distortions.

We find that credit frictions account for barely 2% of the observed cross-country income variance. This margin is also unable to account for the huge income gaps observed in the data. The model implies that in order for the credit friction margin to explain the income gap between the five richest and five poorest countries in our sample, the spread between the lending and deposit rates in the poorest countries must be an astounding 355%! The lending spread required to explain even 5% of this income gap is a high 47%. In this sense, the credit friction margin accounts for less than 5% of the income gap between the richest and poorest countries. Since our model requires all investment to be intermediated through external finance, even these numbers are probably overstatements.

Our results are relatively more encouraging for the public investment distortion. The explanatory power of this margin hinges crucially on the productivity of public capital. Available estimates for the elasticity of output with respect to public capital range from 0.07 to 0.39. Under a conservative estimate of 0.17 for this elasticity, public investment distortions account for only 18% of the cross-country variation in relative incomes. But with elasticity values between 0.24 and 0.3, the model can explain 30-40% of the cross-country income variation. We also find that under an output elasticity of public capital of 0.17, explaining 25% of the income gap between the richest and the poorest countries requires a 96% leakage of tax revenues to non-productive activity. This leakage falls to 90% under an elasticity of 0.24, and 85% under an elasticity of 0.3.

These numbers may seem improbably large at first sight. But, based on our reading of budgetary allocations in some of the poorest countries and accounting for corruption, we find them quite plausible. For instance, Kenya, which is one of the poorest countries in our sample, allocates 85% of its budget to *non-developmental* expenditure, a category that includes wages and salaries and subsidies among other items. Allowing a conservative 5-10% leakage of total spending due to corruption – a pervasive phenomenon in most poor countries, we conclude that public capital distortions can potentially account for 25% or more of the income gap. In concrete terms, a fourth of the income difference between the richest and the poorest five countries corresponds to \$5981. Adding \$5981 to Sierra Leone’s per capita income, the poorest country in our sample, takes it from 5% of Greece’s per capita income to 53%. Hence, we view public investment distortions as being quantitatively important.

We also find that credit frictions in particular, and both frictions in general, seem to be more important in explaining the income distribution across countries *within* an income group rather than across income groups. Thus, in the subset of countries with per capita income at least 50% of the US, half of the income gap between the five richest and five poorest can be accounted for by a lending spread of 10.3% in the poorest countries. We conclude

that financial frictions are likely to be more useful in explaining part of the relative income gaps between countries with *similar* technologies and institutions. But from a quantitative perspective, this margin is not very useful in explaining the, arguably, more challenging question why the US is more than forty times richer than Sierra Leone. To be able to explain gaps of that magnitude, one has to appeal to first order margins such as technological differences.¹

We use as our starting point three key features of the cross-country data. First, as Chari *et al.* (1997), Quah (1997) and others have pointed out, the cross-country dispersion of per capita income has shown no systematic tendency to decline since 1960. Figure 1 illustrates how stable the world relative income distribution has been during 1960-92. Moreover, during this period the richest and poorest countries have, on average, been growing at similar rates: a scatter-plot of per capita income in 1992 against that in 1960 reveals no evidence of convergence (see Figure 2).

A second piece of evidence, captured by Figure 3, is the higher relative price of investment goods in poorer countries. Large and systematic variations in this price have been shown to be important in accounting for income differences across nations (see Jones (1994) and Chari *et al.* (1997)). Growth economists have long deliberated on the role financial institutions play in intermediating investment. Economic historians such as Gerschenkron (1966) cite the importance of financial institutions, arguing that a vibrant banking sector was key to Europe's industrial revolution. More recent work, such as Greenwood and Jovanovic (1990) and Bencivenga and Smith (1991), has analyzed various ways these institutions contribute to industrialization by improving the efficiency of resource allocation. An extensive empirical literature, summarized in Levine (1997), has tested these ideas and concludes that financial

¹These conclusions are not at odds with growth regressions that find financial development to be associated with higher growth and income. The correlation between observed and model-predicted relative income series is 0.60, indicating that there does exist a systematic relationship between credit frictions and relative incomes. The effects are, however, quantitatively small.

development indeed correlates significantly with economic growth.² We read this entire body of work as suggesting that credit frictions in particular, and intertemporal distortions in general,³ are key to understanding cross-country income differences.⁴

The third building block for this paper is provided by two related bodies of work. The first is the empirical literature emphasizing the significant positive effect publicly provided capital has on output (see Eberts, 1986; Aschauer, 1989, 2000; Easterly and Rebelo, 1993; and World Bank, 1994). Economic historians too (Gerschenkron, 1966, for instance), commenting on the industrial revolution, have cited evidence on the role of the state in providing key infrastructure support through investments in roads and railways. The second strand of the literature uncovers empirical support for the negative effects of corruption, bureaucratic inefficiencies and red tape on economic growth. Work along this line can be found in de Soto (1989), Barro (1991), Barro and Sala-i-Martin (1995), and Mauro (1995) among others. Figure 4 shows the relationship between per capita income and the Knack-Keefer index of corruption (lower values correspond to higher degrees of corruption): poorer societies clearly tend to be more corrupt. We interpret this literature as suggesting that productive public capital, and distortions in their provision, are potentially important channels for generating cross-country income dispersions.

In view of the above, we modify the standard one-sector neoclassical growth model along two lines. First, all investment – both private and public – has to be intermediated in our model. Investors who borrow from banks and produce private capital face an idiosyncratic productivity shock that is private information, but may be observed by banks at a cost

²This work also finds an echo in the business cycle literature on credit frictions. See, for example, Bernanke, Gertler and Gilchrist (2000), Carlstrom and Fuerst (1997), and Azariadis and Chakraborty (1999).

³Note that credit market frictions typically affect lending conditions, thereby distorting intertemporal allocations.

⁴As Jones (1994) notes, the relative price of investment goods as measured in the Penn World Tables does not necessarily reflect intertemporal distortions since the measured series is affected by consumption taxes. We interpret the evidence as suggesting how important intertemporal distortions are.

(Townsend, 1979). Costly state verification introduces a wedge between the lending rate charged to investors and the deposit rate received by savers/households, and thereby distorts the relative price of investment away from unity. Since this is an intertemporal distortion, it generates cross-country variation in the steady-state capital-output ratio, over and above variation in steady-state per capita incomes.

Second, we introduce a productive role for public capital as in Barro (1990). Following Glomm and Ravikumar (1994), we assume that non-rival public capital is funded through an optimally chosen uniform tax on wage and capital income. However, public capital has to be intermediated through a public agent, and unlike Barro and Glomm-Ravikumar, this intermediation is costly because of an agency problem. Specifically, by devoting his time to non-productive activities, a public agent can divert some tax revenues for self-consumption. In order to mitigate the potential moral hazard problem, public agents have to be paid wages that are at least as large as the amount they can divert. This pure public consumption generates an additional leakage that reduces the steady-state capital stock and income. However, this is only a static distortion which affects the steady-state income level but leaves the capital-output ratio unchanged. Hence, it is equivalent to changing the level of technology.

The model is calibrated to cross-country data for 1990-97 for a sample of 79 countries. We use the 1990-97 averages from data on net interest rates and central government wages and salaries (as a fraction of total government spending) to calibrate country-specific private and public investment distortions. Assuming that all countries are in steady-state, we generate a predicted value for each country's per capita income relative to the US and compare the statistical properties of this series with those from the actual data. We should note that while we do not have any direct evidence on the resource share of corruption across countries, the correlation between wages and salaries and the Knack-Keefer corruption index is sizeable at -0.53 (Figure 5). Our direct measure of leakage of tax resources, therefore, does partially

pick up some aspects of corruption.

A clarification about our model choice is in order. We adopt the neoclassical paradigm rather than an endogenous growth model for a couple of reasons. First, the post-World War II data displays no systematic pattern of divergence between rich and poor nations, a feature that most endogenous growth models with distortions would not be able to match. Secondly, our measures of private and public investment distortions do not seem to matter for growth rates. Specifically, private capital distortions (as measured by net interest rate data) and public capital distortions (as measured by central government spending on wages and salaries) are only weakly correlated with growth rates of per capita GDP (-0.20 and -0.14 respectively).

The next three sections present the model, the competitive equilibrium and the optimal fiscal policy respectively. Section 5 studies the general equilibrium and steady-state properties of the model while Section 6 presents the calibration methodology and results. The last section concludes.

2 The Model

Our model of costly capital accumulation stays close to the infinite horizon neoclassical framework. The key new element we introduce is intermediation in the production of capital goods. The economy is inhabited by five types of economic agents: final goods producers, households, investors, public agents and banks.

2.1 Final Goods Producers

A unique final consumption good is produced through a technology utilizing raw labor and capital. The distinctive feature of this technology is that it employs two types of comple-

mentary capital goods, private and public capital:

$$Y_t = Ag_t^\lambda K_t^\alpha L_t^{1-\alpha}, \quad \alpha, \lambda \in (0, 1). \quad (1)$$

Here K denotes the aggregate stock of private capital, g denotes public capital per worker, and A is a productivity parameter.⁵ According to this specification, public capital subsumes services like law and order, transportation, and communication facilities that the government provides to the private sector. Although these services improve the efficiency of private production processes, they are pure public goods and external to each firm's production decision.

This implies that while the private technology exhibits constant returns in private capital and labor, there are increasing returns overall. However, labor endowments are fixed in this economy and cannot be augmented by human capital investment. Hence, we rule out the possibility of endogenous growth by restricting output elasticities of the two types of capital to $\alpha + \lambda < 1$.

The private production function may now be expressed in intensive form as:

$$y_t = X_t k_t^\alpha, \quad (2)$$

where we define

$$X_t \equiv Ag_t^\lambda. \quad (3)$$

The representative final goods producer chooses capital and labor to maximize his profits per unit labor:

$$\text{Max}_{\{k_t\}} X_t k_t^\alpha - w_t - R_t k_t, \quad (4)$$

(w_t, R_t) being the vector of prices for labor and private capital. Private inputs are hired in perfectly competitive markets, so that they earn their marginal products in equilibrium.

⁵Since our primary interest lies in studying the determinants of relative steady-state income across countries, we assume, without loss of generality, that A is time invariant.

2.2 Households

Infinitely lived households of unit mass comprise the worker-consumers of this economy. Every period they supply 1 unit of labor inelastically to final goods producers and invest their savings in bank deposits, the only asset available to them.

They maximize their lifetime utility

$$U_0^H = \sum_{t=0}^{\infty} \beta^t \log c_t, \quad (5)$$

subject to period budget constraints

$$c_t + s_t \leq (1 - \tau_t) [w_t + R_t^D s_{t-1}], \quad \forall t = 0, 1, \dots, \infty, \quad (6)$$

taking as given the vector of prices (w_t, R_t^D) . Here s_t denotes a representative household's savings in period- t , τ_t is a proportional tax on income from all sources, and R_t^D is the (gross) return on period- $(t - 1)$ bank deposits paid out at the end of period- t .

2.3 Investors

Private capital is produced by a class of one-period lived agents, also of unit measure, called investment goods producers or, *investors*. These investors are born each period without any endowment of goods or labor time that may be supplied in final goods production. Instead, they are endowed with entrepreneurial skills – the ability to produce capital goods using resources. All investors are *ex ante* identical, producing the same type of capital.

Since investors are born without any resource endowment, the only way they produce capital is through bank-borrowing. At the beginning of period- t , banks have at their disposal savings, s_{t-1} , that were deposited at the end of $t - 1$. These are loaned out to investors who produce capital and rent it out. Investors are expected to pay back their loans at the end of period- t out of their rental incomes.

Consider an investor i who borrows an amount, b_t^i , from the bank at the beginning of period- t and converts it into capital, k_t^i . We assume that all investors are risk-neutral and

maximize their expected utility function:

$$U_t^i = E_t c_t^i \tag{7}$$

subject to a budget constraint,

$$c_t^i \leq R_t k_t^i - R_t^L b_t^i. \tag{8}$$

Here R denotes the rental received on private capital and R^L denotes the loan-rate payable to the bank.

Production of capital goods is characterized by an uncertainty that is resolved only after a loan is taken out.⁶ In particular, each investor uses a stochastic constant returns technology to convert loans into capital:

$$k_t^i = \theta^i b_t^i. \tag{9}$$

The productivity shock θ^i is *privately observed* and distributed identically and independently across investors. We assume that θ^i has an expected value of unity and is drawn from a cumulative distribution function $H(\theta^i)$ defined on the bounded support $\Theta \equiv [\underline{\theta}, \bar{\theta}]$.

An investor realizes her productivity shock after she borrows from a bank. But while she observes her shock, outsiders do not. In fact, outsiders can learn about its value only by paying a cost. Hence, unless lenders are willing to incur verification costs to ascertain project outcomes, investors may renege on loan repayments by under-reporting their capital output. Optimal loan contracts between banks and investors will then have to make certain provisions for project verification. We postpone a discussion of the exact nature of these contracts until later when we analyze financial intermediation.

2.4 Public Agents

Similar to the role performed by investors, a set of *public agents* govern the production of public capital. Also of unit mass, these agents live for only one period. They collect tax

⁶Expectations in (7) are formed with respect to information available at the beginning of period- t , before the investor approaches a bank for a loan.

revenues from households, are paid salaries out of these revenues as they carry out public investment, and consume at the end of the period. Unlike private capital, public capital intermediated in period- t is not available for use until the beginning of period- $(t + 1)$. But the output of public capital is observed costlessly at the end of the period before public agents consume.

What are unobservable, though, are the actions of public agents. Specifically, we assume that these agents have one unit of *indivisible* work time which they can devote to either building public capital or diverting tax revenues for their own consumption. We assume that one unit of time devoted to diversionary activities always succeeds in diverting a fraction, $\rho \in (0, 1)$, of tax revenues for the private consumption of these agents. Outsiders are unable to detect such activities until they observe how much public capital has been produced. Hence, to alleviate this moral hazard and induce agents to produce capital, public agents have to be ensured incentive-compatible wages. In other words, for tax revenues totalling T_t , public agents have to be paid at least ρT_t .^{7,8}

Since there is a continuum of these agents, in equilibrium, government salaries exactly equal ρT_t . Tax revenues, net of intermediation costs, are then converted into public capital using a constant returns technology:

$$g_{t+1} = (1 - \rho)T_t. \tag{10}$$

For ease of analysis, we assume that public capital depreciates fully upon use as does private

⁷Note that we are implicitly assuming that a public agent cannot simultaneously draw a salary and divert a fraction of investment resources.

⁸An alternative way of formalizing the public investment process is to assume that public agents have one unit of labor time which can be supplied either to the market or to public sector employment. Hence, the reservation wage of the public agent is the current wage rate. Unless the agent receives at least this reservation wage he would not supply any labor to the public sector. Under this formulation, the leakage would be ρw , with ρ being interpreted as the ratio of public sector employment to the labor force. This formulation leads to similar analytical results.

capital.

2.5 Banks

As discussed above, costly state verification (CSV) in the production of private capital induces a moral hazard problem in the loan market. Williamson (1987) shows that it is optimal to entrust the function of lending to financial intermediaries, or *banks*, in this environment. By intermediating between borrowers (investors) and savers (households), banks economize on resources spent in verifying project outcomes.

Moreover, by lending to multiple investors at the same time, banks are able to diversify investor-specific risks and guarantee a risk-free return to households. This is possible because they exploit the law of large numbers to predict with certainty the proportion of projects that will go bankrupt every period. Risk-neutral banks maximize their expected returns net of the costs of loan production and operate in a perfectly competitive environment.

2.6 Financial Intermediation

An optimal loan contract between a potential investor and a bank has to recognize the possibility that the investor may misreport project returns since information about that is costly to acquire. Such a loan contract clearly has to make provision for some project verification. At the same time, verification cannot be an optimal arrangement for all states of the productivity shock, since that would be too uneconomical.

In CSV environments such as this and when monitoring is deterministic, Townsend (1979) demonstrates that verification occurs for sure below a critical state, $x \in \Theta$.⁹ Gale and Hellwig (1985) extend the analysis to show that a borrower declares bankruptcy when her realized

⁹Stochastic monitoring does not yield significantly larger gains over deterministic monitoring as Boyd and Smith (1994) show. Moreover, actual debt contracts are seldom as complicated as stochastic monitoring would require.

productivity shock is below x since she is unable to pay the agreed-upon return R^L .¹⁰

When an investor declares bankruptcy under such conditions, we assume that the bank verifies the realized state by spending γ units of *capital* per unit lent. In equilibrium, an investor never declares bankruptcy unless her productivity turns out to be below x , in which case the bank verifies the state, takes over the project, brings it to completion and recoups an amount $Q(\theta)$ from the investment. The recovery amount is essentially the rental income from the project, $R\theta b$.

Should the realized state be above x , the investor remains solvent and is able to pay back the contracted amount, $R^L b$. However, for such behavior to be incentive-compatible, the repayment amount cannot depend upon the actual state θ^i since the bank does not verify in solvent states. Hence, by continuity of the bank's payoff function, the loan amount can only be:

$$R^L b = Q(x) = Rxb. \quad (11)$$

The optimal loan contract can now be characterized by a standard debt contract of the form $\delta = (b, x) \in \mathbf{R}_+^2$ that specifies a loan amount and a critical value of the state space of idiosyncratic shocks. Given an investor's utility function (7), her expected payoff from such a contract is:

$$\begin{aligned} U^i(\delta) &= \int_x^{\bar{\theta}} [R\theta b - R^L b] dH(\theta) \\ &= Rb\mu(x), \end{aligned} \quad (12)$$

where $\mu(x) \equiv \int_x^{\bar{\theta}} \theta dH(\theta) - x[1 - H(x)]$.

Consider now the bank's expected profit from a contract δ . The bank earns a return of $R^L = Rx$ for all states $\theta \in [x, \bar{\theta}]$. For all other states $\theta \in [\underline{\theta}, x]$, the bank's return net of

¹⁰The formalization of the CSV problem closely follows that in Azariadis and Chakraborty (1999).

verification costs is simply $(\theta - \gamma)R$.¹¹ The expected profit function is then:

$$\Pi(\delta) = Rxb \int_x^{\bar{\theta}} dH(\theta) + Rb \int_{\underline{\theta}}^x (\theta - \gamma) dH(\theta) - R^D s, \quad (13)$$

which the bank maximizes subject to its resource constraint

$$b \leq s. \quad (14)$$

An optimal loan contract solves the principal-agent problem where a bank offers contract δ to a potential investor, taking as given the flow of deposits s , the return on bank deposits R^D , and the rental on capital R . In making such an offer, the bank has to recognize an investor's participation constraint. We assume that all investors have an identical reservation utility, \bar{U} . The principal-agent problem can then be stated as:

$$\begin{aligned} & \text{Max}_{\{\delta\}} \Pi(\delta) \\ & \text{subject to (14) and } U^i(\delta) \geq \bar{U}, \end{aligned} \quad (15)$$

where $U^i(\delta)$ and $\Pi(\delta)$ are defined by (12) and (13) above.

2.6.1 The Optimal Loan Contract

To characterize the optimal loan contract, note first that a profit-maximizing bank will clearly lend out as much as it can, so that (14) holds as an equality.

The bank's expected profit function may now be expressed as:

$$\begin{aligned} \Pi(\delta) &= \left[Rx \int_x^{\bar{\theta}} dH(\theta) + R \int_{\underline{\theta}}^x (\theta - \gamma) dH(\theta) - R^D \right] b \\ &= Rb [\sigma(x, \gamma) - q], \end{aligned} \quad (16)$$

where,

$$\begin{aligned} \sigma(x, \gamma) &\equiv \left[x \int_x^{\bar{\theta}} dH(\theta) + \int_{\underline{\theta}}^x (\theta - \gamma) dH(\theta) \right], \\ \text{and, } q &\equiv R^D/R. \end{aligned} \quad (17)$$

¹¹Since verification costs are incurred in units of capital, the bank has to hire γ units of capital per unit lent.

Here σ represents the bank's return (net of auditing costs) relative to the rental on capital. Note that if $\int_{\underline{\theta}}^x (\theta - \gamma) dH < 0$, the loan contract is not renegotiation-proof, as the bank would prefer to abandon bankrupt projects. To rule this out, we assume that γ is small enough, that is, $\gamma \in [0, \bar{\theta}]$. The details of the optimal contract are characterized by Theorem 1 below.¹²

Theorem 1 *Given (R, γ) and the expected investor payoff \bar{U} , the optimal loan contract $\hat{\delta}$ satisfies the following conditions:*

- (i) $\hat{x}(\gamma) = \arg \max_{x \in \Theta} \sigma(x, \gamma)$,
- (ii) $\hat{b} = \bar{U} / R\mu[\hat{x}(\gamma)]$.

Since the banking industry is perfectly competitive, with free entry and exit, maximal bank profits can only be equal to zero in equilibrium. Given our solution $\hat{x}(\gamma)$, this zero profit condition, together with (13), determines the deposit rate, R^D , as a function of the rental rate, R :

$$R^D = \sigma[\hat{x}(\gamma), \gamma] R. \quad (18)$$

Note that $\sigma < 1$ as long as $\gamma > 0$, so that agency costs distort the incentive to save.

To obtain closed-form solutions, we shall henceforth assume that $H(\theta)$ is uniform on $[1 - \varepsilon, 1 + \varepsilon]$, $\varepsilon \in (0, 1)$. Under this assumption, it is easy to check that $\mu(x) = (1 + \varepsilon - x)^2 / 4\varepsilon$ and

$$\sigma(x, \gamma) = [x(1 + \varepsilon - x) + (x - 1 + \varepsilon)\{(x + 1 - \varepsilon)/2 - \gamma\}] / 2\varepsilon. \quad (19)$$

From Theorem 1, the critical state is given by

$$\hat{x}(\gamma) = 1 + \varepsilon - \gamma. \quad (20)$$

¹²The investor's payoff is monotonically decreasing in x , while bank profits are inverted-U shaped. The tangency of $U^i(x)$ with $\Pi(x)$ occurs in the downward sloping part of the latter; both parties would prefer an x lower than the one corresponding to that tangency point. Hence, \hat{x} is given by the maximal point of $\Pi(x)$, with \hat{b} adjusted such that $U^i(\hat{\delta}) = \bar{U}$. Flow of savings in the economy determines \bar{U} in equilibrium.

We impose the condition that $\gamma < 2\varepsilon$ to obtain sensible results. This ensures that states over which verification occurs are of positive measure, that is, $\hat{x} > \underline{\theta}$. As shown in Figure 6, σ falls as ε or γ rise. In other words, the distortion rises with both the variance of the idiosyncratic shock and the cost of verification.

Finally, note that the proportion of investment projects that go bankrupt every period is given by

$$\psi = H[\hat{x}(\gamma)] = 1 - \frac{\gamma}{2\varepsilon}. \quad (21)$$

3 Competitive Equilibrium

Given a tax rate, we shall now characterize and solve for the competitive equilibrium of this economy. Households and firms take the fiscal policy as given in deciding to consume and save. Consider first the representative household's problem of maximizing lifetime utility (5) subject to the budget constraint (6). The first-order condition for this is the familiar Euler equation,

$$\frac{c_{t+1}}{c_t} = \beta(1 - \tau_{t+1})R_{t+1}^D, \quad (22)$$

that equates marginal utility from current consumption to that from future consumption, discounted by the subjective discount factor and adjusted for taxes on interest income.

A representative final goods producer, on the other hand, faces a static maximization problem. At an interior optimum, a firm hires labor and capital to equate marginal products and costs:

$$\begin{aligned} w_t &= (1 - \alpha)X_t k_t^\alpha, \\ R_t &= \alpha X_t k_t^{\alpha-1}. \end{aligned} \quad (23)$$

Using (18) and (23), we obtain the equilibrium return on savings as:

$$R_t^D = \sigma R_t = \alpha \sigma X_t k_t^{\alpha-1}. \quad (24)$$

Banks lend to a large number of investors, predicting with certainty the fraction of bankrupt projects. By the law of large numbers, since the expected value of θ is unity, as much capital

is produced every period as was lent out. However, not all of the capital is available for production of final goods since some of it is spent auditing bankrupt investors. In particular, for every bankrupt project, γ units of capital are ‘lost’ on project verification. Since capital depreciates fully upon use, this implies that

$$k_{t+1} = (1 - \gamma\psi)b_{t+1} = (1 - \gamma\psi)s_t, \quad (25)$$

in equilibrium, where ψ is given by (21) above.

The equilibrium relations (23), (24) and (25) can be used to construct the economy’s period- t resource constraint:

$$c_t + \frac{k_{t+1}}{1 - \gamma\psi} = (1 - \tau_t) [R_t^D s_{t-1} + w_t] = (1 - \tau_t)\nu A g_t^\lambda k_t^\alpha, \quad (26)$$

where $\nu \equiv \alpha\sigma/(1 - \gamma\psi) + (1 - \alpha) < 1$ as long as $\gamma > 0$.

As in Glomm and Ravikumar (1994), we define a competitive equilibrium given an arbitrary fiscal policy $\mathcal{F} = \{\tau_t, g_{t+1}\}_{t=0}^\infty$:

Definition 1 *An \mathcal{F} -competitive equilibrium is a set of allocations $\{c_t, s_t, k_{t+1}\}_{t=0}^\infty$ and prices $\{w_t, R_t^D, R_t\}_{t=0}^\infty$ such that, given (k_0, g_0) ,*

- (i) $\{c_t, s_t\}_{t=0}^\infty$ solves a representative household’s problem, given prices;
- (ii) $\{k_{t+1}\}_{t=0}^\infty$ solves a representative final goods producing firm’s problem given prices; and
- (iii) Markets clear, so that (25) and (26) are satisfied.

We can solve explicitly for the optimal decision rules in an \mathcal{F} -competitive equilibrium.¹³ Assume first that per-capita consumption is proportional to post-tax per capita GDP

$$c_t = \chi(1 - \tau_t)X_t k_t^\alpha. \quad (27)$$

¹³As long as the arbitrary fiscal policy \mathcal{F} is bounded above, the solution obtained below is the unique \mathcal{F} -competitive equilibrium. See Glomm and Ravikumar (1994) for details.

Combining (27) with the equilibrium returns on savings, (24), and the Euler equation, (22), yields the decision rule for capital accumulation:

$$k_{t+1} = \alpha\beta\sigma(1 - \tau_t)X_t k_t^\alpha. \quad (28)$$

Our assumption of a linear decision rule for consumption is verified by using (27) and (28) in (26):

$$\chi = \nu - \alpha\beta\sigma = [(1 - \beta)\alpha\sigma/(1 - \gamma\psi) + (1 - \alpha)]. \quad (29)$$

4 Optimal Fiscal Policy

The optimal decision rules obtained above allow us to solve for the optimal fiscal policy. Denoting by $z(\mathcal{F})$ the value of z in an \mathcal{F} -competitive equilibrium, define an optimal fiscal policy as a sequence $\{\hat{\tau}_t, \hat{g}_{t+1}\}_{t=1}^\infty$ that solves:

$$\text{Max} \sum_{t=0}^{\infty} \beta^t \log c_t(\mathcal{F})$$

subject to:

$$\begin{aligned} g_{t+1} &= (1 - \rho)\tau_t[w_t(\mathcal{F}) + R_t^D(\mathcal{F})s_t(\mathcal{F})], \\ \tau_t &\in [0, 1], \text{ given } (k_0, g_0). \end{aligned}$$

For analytical simplicity, we restrict ourselves to an equilibrium where the tax rate is time-invariant. In that case, the optimal tax rate $\hat{\tau}$ is chosen to maximize the value function and is given by (see Appendix 1 for details)

$$\hat{\tau} = \lambda\beta. \quad (30)$$

This uniform tax rate effectively equates the proportion of national income invested in public capital to the discounted marginal contribution of that capital. The subjective discount rate factors in since public capital is utilized with a lag of one period. Note also that the optimal tax rate is independent of public intermediation costs as well as distortions in private sector investment.

5 General Equilibrium Analysis

Combining the optimal tax rate from (30) with the production function for public capital (10) and the decision rule (28), we can characterize the general equilibrium of this economy by a set of difference equations

$$k_{t+1} = (1 - \lambda\beta)\alpha\beta\sigma Ag_t^\lambda k_t^\alpha, \quad (31)$$

$$g_{t+1} = (1 - \rho)\lambda\beta\nu Ag_t^\lambda k_t^\alpha. \quad (32)$$

Note that (31) and (32) imply the ratio of public to private capital is constant along the saddle-path equilibrium:

$$\frac{g_t}{k_t} = (1 - \rho) \left(\frac{\lambda\beta}{1 - \lambda\beta} \right) \frac{\nu}{\alpha\beta\sigma} \equiv \phi. \quad (33)$$

Thus, the general equilibrium may be characterized by a single difference equation in capital per worker:

$$k_{t+1} = (1 - \lambda\beta)\alpha\beta\sigma A\phi^\lambda k_t^{\alpha+\lambda}. \quad (34)$$

This monotonically increasing policy function allows us to obtain closed-form solution for the steady-state income level and compare it across nations that differ only in intermediation costs of capital.

5.1 Steady-State Comparisons

Since $\alpha + \lambda < 1$ by assumption, equation (34) possesses a unique asymptotically stable steady-state given by

$$\bar{k} = [(1 - \lambda\beta)\alpha\beta\sigma A\phi^\lambda]^{1/[1-(\alpha+\lambda)]}. \quad (35)$$

By substituting (33) into the private production function (2), we can relate per capita GDP solely to per capita private capital,

$$y_t = Ag_t^\lambda k_t^\alpha = A\phi^\lambda k_t^{\alpha+\lambda}.$$

Using equation (33) and the expression for the steady state capital stock in the above, gives steady-state per capita income as

$$\bar{y} = \Omega \left[(1 - \rho)^\lambda \sigma^\alpha \left\{ \alpha \sigma / (1 - \gamma \psi) + (1 - \alpha) \right\}^\lambda \right]^{1/[1-(\alpha+\lambda)]}, \quad (36)$$

where

$$\Omega \equiv \left[A(\lambda\beta)^\lambda (1 - \lambda\beta)^\alpha (\alpha\beta)^\alpha \right]^{1/[1-(\alpha+\lambda)]}.$$

Consider now two countries that differ only in their intermediation costs, that is in $(\gamma, \varepsilon, \rho)$. Their ratio of steady-state per capita incomes is given by

$$\frac{\bar{y}'}{\bar{y}} = \left[\left(\frac{1 - \rho'}{1 - \rho} \right)^\lambda \left(\frac{\sigma'}{\sigma} \right)^\alpha \left(\frac{\alpha \sigma' / (1 - \gamma' \psi') + 1 - \alpha}{\alpha \sigma / (1 - \gamma \psi) + 1 - \alpha} \right)^\lambda \right]^{1/[1-(\alpha+\lambda)]}. \quad (37)$$

Equations (35) and (37) imply that steady-state capital stocks as well as income ratios across countries are functions of both types of distortion – ρ and σ . Since σ is a function of the variance of the idiosyncratic shock ε , and the cost of verification γ , both \bar{k} and \bar{y}'/\bar{y} are functions of ρ, ε and γ . Figure 7 reports simulations of the relative income ratio assuming that no distortions exist in the country with a prime (the numerator country), that is, by setting $\rho' = \gamma' = 0$. The relative income ratio is rising in all three parameters, ρ, ε and γ .

Turning now to the implications of the model for steady state capital-output ratios, we can use equations (35) and (36) to get

$$\frac{\bar{k}}{\bar{y}} = (1 - \lambda\beta)\alpha\beta\sigma \quad (38)$$

This implies that in steady state, the relative capital-output ratios across countries with the same preference and technology, i.e., identical α, β and λ , is given by

$$\frac{\bar{k}'/\bar{y}'}{\bar{k}/\bar{y}} = \frac{\sigma'}{\sigma}.$$

Cross-country variations in the steady-state capital-output ratio, in this model, arise solely from distortions to private investment. In other words, intermediation costs in private capital introduce an intertemporal distortion in our model, whereas costs of intermediating public capital are purely static distortions.

6 Calibration

Our calibration exercise quantifies the effect of intermediation costs in private and public capital formation on steady-state incomes. We assume that the world income distribution is in steady-state during 1990-97 and that nations differ solely in their costs of intermediation. Our data comes from the World Development Indicators (World Bank, 2000) and the Financial Structure Database (Beck *et al.*, 1999). The basic exercise is to calibrate the model to the 1990-97 average for the relevant data series, and then compare predicted relative incomes to the actual series, averaged over the same period. We use averages to avoid the usual pitfalls of picking a particular year.

The distortion, ρ , in the provision of public capital, has a direct interpretation in our model as the proportion of total government spending devoted to wage and salary payments. Government employment practices and sizeable presence of the public sector, especially in poorer countries, raise the labor cost of governance as also the scope for corruption. The efficiency with which tax revenues are converted into public capital ought to be, in that case, systematically related to the cost of employing public servants. We therefore feel comfortable assuming that the proportion of government expenditure spent on the wages of these workers reflect costs of intermediating public capital. Accordingly, we calibrate ρ for each country in our sample to its share of total central government expenditure (net of military spending) spent on wages and salaries. The data for this comes from the World Development Indicators.¹⁴

Intermediation costs in private capital formation, on the other hand, depend upon two parameters, ε and γ . These parameters have a distinct prediction in our model for the spread

¹⁴We also experimented with government spending unadjusted for military spending and obtained broadly similar results.

between lending and deposit rates. From (11), (24) and (38), the lending spread is

$$\begin{aligned}\Delta &\equiv i^L - i^D = R^L - R^D \\ &= \sigma R \left[\frac{\hat{x}}{\hat{\sigma}} - 1 \right] = \frac{1}{\beta(1 - \lambda\beta)} \left[\frac{1 + \varepsilon - \gamma}{1 - \gamma + \gamma^2/4\varepsilon} - 1 \right].\end{aligned}$$

The spread Δ is thus a function of two parameters (ε, γ) . However, we have only one data series with which to estimate both. To get around this problem, we postulate a linear specification, $\gamma = a\varepsilon$, and estimate γ from the lending spread data based upon different values for a . Since ε captures the standard deviation of idiosyncratic productivity shocks, θ (variance = $\varepsilon^2/3$), it seems reasonable to assume that verification costs are proportional to ε : the more uncertain the process of converting savings into capital, the greater the costs of ascertaining the true productivity shock.

For the lending spread, we use data on net interest rate from the Financial Structure Database. This variable gives bank net interest income as a fraction of total bank assets, and corresponds exactly to the lending spread in our model. We preferred this series to the lending spread data in the International Financial Statistics (IFS) Yearbook for two reasons. First, the net interest rate series is constructed from microdata on individual banks in each country. Second, the IFS lending spread series reflects mostly prime lending rates and is also often subject to the problem of managed lending rates. This problem is less severe for the net interest rate data.

Finally, our data on per capita income comes from the PPP-adjusted GDP per capita series reported in the World Development Indicators. We express each country's per capita income relative to the US. Table 1 shows statistical properties of the data on the three variables that are of interest to us: relative per capita income, net interest rate series, and central government wages and salaries as a fraction of total government expenditure (ρ). It is important to note that both the net interest rate and ρ are negatively correlated with relative income.

We calibrate the model in two steps. First, we use the average annual value of the

net interest rate for 1990-97 to estimate γ for each country under the assumption $\gamma = a\varepsilon$. The calibrated parameters γ and ρ are then used to predict each country's per capita income relative to the US for that period, assuming that all countries in our sample are on a balanced growth path by 1990. We then compare the resulting series with actual data on relative income.¹⁵

6.1 Baseline Results

To operationalize the model, a few parameter choices need to be made. For the discount rate, the choice of $\beta = 0.94$ is standard in the literature. Choices of the private and public capital share parameters, α and λ , are more problematic. In our model $\alpha + \lambda$ is the income share of a broadly measured capital stock, a number of alternative values for which have been used in the literature. Thus, Barro and Sala-i-Martin (1995) use 0.75, Chari *et al.* (1997) and Mankiw *et al.* (1992) use 0.67, while Parente and Prescott (1994) use 0.71. Since the higher the share of broadly measured capital the greater is the magnification of cross-country distortions, we use the highest reported value for this share in the existing literature, setting $\alpha + \lambda = 0.75$. A number of measures for the public capital share have also been suggested in the literature. An excellent overview of this literature is contained in World Bank (1994). Table 2 summarizes the main estimates that have been proposed. For our baseline case we fix the share at $\lambda = 0.17$.

Table 3 reports calibration results for the baseline model. Column 2 gives the results for all 79 countries in our sample. The correlation of predicted income relative to the US with the actual relative income series is 0.60, while the mean squared error (MSE) of the

¹⁵The model implies that the lending spread and bankruptcy rate are both functions of ε and γ . Recall that the fraction of bankrupt investment projects, or non-performing loans ψ , is given by (21). Given these two equations in (ε, γ) and data on (Δ, ψ) , in principle, we should be able to calibrate both ε and γ for countries in our sample. Unfortunately, this approach cannot be implemented as data on non-performing loans is either unavailable or unreliable for most countries.

predicted series relative to the actual is 0.33. The fifth row of column 2 shows that the ratio of the variance of the model’s relative income to that of actual relative income is 0.21. In this sense, the model can account for 21% of the cross-country variation in relative incomes. Moreover, the lowest relative income that the model generates is 0.49, while it is 0.02 in the data.

The results from the baseline model have a couple of key implications. First, the high correlation between the predicted and actual relative incomes suggests that there is indeed a systematic effect of financial and public capital distortions on cross-country income. Moreover, there is also some support for the structure of the model since the correlation of predicted relative income with actual relative income (0.60) is higher than the correlations with relative GDP of either of the individual series used for calibration (see Table 1).¹⁶

Second, the low variance ratio of the model suggests that there is insufficient variation in the measured distortions – both financial and public capital – to account for observed variations of relative income. Table 4 sheds additional light on this issue by decomposing the total relative income effect of the distortions into its two components. The fourth row reports the ratio of the variance of model-predicted relative income under private capital distortions alone, to that in the data. Credit friction accounts for only 2% of the cross-country income variation. The last row of Table 4 gives the corresponding variance ratio when only public capital distortions operate. For the full sample (column 2), public capital distortion accounts for about 18% of the variance in cross-country relative income, and hence,

¹⁶We should note that our model does generate a relative price of investment goods ($p^I = (1 - \gamma\psi)^{-1}$) which is distorted away from unity. The correlation of this predicted series with the actual relative price of investment goods from the Penn World Tables is 0.29. However, we do not try to calibrate the model to the relative price of investment goods data for two reasons. First, as pointed out earlier, the relative price of investment goods also reflects consumption taxes which are not intertemporal distortions. In the model, on other hand, the only distortion is an intertemporal one. Second, the data for relative investment goods prices does not extend beyond 1992 making comparisons with the model-generated numbers problematic.

accounts for about 90% (18/21) of the income variance generated by the model.

The lower explanatory power of credit frictions is not surprising given the implied estimates for verification costs reported in Table 5. These costs are generally higher for poorer countries as one would expect, and range from 1% to 12% of total investment for the full sample of countries (second column). But its low variability reflects a similar pattern observed in the net interest rate data, and contributes directly to the weak explanatory power of the credit friction channel.

The preceding results indicate that a lot of the observed cross-country variance in relative incomes is not accounted for by the model. One of the key assumptions we have made is that technological efficiency, A , is identical across countries. Casual empiricism suggests that this is violated in the data. Moreover, a number of authors (for instance, Hall and Jones, 1999, and Parente and Prescott, 1994) have pointed out that dispersions in total factor productivity and barriers to technology adoption are fundamental determinants of the world income distribution.

To examine whether differences in technology are accounting for the somewhat indifferent fit of the model in the full sample, we split up countries into four income groups – Rich, Upper-middle, Lower-middle and Poor. In Rich we include countries whose income levels are at least 50% of the US. The Upper-middle consists of countries whose incomes lie between 20% and 50% of the US. The Lower-middle includes countries between 10% and 20% of US per capita income while the Poor consists of countries below 10% of US income. This way of splitting the sample should control for at least part of the technology differences across countries since within-group countries are relatively similar compared to countries across groups. If technology differences were accounting for the low variance ratio and high mean squared error in the full sample then both statistics should improve for each sub-group of countries.¹⁷

¹⁷An alternative and perhaps more direct way of testing the importance of private and public investment distortions would be to compare the model-predicted private and public capital shares to share estimates from

For each group we express income of a country relative to the richest country in that group and compare the group-specific statistics from the model with those from the data. The only exception is the Rich group where we continue to take the US as the numeraire country even though Luxembourg is the richest country in our sample.¹⁸ The last four columns of Tables 3 and 4 show the group specific results. The bracketed terms in the last two rows of Table 3 give the corresponding numbers from the data.

Table 3 shows that indeed, relative to the full sample, the MSE is smaller for all groups while the variance ratio is higher. Hence, within each group, the measured distortions in private and public investment do a better job of explaining the income dispersion. The model does particularly well in accounting for income dispersion among the richest countries ($y/y_{US} > 0.5$). In this group, the correlation between the predicted and the actual relative income series is 0.44, while the variance ratio is 81%. Moreover, the MSE is a remarkably low 0.07, while the maximum and minimum relative incomes generated by the model correspond well with those in the data.

Table 4 shows group-specific variance decompositions. The results here are instructive. Especially noteworthy is the fact that in all groups the public investment margin accounts for more than 80% of the model-predicted cross-country income variation. The net interest rate spread, which measures private investment distortions induced by credit frictions, exhibits very little cross-sectional variance. Hence, it fails to account for much of the dispersion. This

the data. This direct approach has the advantage that factor share measures are not affected by technology. However, there are significant measurement problems associated with estimates of capital stocks, both public and private. Since per capita income is much better measured in the national income accounts we chose to control for technology dispersion by splitting the sample by income. Moreover, in the interest of simplicity, the model has assumed full depreciation of both types of capital. Since this is obviously not true in the data, there would be problems in matching the shares from the model with those from the data even if the theory was working well.

¹⁸Portugal is the richest country in the Upper-middle group, Panama is the richest in the Lower-middle while Indonesia is the richest country in the last group.

is despite the fact that the net interest rate series correlates highly with relative income.

6.2 Parameter Sensitivity of Results

We next turn to the parameter sensitivity of our results. In particular, there are three parameters, α , λ and a , for which we do not have tight estimates. Table 6 reports the implications of varying these parameters for the full sample. Columns 2 and 3 show calibration results for alternative values of a . Recall that we imposed the identifying restriction $\gamma = a\varepsilon$ in order to estimate the two credit friction parameters, γ and ε , from net interest rate data. As Table 6 shows, the results are not sensitive to the proportionality factor a . Lower values of a change the results only marginally relative to the baseline case (see Table 3).

Columns 4-7 of Table 6 show the effect of varying λ . Importantly, in these experiments we keep $\alpha + \lambda = 0.75$. Raising λ implies an offsetting reduction in the share of private capital α so that the share of broadly measured capital is held constant at 0.75. The range over which we vary λ is based on the range of parameter estimates for λ that have been reported in the literature and summarized in Table 2. Increasing λ results in a marginal reduction of the correlation between the predicted and relative income series. But it improves all other statistics significantly. In particular, higher values of λ reduce the MSE, increase the variance ratio and also increase the maximum income disparity that the model generates. Thus, for $\lambda = 0.3$ the MSE drops to 0.27 from 0.33 in the baseline case while the variance ratio rises from 0.21 to 0.43. For $\lambda = 0.4$ (which corresponds to $\alpha = 0.35$, a more conventional measure for the income share of private capital), the model can account for 62% of the cross-country income variation while the MSE is 0.24. Note that for $\lambda = 0.4$, the lowest relative income generated by the model is 0.18 compared to 0.02 in the data.¹⁹

Lastly, the row “Private capital” reports the variance ratio due to credit frictions alone while the row “Public capital” reports the corresponding ratio due solely to public capital

¹⁹The implied maximum size of government, T_t/Y_t , ranges from 0.16 for $\lambda = 0.17$ to 0.38 for $\lambda = 0.40$.

distortions. As we saw earlier, public capital distortions account for most of the cross-country income variation that the model actually generates.

These results suggest to us that relative to the financial friction margin, the public capital distortion appears to be more substantive in accounting for the cross-country income distribution. While the financial friction as measured by the lending spread does not exhibit much cross-country variation, the public capital distortion as measured by the wage share of government expenditures, does so significantly. So, if one is willing to accept relatively high estimates of the output elasticity of public capital (between 0.24 and 0.30), public capital distortions can indeed account for 30-40% of the cross-country income dispersion as well as generate large income gaps.

6.3 Is it Measurement Error?

It is conceivable that the relatively poor fit of the model in the full sample is simply because credit market and public capital distortions are not being measured accurately. In particular, it is possible that credit frictions are much more severe in developing countries than the net interest rate data suggests. Likewise, public investment distortions may be much greater in developing countries due to corruption and related factors that the wage data does not fully capture.

To address this mismeasurement issue, we ask the following two questions: (i) Given measured public investment distortions, how large must the lending spread be in the poorest five countries of our sample in order for the model to account for their observed income gap relative to the richest five countries in the sample? (ii) Given the measured lending spread in the net interest rate data, how large must be the leakage of tax resources from public investment in the five poorest countries for the model to account for their observed income gap relative to the five richest countries? The inference regarding the importance of these two margins for income gaps rests then on the plausibility of the values required for these

distortions.

Recall that the model implies that in steady-state, the relative income of country i is given by

$$\frac{\bar{y}_i}{\bar{y}} = \left[\left(\frac{1 - \rho_i}{1 - \rho} \right)^\lambda \left(\frac{\sigma_i}{\sigma} \right)^\alpha \left(\frac{\alpha \sigma_i / (1 - \gamma_i \psi_i) + 1 - \alpha}{\alpha \sigma / (1 - \gamma \psi) + 1 - \alpha} \right)^\lambda \right]^{1/[1 - (\alpha + \lambda)]}$$

where σ and ψ are both functions of the verification cost parameter γ under our identifying restriction $\gamma = \varepsilon$ (see equations (19) and (21)). For \bar{y} , ρ , σ and ψ , we compute their corresponding average values for the five richest countries in our sample – Canada, Luxembourg, Norway, Switzerland and US. Similarly, we compute the corresponding averages of these variables for the five poorest countries in our sample – Burundi, Kenya, Madagascar, Sierra Leone and Yemen. The computed relative income ratio is $y_i/\bar{y} = 0.03$ ($= 745/24672$).

To answer (i), we take \bar{y} , y_i , ρ , ρ_i , σ and ψ from the data and compute the γ_i for which the relative income equation holds exactly. Under the restriction $\gamma = \varepsilon$ the lending spread in the model is given by

$$\Delta_i \equiv R_i^L - R_i^D = \frac{1}{\beta(1 - \lambda\beta)} \left[\frac{1}{1 - \gamma_i + \gamma_i/4} - 1 \right].$$

Substituting the derived value of γ_i into this expression gives us the implied lending spread in the five poorest countries required for the credit market friction to account for their income gap relative to the five richest countries. We also compute the γ_i that is required to explain $z\%$ of the income gap between the richest and the poorest five countries by requiring γ_i to match the relative income $\frac{100y_i}{(100-z)y_i + z\bar{y}}$.

Table 7 shows that to explain the entire income gap through credit frictions alone, the average lending spread in the poorest countries must be 355% per annum! To explain 50% of the income gap the required spread falls to 244%. Even explaining 10% of the income gap requires a spread of 85% in the five poorest countries. These numbers seem implausibly large. The bottom panel of Table 7 repeats the same exercise for the income gap between the five richest countries and the five poorest countries in a sub-sample of countries whose relative incomes are at least 50% of the US (the Rich group in Tables 3 and 4). The lending

spread required to explain the entire income gap for the poorest five countries in this group relative to five richest is a more plausible 24%. Moreover, to explain 50% of the gap, the required lending spread falls to just 10%.

We conduct a symmetric exercise to calculate the leakage of tax resources (the parameter ρ in the model) needed to explain the income gap between the five richest and poorest countries in the full sample. For this experiment, we take \bar{y} , y_i , ρ , γ , and γ_i from the data and retrieve the required ρ_i to match y_i/\bar{y} . Table 8 indicates that for the baseline case of $\lambda = 0.17$, 98% of tax revenues must be leaking out of the public investment process for this margin to account for 50% of the income gap. This number falls to 96% and 88% in order to explain, respectively, 25% and 10% of the gap. In fact, 50% of the income gap can be explained by the model with $\rho_i = 0.95$ under $\lambda = 0.24$ and $\rho_i = 0.91$ under $\lambda = 0.3$.

Are these numbers for the public investment leakage sensible? To answer this, recall that the parameter ρ in the model corresponds to the fraction of total spending devoted to activities that are not directly productive or are non-developmental. Wages and salaries are only one component of non-productive spending. Subsidies and interest payments, for instance, are typically major claimants of government spending. To get a handle on this issue, we looked at the breakdown of total government spending into developmental and non-developmental expenditures for some selected poor countries. For India, the ratio of non-developmental to total expenditure was 0.61 in 2000-01.²⁰ The corresponding number for Indonesia was 0.69 for the same period. For Kenya, which is one of the five poorest countries in our sample, non-developmental spending amounted to 85% of total government expenditure in 2000-01.²¹ Given that we are not directly accounting for corruption which,

²⁰The actual number is higher still since food subsidies are included under developmental spending in the Indian budget.

²¹*Sources:* (i) Reserve Bank of India: Handbook of Statistics on the Indian Economy 1999-2000 (online: www.rbi.org.in); (ii) Bank of Indonesia: Government Finance Operations Statistics (online: www.bi.go.id); Central Bank of Kenya: Monthly Economic Review, July 2000 (online: <http://home.centralbank.go.ke>).

from all accounts, is a major issue in these countries, numbers for ρ in the range 0.90 – 0.95 seem quite plausible (though possibly shocking). Note that even with $\lambda = 0.17$, 25% of the income gap between the poorest and the richest five countries can be explained with $\rho = 0.96$.²²

We view these results as suggesting that distortions to public investment appear to be a promising channel for explaining income disparities between rich and poor nations. Based on the non-developmental spending to total expenditure ratio for Kenya, and incorporating a conservative estimate for corruption in the poorest countries at 5-10% of total government spending, this margin can account for more than 25% of the income gap between the five richest and the five poorest countries under most parameter configurations. Credit distortions, on the other hand, typically explain less than 5% of the income gap between richest and poorest countries even after accounting for mismeasurement problems. This margin is, at best, relevant for explaining income disparities within countries that share similar technologies and institutions.^{23,24}

²²We were, unfortunately, unable to use data on the ratio of non-developmental to total spending for our calibration as this budgetary breakdown is not available for a number of countries.

²³It is possible that from a quantitative perspective, the more relevant costs of financial intermediation are not captured by the net interest rate data at all. Beck *et al.* (1999) report data on an alternative cost measure, overhead costs, defined as the accounting value of a bank's overhead cost as a share of its total assets. Denoting such intermediation costs by c , an easy way to incorporate them is to assume that $R^D = (1-c)R$. This formulation, combined with public capital distortions as in our model, gives the relative income of country- i as:

$$\frac{\bar{y}_i}{\bar{y}} = \left[\left(\frac{1-\rho_i}{1-\rho} \right)^\lambda \left(\frac{1-c_i}{1-c} \right)^\alpha \left(\frac{\alpha(1-c_i)+1-\alpha}{\alpha(1-c)+1-\alpha} \right)^\lambda \right]^{1/[1-(\alpha+\lambda)]}$$

Calibrating c to overhead costs for each country does not alter the fit of the modified model. In particular, the MSE for the full sample is about 0.34, close to that obtained with net interest rate data. The variance ratio (13%), lowest generated income gap (0.67) and correlation between predicted and actual relative income series (0.65) are all remarkably similar to those obtained earlier.

²⁴We also calibrated a modified version of Parente's (1995) model of technology adoption where investments

7 Conclusion

Agency costs in the process of intermediating savings and private investment have been the focus of a lot of work on growth and financial development. Intermediation costs, or leakages, in the process of converting tax revenues into productive public capital has also been a commonly cited issue among growth researchers. While neither idea is novel to this paper, our chief contribution has been to bring the two together in the context of the one-sector neoclassical growth model and quantify their explanatory power.

We interpret our results as delivering a mixed verdict for the two margins isolated here. The calibration results suggest that the private investment distortion as measured by the lending spread data is insufficient to quantitatively account for the huge income dispersion observed in the data. In particular, financial frictions account for barely 2% of the cross-country variance in relative income. The public investment distortion, on the other hand, can account for up to 40% of the cross-country income variance.

Our results also suggest that even after allowing for mismeasurement of these distortions, credit frictions can, at best, explain only 5% of the income gap between the richest and poorest countries. More generally, financial frictions perform especially well in explaining the cross-country income distribution among the richest countries ($y/y_{US} > 0.5$), and moderately well in explaining income disparities across countries within other income groups. However, quantitatively they are not very important in accounting for the observed forty-fold income gap between the richest and poorest countries. For that, accounting for differences in technology appears to be key.

The public investment distortion, on the other hand, can potentially explain more than

in new technology require bank loans. Calibrating borrowing costs to the net interest rate data, we found that the lowest relative income generated by that model is about 0.94. Using data on overhead costs lowers this income gap to 0.86, but neither number is close to the data. In other words, even allowing for the credit market to have a first-order effect through technology choice, observed income gaps are not satisfactorily explained by credit distortions. Further details on this are available upon request.

25% of the observed income gap. To gain a perspective on the magnitude of this number, note that 25% of the income gap between the richest and the poorest countries corresponds to \$5981. Adding this to the per capita income of Sierra Leone, the poorest country in our sample at \$639, raises its per capita income from 5% to 53% of Greece's per capita income (\$12498). We view this as suggesting that public investment distortions are much more substantive explanations of cross-country income gaps than are credit frictions.

Lastly, our model formalized and tested one potential margin, credit frictions, through which intertemporal allocations may get distorted. As we noted earlier, intertemporal distortions typically affect the capital–output ratio (K/Y). While we did not explicitly compare the predicted K/Y from the model with that from the data due to measurement error issues, our predicted K/Y series shows very little cross-country variation relative to the variation that is typically obtained from the constructed series for capital estimated by Chari *et al.* (1997) as well as the measured series in the Penn World Tables. This suggests that important intertemporal distortions do exist in the data but these are orthogonal to those induced by credit frictions.

Appendix 1: The Optimal Fiscal Policy The sequence of tax rates $\{\tau_t\}_{t=0}^{\infty}$ is chosen

to:

$$\text{Max} \sum_{t=0}^{\infty} \beta^t \log [\chi(1 - \tau_t) A g_t^\lambda k_t^\alpha]$$

subject to:

$$\begin{aligned} g_{t+1} &= (1 - \rho)\tau_t \nu A g_t^\lambda k_t^\alpha, \\ \tau_t &\in [0, 1], \text{ given } (k_0, g_0). \end{aligned}$$

It will be more convenient to formalize this maximization problem as a dynamic programming problem:

$$V(k_t, g_t) = \max_{\tau_t \in [0, 1]} \{ \log [\chi(1 - \tau_t) A g_t^\lambda k_t^\alpha] + \beta V(k_{t+1}, g_{t+1}) \}, \quad (39)$$

subject to

$$\begin{aligned} g_{t+1} &= (1 - \rho)\tau_t \nu A g_t^\lambda k_t^\alpha, \\ k_{t+1} &= (1 - \tau_t)\alpha\beta\sigma A g_t^\lambda k_t^\alpha. \end{aligned}$$

Let us assume that V takes the form:

$$V(k_t, g_t) = a + b \log(k_t) + c \log(g_t). \quad (40)$$

This guess will be used to iterate for a ‘new’ value function from the Bellman equation, (39).

Substituting the decision rule, (28), into (40) for period- $(t + 1)$, we obtain

$$\begin{aligned} V(k_{t+1}, g_{t+1}) &= a + b \log(k_{t+1}) + c \log(g_{t+1}) \\ &= a + b \log[\alpha\beta\sigma(1 - \tau) A g_t^\lambda k_t^\alpha] + c \log[(1 - \rho)\nu\tau A g_t^\lambda k_t^\alpha] \\ &= a + b [\alpha \log\{\alpha\beta\sigma A\}] + c \log[b(1 - \rho)\nu A] + [b \log(1 - \tau) + c \log \tau] \\ &\quad + \alpha(b + c) \log(k_t) + \lambda(b + c) \log(g_t). \end{aligned}$$

where we have used the fact that we are focusing on an equilibrium with a fixed τ . Similarly, using (27),

$$\begin{aligned}\log c_t &= \log(1 - \tau) + \log[A\{\alpha\sigma(1 - \beta) + (1 - \alpha)\}] \\ &\quad + \alpha \log(k_t) + \lambda \log(g_t).\end{aligned}$$

Thus, the optimized expression on the right-hand side of (39) becomes

$$\begin{aligned}\log c_t + \beta V(k_{t+1}) &= a\beta + \log[A\{\alpha\sigma(1 - \beta) + (1 - \alpha)\}] \\ &\quad + \beta b [\alpha \log\{\alpha\beta\sigma A\}] + \beta c \log[b(1 - \rho)\nu A] \\ &\quad + \log(1 - \tau) + \beta [b \log(1 - \tau) + c \log \tau] \\ &\quad + \alpha [1 + \beta(b + c) \log(k_t) + \lambda [1 + \beta(b + c)] \log(g_t)].\end{aligned}\quad (41)$$

This, by (39), should equal our original guess for the value function.

The functional form of V we guessed is evidently verified. Hence, we solve for (a, b, c) by equating coefficients from (40) and (41), so that:

$$\begin{aligned}(1 - \beta)a &= \log[A\{\alpha\sigma(1 - \beta) + (1 - \alpha)\}] \\ &\quad + \beta b [\alpha \log\{\alpha\beta\sigma A\}] + \beta c \log[b(1 - \rho)\nu A] \\ &\quad + \log(1 - \tau) + \beta [b \log(1 - \tau) + c \log \tau],\end{aligned}\quad (42)$$

and

$$b = \alpha [1 + \beta(b + c)],\quad (43)$$

$$c = \lambda [1 + \beta(b + c)].\quad (44)$$

The last two equations give:

$$\hat{b} = \frac{\alpha}{1 - \beta(\alpha + \lambda)}, \quad \hat{c} = \frac{\lambda}{1 - \beta(\alpha + \lambda)}.\quad (45)$$

The optimal fiscal policy with a time-invariant tax rate can now be obtained by simply maximizing the value function $V(k, g)$. Since taxes affect the value function only through

the ‘constant’ a , the optimal tax solves

$$\text{Max}_{\tau \in [0,1]} \log(1 - \tau) + \beta \left[\widehat{b} \log(1 - \tau) + \widehat{c} \log \tau \right].$$

The first-order condition for this gives

$$\frac{\beta \widehat{c}}{\tau} = \frac{1 + \widehat{b} \beta}{1 - \tau},$$

so that

$$\widehat{\tau} = \frac{\beta \widehat{c}}{1 + \beta(\widehat{b} + \widehat{c})} = \lambda \beta,$$

where the last step follows using (45).

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Table 1. Statistical Properties of the Data

Sample: 79 countries, 1990-97 annual average

	$\frac{y}{y_{US}}$	<i>Net interest rate</i>	ρ
Mean	0.36	0.04	0.25
Standard deviation	0.29	0.03	0.14
Max	1.12	0.13	0.70
Min	0.02	0.01	0.02
Correlation with $\frac{y}{y_{US}}$	1	-0.48	-0.50

Table 2. Public Capital Share Estimates

<i>Sample</i>	λ	<i>Author/year</i>	<i>Public capital measure</i>
USA	0.39	Aschauer 1989	Nonmilitary public capital
OECD	0.07	Canning and Fay 1993	Transportation
Developing	0.07	Canning and Fay 1993	Transportation
Developing	0.16	Easterly and Rebelo 1993	Transport & communication

Table 3. Baseline Model: Predicted Relative IncomeParameters: $\beta = 0.94$, $\alpha = 0.58$, $\lambda = 0.17$, $a = 1$

	<i>Full Sample</i>	<i>Rich</i>	<i>Upper-middle</i>	<i>Lower-middle</i>	<i>Poor</i>
Countries	79	23	28	13	15
Corr with $\frac{y}{y_{US}}$	0.60	0.44	0.30	0.16	0.46
MSE	0.33	0.07	0.23	0.10	0.12
Variance ratio	0.21	0.81	0.29	0.97	0.18
Max	1.11	1.11 (1.12)	1.27 (1)	1.28 (1)	1.06 (1)
Min	0.49	0.49 (.5)	0.81 (.4)	0.79 (.57)	0.51 (.25)

Table 4. Baseline Model: Variance Ratio DecompositionParameters: $\beta = 0.94$, $\alpha = 0.58$, $\lambda = 0.17$, $a = 1$

	<i>Full Sample</i>	<i>Rich</i>	<i>Upper-middle</i>	<i>Lower-middle</i>	<i>Poor</i>
Countries	79	23	28	13	15
Variance ratio	0.21	0.81	0.29	0.97	0.18
Private capital	0.02	0.03	0.07	0.06	0.02
Public capital	0.18	0.71	0.28	0.92	0.18

Table 5. Baseline Model: Predicted Verification Costs (γ)

	<i>Full Sample</i>	<i>Rich</i>	<i>Upper-middle</i>	<i>Lower-middle</i>	<i>Poor</i>
Mean	0.04	0.03	0.05	0.04	0.05
Standard deviation	0.02	0.01	0.03	0.02	0.02
Max	0.12	0.06	0.12	0.08	0.10
Min	0.01	0.01	0.02	0.01	0.03

Table 6. Parameter Sensitivity of Predicted Relative IncomeFull sample; Parameterization: $\alpha + \lambda = 0.75$ Baseline case: $\alpha = 0.58$, $\lambda = 0.17$, $a = 1$

	$a = 0.75$	$a = 0.5$	$\lambda = 0.10$	$\lambda = 0.24$	$\lambda = 0.30$	$\lambda = 0.40$
Corr with $\frac{y}{y_{US}}$	0.58	0.55	0.64	0.58	0.57	0.56
MSE	0.34	0.34	0.38	0.30	0.27	0.24
Variance ratio	0.20	0.19	0.11	0.33	0.43	0.62
Private capital	0.01	0.01	0.03	0.02	0.01	0.01
Public capital	0.18	0.18	0.07	0.30	0.41	0.60
Max	1.10	1.09	1.08	1.13	1.15	1.19
Min	0.48	0.48	0.66	0.36	0.28	0.18

Table 7. Financial Friction Required to Explain Income Gap between Richest Five and Poorest Five Countries

<i>Full Sample: 79 countries</i>					
% of income gap explained	100	50	25	10	5
Lending spread	3.55	2.44	1.60	0.85	0.47
Verification cost (γ)	0.98	0.88	0.75	0.53	0.36
<i>Rich Sample ($y/y_{US} > 0.5$): 23 countries</i>					
% of income gap explained	100	50	25	20	
Lending spread	0.24	0.10	0.03	0.01	
Verification cost (γ)	0.21	0.10	0.03	0.01	

Table 8. Tax Leakage (ρ) Required to Explain Income Gap between Richest Five and Poorest Five Countries

<i>Full Sample: 79 countries; $\alpha + \lambda = 0.75$</i>					
% of income gap explained	100	50	25	20	10
$\lambda = 0.17$	0.99	0.98	0.96	0.95	0.88
$\lambda = 0.24$	0.97	0.95	0.90	0.88	0.79
$\lambda = 0.30$	0.95	0.91	0.85	0.82	0.72
<i>Rich Sample ($y/y_{US} > 0.5$): 23 countries; $\alpha + \lambda = 0.75$</i>					
% of income gap explained	100	50	25	20	10
$\lambda = 0.17$	0.57	0.40	0.27	0.23	0.16
$\lambda = 0.24$	0.47	0.33	0.23	0.20	0.15
$\lambda = 0.30$	0.41	0.29	0.21	0.19	0.14

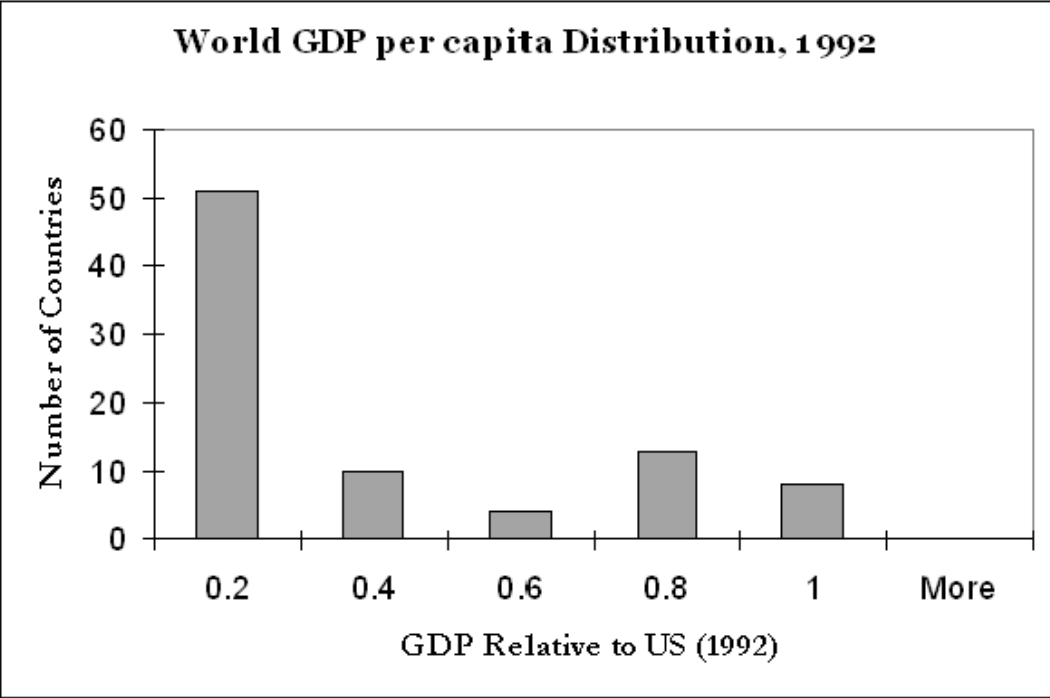
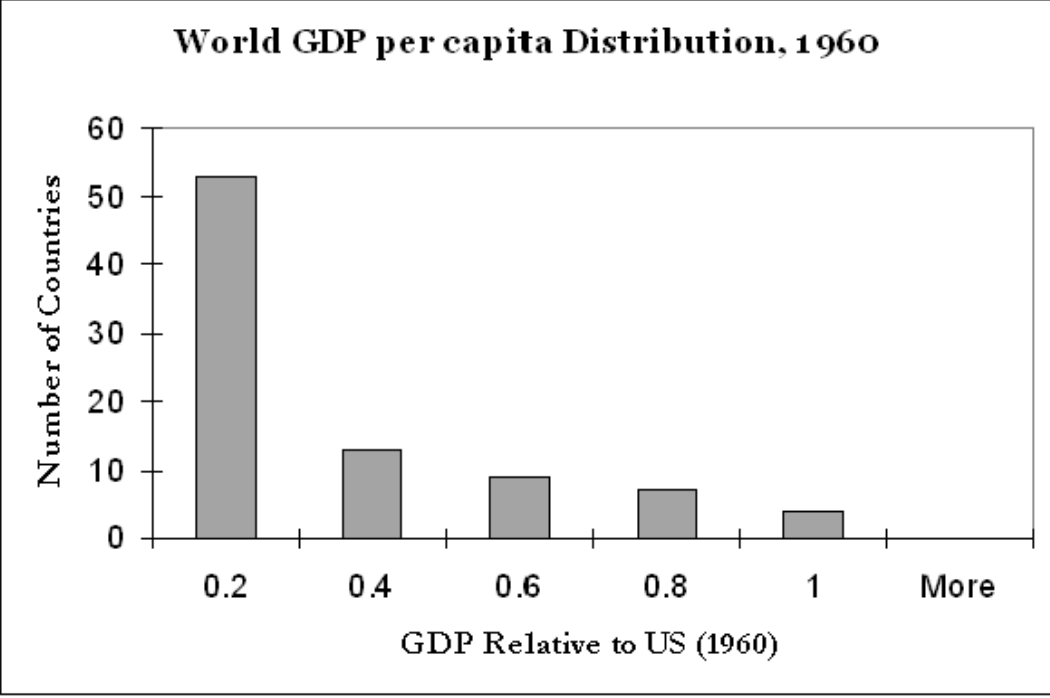


Figure 1: World Income Distribution, 1960 – 92

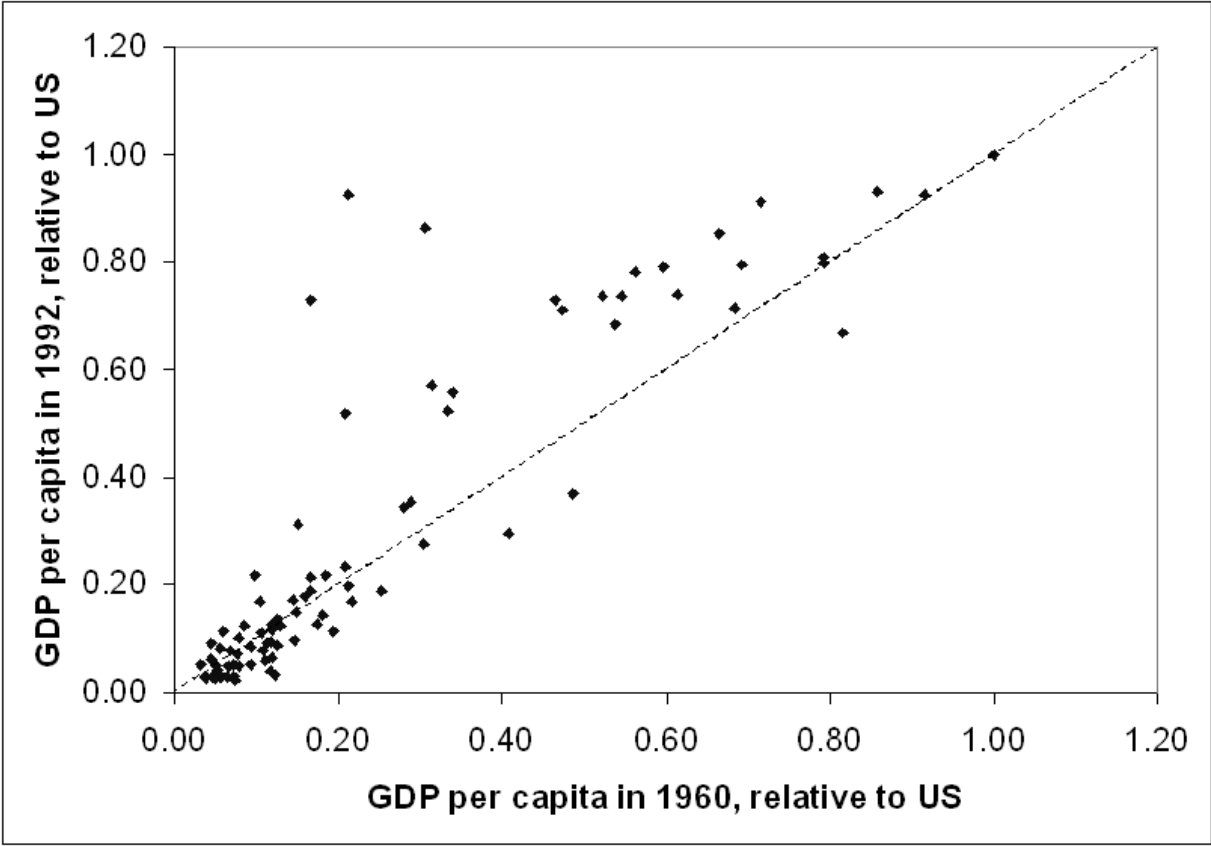


Figure 2: Persistent Income Gaps, 1960 – 92

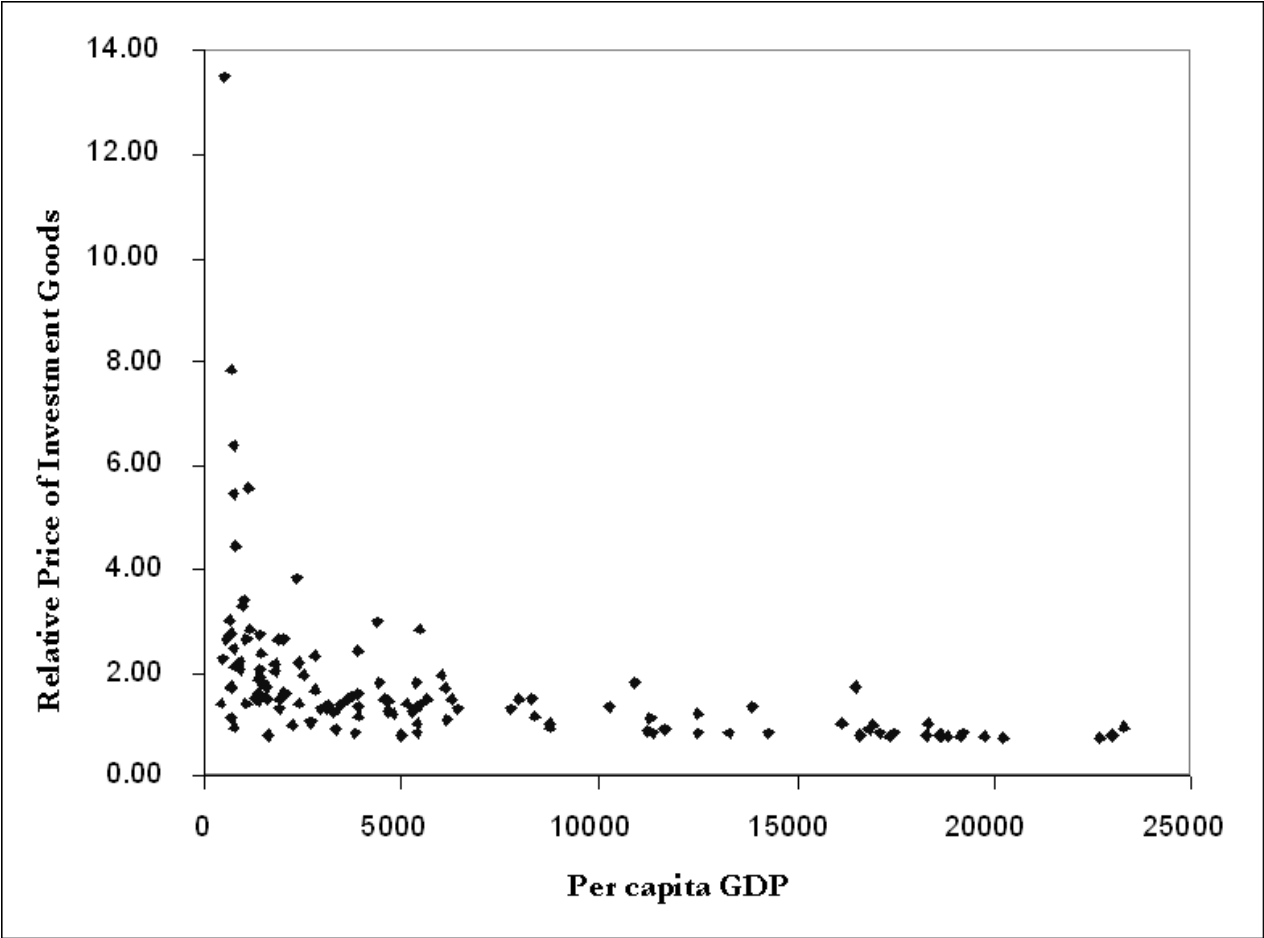


Figure 3: Relative Price of Investment Goods, 1988 – 92

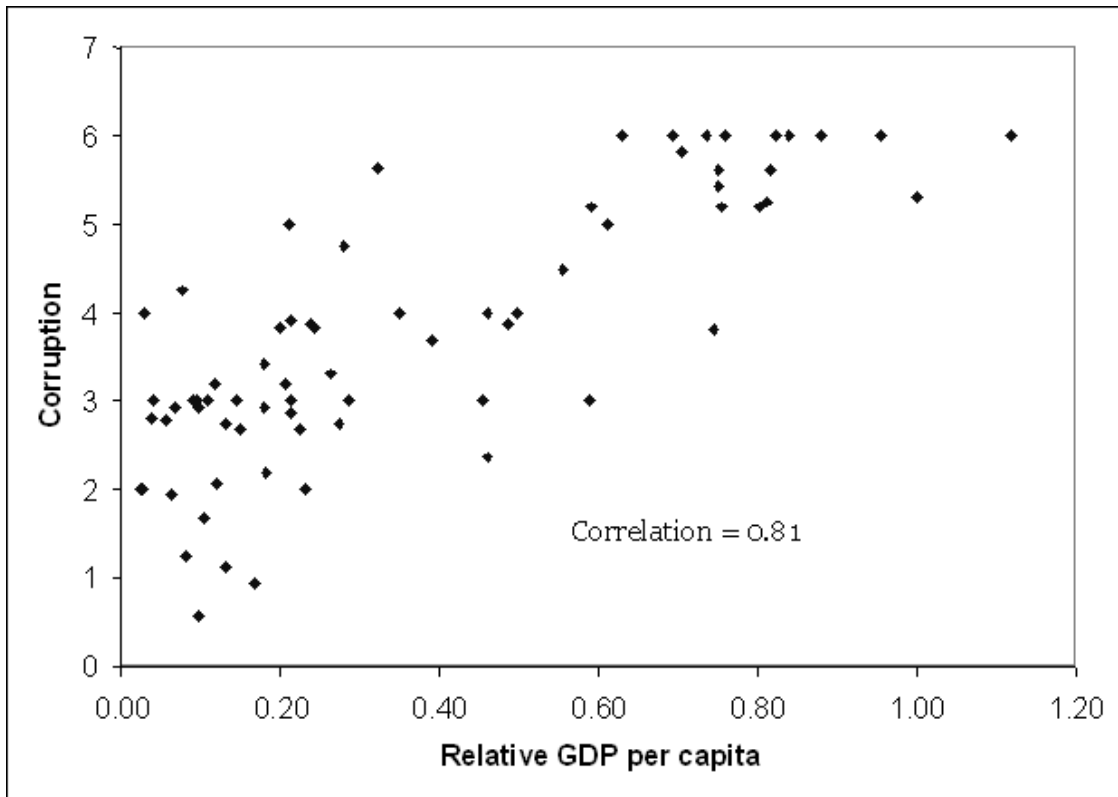


Figure 4: Corruption and Relative Income, 1990 – 97

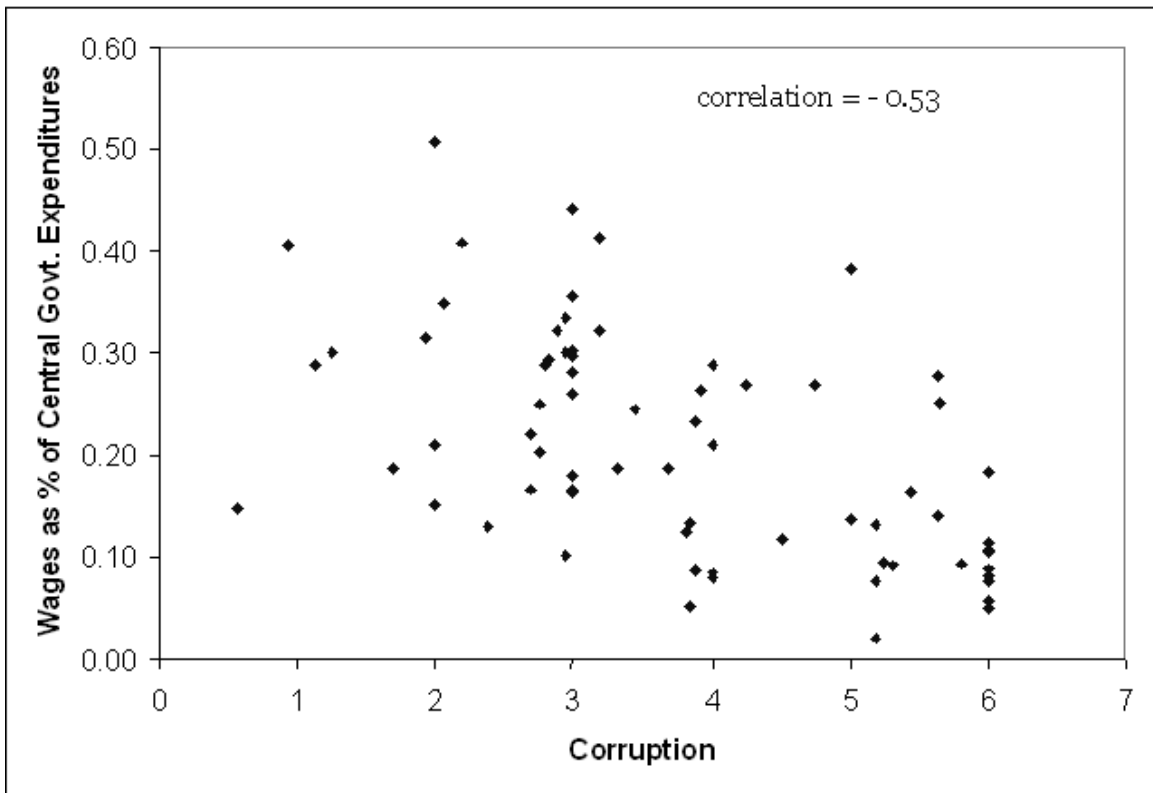


Figure 5: Corruption and Government Wages, 1990 – 97

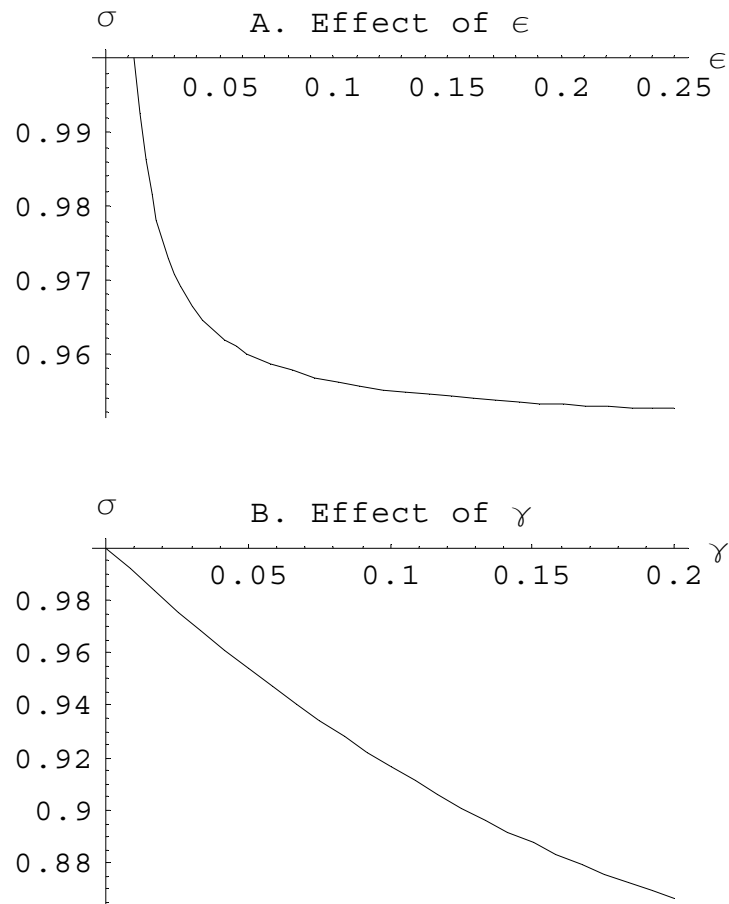


Figure 6: Investment Distortions due to Costly State Verification

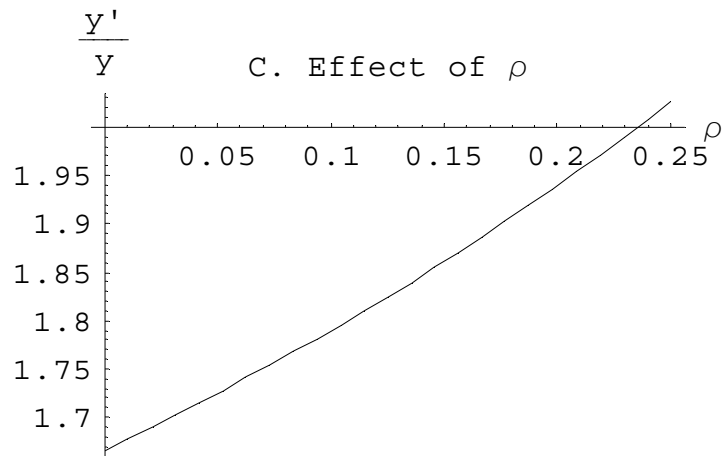
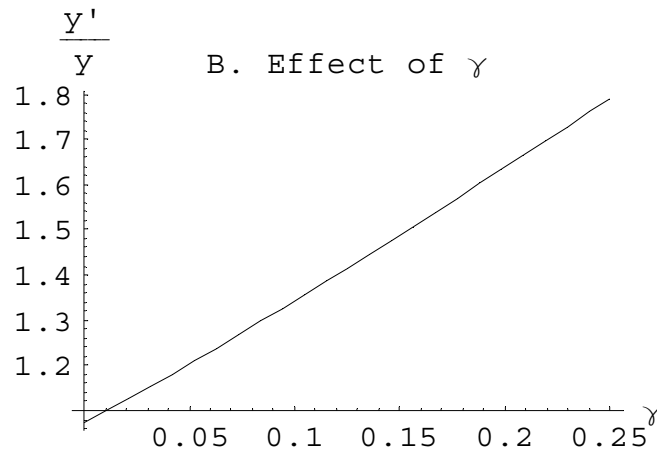
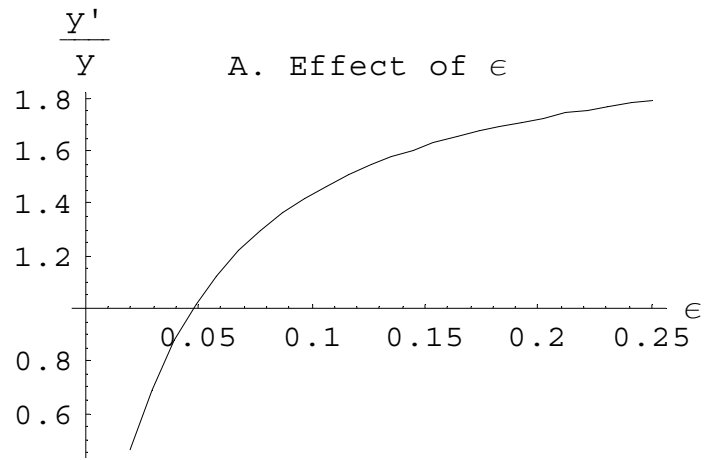


Figure 7: Steady-state Relative Incomes