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"Public Policy, Price Distortions, and Investment Rates"

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Abstract

Differences in the relative price of investment over consumption goods across countries are big, even after excluding non-tradable consumption goods. We interpret these differences as arising from differences in a wide range of policies that increase the cost of investment. Under this interpretation, we measure investment distortions using Summers and Heston's data and show that this measure is negatively correlated with investment rates and income per worker in a cross section of countries.

We show that the steady state relation between relative investment distortions and relative investment rates predicted by a standard growth model closely resembles what we observe in the data. Moreover, simulations of a calibrated version of the model in which distortions follow a stochastic process common to all countries account for around 90% of the final disparity in relative investment rates. The model, however, cannot account for the disparity in income across countries and its evolution over time.

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1 Introduction

Many authors following Solow have argued that understanding differences in investment rates (or investment-output ratios) across countries is an important step towards explaining the huge differences in income per worker that we observe in the data.

In an influential paper, Mankiw, Romer and Weil (1992) find that investment rate differences account for around half of the income disparity across countries, using a steady state version of the Solow model. This result turned out to be rather controversial, since it was against the observation that investment rates measured at domestic prices (as the ones obtained from National Income and Product Accounts) do not vary much across countries. However, these authors show that using a common set of international prices (that is, using the Summers and Heston's database) differences in investment rates across countries are big and positively correlated with differences in income per worker.

In other words, as Summers and Heston (1991) report, the relative price of investment over consumption goods is higher in poor countries. This explains why rich and poor countries spend a similar fraction of their income in investment goods (comparing investment rates at domestic prices), even though rich countries devote a higher fraction of their output to investment (comparing investment rates at international prices). Of course, the second measure of investment rates, that cleans up the effect of differences in relative prices, is the one closer to the notion of the investment-output ratio in Solow and all standard one-sector growth models.

We have then two related empirical observations: (i) poor countries invest less as a fraction of their output, and (ii) investment goods are more expensive in poor countries. In our view, a theory of development needs to account for these two observations in a unified framework. This is the main objective of the paper.

We interpret the differences in the relative price of investment over consumption goods as arising from differences in a wide range of market distortions such as taxes, barriers or prohibitions, some resulting directly from a wide range of public policy actions, while others are more related with interest groups and market imperfections. What these distortions have in common is that they increase the relative price of investment, therefore reducing its real rate of return. Our story is that agents in poor countries face higher *investment distortions*, reflected in more expensive investment goods. With some inter-temporal substitution, it follows that agents in poor countries invest less in capital.

Similar ideas have been previously explored in the literature. Growth models with different types of taxes can be found in King and Rebelo (1990), Jones and Manuelli (1990) and Chari, Kehoe and McGrattan (1996). Other models that incorporate barriers to technology adoption include Parente and Prescott (1994) and Holmes and Schmitz (1995). In all these models, the market distortion reduces the incentive to invest.

However, a limitation of this literature is the lack of empirical support. With no actual data for a representative sample of countries and years, there is no way to observe if these distortions are important enough to account for the observed differences in investment rates. Moreover, there is no evidence that they go in the right direction, that is, that distortions are higher in poor countries.

We try to avoid this limitation by introducing additional data to the discussion. Modeling distortions in the standard (Ramsey) growth model as a sale tax, there is a simple mapping between the level of investment distortions in the model and the relative price of investment over consumption goods in the data. We use this mapping to construct a panel of relative investment distortions (relative to the US level) using the information on prices in the Summers and Heston database. The panel includes 125 countries and 26 years, from 1960 to 1985.

Summers and Heston's relative prices have also been used by De Long and Summers (1993), Jones (1994) and Sarel (1995). De Long and Summers' regressions link the rate of growth of GDP to the investment rate and other variables. They find that their regressions fit better using the ratio of equipment investment to output, and show that there is a negative relation between this investment rate and the relative price of equipment. Jones includes the relative price of machinery in a Barro-style growth regression, obtaining a significant result. Finally, Sarel uses explicitly an endogenous growth model to derive a relation between the relative price of investment and income growth rate. In one dimension, our analysis is different from these authors in that the model we use suggest that the relative price of investment should be related to the level of income, not to its growth rate.

Analyzing our panel of investment distortions, some interesting findings arise. First, differences in investment distortions across countries are big, even after excluding non-tradable consumption goods. Second, there is a lot of mobility in the cross-section distribution of investment distortions, that is, many countries change dramatically their position during the period. Finally, changes in investment distortions show no persistence across sub-sample periods; many countries that increase their level of distortions in the 1960-1972 period, decreased them in the 1973-1985 period and viceversa.

Most of the paper is devoted to analyze the ability of the standard growth model with investment distortions (measured as explained before) to account for the disparity and mobility in investment rates observed in the data. We also study the ability of the model to account for the differences and movements in the distribution of income per worker across countries.

As a first approximation, we use a steady state version of the model. We show that the relation between relative investment distortions and relative investment rates predicted by the model closely resembles what we observe in the data in terms of disparity and mobility. In particular, we show that the model is able to account for the big differences in investment rates (measured at international prices) across countries and, at the same time, to explain the low variability in investment rates measured at domestic prices. We also suggest an explanation for the existence of miracles and disasters, that is, countries that grew over the period at rates considerably higher (lower) than the rest of the world.

Since the concept of mobility refers to transitional dynamics, we also simulate a calibrated version of the model in which distortions follow a stochastic process estimated from the data and common to all countries. The statistics obtained from the simulation for investment rates match surprisingly well the data. The model is able to account for around 90% of the final disparity in relative investment rates (in 1985), and reproduces the mobility in the distribution of investment rates during the period (1960-85).

The model, however, is less successful in accounting for the income disparity across countries and its evolution over time. The steady state relation between investment distortions and income per worker can only come close to the data by increasing the capital share in the production function to around 2/3. That would imply to assume that there is accumulation of some unmeasured capital facing the same distortions as physical capital, an assumption that we believe to be extreme. But even in this case the model cannot reproduce the observed mobility in the distribution of relative income.

The organization of the paper is as follows. In Section 2, we present a simple growth model with investment distortions. We use the model to construct a the panel for this variable, using the information about relative prices from Summers and Heston, and analyze some of its properties. In Section 3, we provide evidence on the relation of investment distortions, investment rates, and income, using a deterministic steady state version of the model. In Section 4, we describe a computational experiment, in which we simulate a stochastic version of the model and report the main results. Finally, we conclude and suggest some directions for future research.

2 Relative Prices and Investment Distortions

We begin this section presenting a simple growth model in which investment distortions are modeled as a sales tax. This is our theoretical reference through all the paper. After a brief discussion of Summers and Heston methodology, we use their data on relative prices and the model to construct a measure of investment distortions. At the end of the section, we present some of the main features of this measure, focusing on the disparity across countries, mobility, and persistence over time.

2.1 Modeling Investment Distortions

Consider a standard growth model with the following features. There is only one sector, that produces consumption and investment goods using the same constant returns to scale technology:

$$Y_t = F(K_t, L_t) = K_t^{\alpha}(A_t L_t)^{1-\alpha} \tag{1}$$

where A_t is a technology parameter that grows at the exogenous rate g. Since output can be used either for consumption or investment, the resource constraint is given by:

$$C_t + X_t = Y_t \tag{2}$$

and the price received by producers of consumption and investment goods will be equal. We normalize this price to one in each period.

There is an infinitely lived representative agent, with preferences:

$$\sum_{t=0}^{\infty} \beta^t \frac{(C_t/L_t)^{1-\sigma}}{1-\sigma} \tag{3}$$

where L is the population size, growing exogenously according to:

$$L_{t+1} = (1+n)L_t \tag{4}$$

The representative agent owns all the capital in the economy. He rents labor and capital services to firms, and spends all income on consumption and investment. The key assumption is that, while he can buy consumption goods at the same producer price (normalized to one), he has to pay an extra amount θ over this price for a unit of investment. That is, θ represents the level of *investment distortions* in the economy. For simplicity, we model θ just as a sales tax, and we assume that all revenues are collected by the government and rebated to consumers as a lump-sum transfer T. The budget constraint for the representative agent is then:

$$C_t + (1+\theta_t)X_t = w_t L_t + r_t K_t + T_t \tag{5}$$

and the law of motion for capital:

$$K_{t+1} = (1-\delta)K_t + X_t \tag{6}$$

Before defining equilibrium for this economy, we transform all variables in effective units of labor. That is:

$$y_t = \frac{Y_t}{A_t L_t}$$

and the same for c, k, x and transfers τ. We also transform the discount factor to $\tilde{\beta} = \beta(1+g)^{1-\sigma}(1+n)$.

Let κ be the aggregate capital per effective units of labor. A *recursive competitive equilibrium* for this economy is a list of functions: $v(k,\kappa)$, $g^c(k,\kappa)$, $g^x(k,\kappa)$, $g^{k'}(k,\kappa)$, $f^k(\kappa)$, $w(\kappa)$, $r(\kappa)$, $\tau(\kappa)$ and $\Psi(\kappa)$ such that:

- Given $w(\kappa)$, $r(\kappa)$, $\tau(\kappa)$ and the aggregate law of motion $\Psi(\kappa)$, the value function $v(k,\kappa)$ solves the consumer's functional equation:

  $$v(k,\kappa) = \max_{c,i,k'} \left\{ \frac{c^{1-\sigma}}{1-\sigma} + \tilde{\beta} v(k',\kappa') \right\}$$

  $$\begin{aligned} s.t. \;\; c + (1+\theta)x &= w(\kappa) + r(\kappa)k + \tau(\kappa) \\ (1+g)(1+n)k' &= (1-\delta)k + x \\ \kappa' &= \Psi(\kappa) \end{aligned}$$

  where $g^c(k,\kappa)$, $g^x(k,\kappa)$, $g^{k'}(k,\kappa)$ are optimal decision rules for this problem;

- Given $w(\kappa)$, $r(\kappa)$, the decision function $f^k(\kappa)$ solves the firm's problem:

  $$\max_{k>0} \;\; k^\alpha - w(\kappa) - r(\kappa)k$$

- Markets clear:

  $$\begin{aligned} g^c(\kappa,\kappa) + g^x(\kappa,\kappa) &= \kappa^\alpha \\ \kappa &= f^k(\kappa) \end{aligned}$$

- Government's budget constraint is satisfied:

$$\theta g^{x}(\kappa,\kappa)=\tau(\kappa)$$

and

- Laws of motion are consistent:

$$g^{k'}(\kappa,\kappa)=\Psi(\kappa)$$

2.2 Measuring Investment Distortions

The relationship between the level of investment distortions θ and prices of investment and consumption goods is straightforward in the context of our model. Agents pay a price $p_C=1$ for one unit of the consumption good and a price $p_I=(1+\theta)$ for one unit of the investment good. Therefore, if we had information on the prices p_C and p_I, we can measure the level of investment distortions by:

$$\frac{p_I}{p_C}=1+\theta \tag{7}$$

that is, the relative price of the investment good in terms of the consumption good.

It is useful to summarize at this point what are the key assumptions of the model that allow us to infer the previous relation. Those are: (i) consumption and investment goods are produced using the same technology; and (ii) distortions affect only the price of the investment good, not the consumption good. We will come back to this point at the end of the section and analyze alternative interpretations.

We use the Summers and Heston database (PWT version 5.6) to obtain information on relative prices. This data provides a panel of final sale prices from which we can construct the relative price of investment over consumption for most countries in different years. A brief explanation of their methodology is required in order to understand the relevance of the data for our purpose.

Summers and Heston use price data from the International Comparisons Program (ICP). This is a collection of prices for specific commodities in a sample of benchmark countries. Prices, denominated in local currency, correspond to final sales prices, and therefore they include a wide range of distortions. The ICP collects information for 1,500 commodities, which are then classified into 139 detailed categories (divided between consumption, investment, and government categories). Expenditure data is collected for each benchmark country for each of these categories. An aggregation procedure is required to use individual prices for commodities to construct a price for an aggregate category.

Denote category-goods by i and countries by j. The idea is to solve for an average international price for each category-goods, π_i, and for an aggregate price of GDP for each country, using a specified system of equations. One issue is that the system requires quantities of each category-good for each country as inputs. Remember that a category-good is an aggregate of very different commodities, and aggregation is done using prices. In order to obtain a quantity-like measure, comparable across countries, a transformation of expenditures in local currency, E_i^j for each category-good i and country j is required. Define purchasing power parity of category-good i in country j as:

$$PPP_i^j \equiv \frac{p_i^j}{p_i^{us}}$$

and notional quantities as:

$$Q_i^j \equiv \frac{E_i^j}{PPP_i^j} = p_i^{us} q_i^j$$

Notional quantities act as the quantity-like measure, since they are quantities at a common set of prices (dollars) and therefore comparable across countries. Use notional quantities, Q_i^j's, and PPP_i^j's as inputs to solve for the fixed point (π_i, PPP^j) of the following system of equations:

$$\begin{aligned} PPP^j &= \frac{\sum_i (PPP_i^j \times Q_i^j)}{\sum_i (\pi_i \times Q_i^j)} \\ \pi_i &= \sum_j \left(\frac{PPP_i^j}{PPP^j} \times \gamma_{i,j}\right) \end{aligned}$$

where γ_{ij} are weights defined as:

$$\gamma_{i,j} \equiv \frac{Q_i^j}{\sum_j Q_i^j}$$

The intuition for this system of equations is as follows. The first set of equations defines Purchasing Power Parity of overall GDP for each country, PPP^j, as GDP in domestic prices over GDP in international prices. The second set of equations defines international prices for each category-good, π_i, as the weighted average of prices for each country. Total PPP of GDP works as the real exchange rate, and therefore produces an index that is comparable across countries.

Once international prices are computed, it is possible from the first set of equations to generate PPP's for any aggregate we like by adding up the corresponding category-goods. In particular we can calculate PPP's for aggregate consumption and investment.

If we follow this procedure in the model economy above, PPP for aggregate investment and consumption are given by the following equations:

$$\begin{aligned} PPP_I^j &= \frac{(1+\theta^j) \times I_j}{\pi_I \times (1+\theta^{us}) \times I_j} \\ PPP_C^j &= \frac{C_j}{\pi_C \times C_j} \end{aligned}$$

Note that the simple ratio of these two gives a measure of relative distortions that depends upon international prices. Since PPP's are used to generate real aggregates like income and investment, measurement error in international prices generates a spurious correlation between relative prices and income or investment rates. Therefore, we measure investment distortions as the ratio of relative price of investment over consumption relative to the same ratio for the US. Clearly this measure is independent of international prices:

$$\frac{PPP_I^j/PPP_C^j}{PPP_I^{us}/PPP_C^{us}} = \frac{(1+\theta^j)}{(1+\theta^{us})}$$

This concludes our exposition of Summers and Heston procedure. We refer to the previous ratio as our *index of relative distortions* (RDIST), and we calculate a panel for this variable in the following way:

$$RDIST_t^i = \frac{(1+\theta_t^i)}{(1+\theta_t^{us})} = \frac{PI_t^i/PC_t^i}{PI_t^{us}/PC_t^{us}}$$

where PI and PC are the price levels of investment and consumption reported by Summers and Heston as the ratio of the corresponding purchasing power parity ratio divided by the official exchange rate. Note that the exchange rates are cancelled by taking the ratio of PI over PC, and international prices also disappear by taking the ratio with respect to the US. Eliminating countries with missing information in the 1960-85 period we end up with a panel of 125 countries over the 26 year interval.[1]

2.3 A First Look at the Data

The first question that our panel of investment distortions may help us to answer is: How big differences in these distortions are? The question is relevant, since we will see that we need big differences in distortions to generate the observed differences in investment rates and income per worker.

Table 1 reports summary statistics for RDIST, while the complete distribution is sketched for the initial and final sub-periods in Figure 1[2]. Note that numbers less than one mean that the country has a lower level of investment distortions than the US. This does not necessarily mean that the country is *less distorted*, in the usual meaning associated with welfare. It can be the case that a country subsidizes investment heavily; since the relative cost of investment drops, it would appear in our data as a country with relatively low distortions.

Table 1 shows that the range of the distribution of RDIST is big for each year. The ratio between the most distorted country and the least distorted is around 10. Even if we consider the ratio between the average level of distortions for countries at the top 5% and the bottom 5% of the distribution, the number is still around 8. However, the range of the distribution declines during the sample period by almost a half.

Table 2 studies the extent to which the differences in relative distortions are due to overestimation in the Summers and Heston extrapolation to non-benchmark countries or to the role of non-tradable consumption goods. Considering only the 64 benchmark countries

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[1] From the original 152 countries in Summers-Heston we exclude Djibouti, Sierra Leone, Sudan, Bahamas, Belize, Dominica, Grenada, St.Kitts, St.Lucia, St.Vincent, Bahrain, Bhutan, Kuwait, Laos, Mongolia, Oman, Qatar, United Arab Emirates, Yemen, Bulgaria, East Germany, Hungary, Poland, Solomon, Tonga, Vanuatu and Western Samoa.

[2] The range of the bins are 1=[0, 1], 2=[1, 1.5], 3=[1.5, 2.25], 4=[2.25, 4], 5=[4, 15].

for 1985 from Summers and Heston, the results on disparity do not change significantly. Also, computing relative distortions as the relative price of investment over tradable consumption goods only, the ratio between the most distorted country and the least distorted increases to 11. Therefore, the idea that non-tradable consumption goods are explaining the disparity in relative distortions is not supported by the data. Note that in any event, relative prices without non-tradable consumption goods is a lower bound of the true disparity, since it is common in poor countries to have tariffs to tradable consumption goods.

A second question that we may ask is: How much action do we see in this panel? Is there a lot of mobility? or countries occupy the same position in the distribution of distortions over time. This is another relevant question, since we see countries changing their position in other dimensions of economic development.

Table 3 reports a mobility matrix for RDIST. It shows movements of countries across different states or bins in the distribution of investment distortions between the initial and final sub-period. Each cell $c_{i,j}$ represents the fraction of countries that started in bin (row) i between 1960-64, and ended in bin (column) j between 1981-85. The bins are the same used for the histograms in Figure A.1, but the results are robust to changes in the way those bins are defined. As we can see, almost all cells have strictly positive entries and numbers off the main diagonal (corresponding to countries that change their relative position) are relatively big, suggesting a lot of mobility in the distribution. Note also that the elements in the extremes of the main diagonal are smaller than in the middle. This is consistent with the reported decline in the range of the distribution.

Moreover, we claim that the mobility matrix above underestimates the level of action in the panel of investment distortions. Most countries experience big changes in their level of distortions over time, but these changes are not persistent. Therefore, they may end up in the same position of the distribution than at the beginning of the period.

Figure 2 shows the rates of growth of RDIST between the sub-sample periods 1960-72 and 1973-85. Many countries lie in quadrants I and IV, far off from the 45 degree line. In other words, many countries that increased their levels of distortions between 1960-72 decreased them between 1973-85, and the opposite is also true. In fact, the correlation between the variables in the axis is 0.10, summarizing the lack of persistence. This fact is robust to changes in the dimension of sub-periods.

To summarize, differences in investment distortions across countries are big, although it is difficult to put a number to the exact level of disparity. Moreover, these differences are falling over time. Changes in the relative level of distortions during the period are also big for most countries, but they are in general not persistent. In the next section we explore if these properties of the data are consistent with other development facts.

2.4 Alternative Interpretations

There are other possible interpretations for the observation that the relative price of investment is higher in poor countries. One alternative story is that these prices reflect differences in factor endowments across countries. We argue that this interpretation is inconsistent with the lack of persistence that we observe in the changes of relative prices and the behavior of miracle countries in particular. In the same line, we may think that the relative price of investment is high in poor countries not because investment prices are higher but because non-tradable consumption goods are cheaper. As we show in Table 2, it turns out that the disparity in relative prices is not affected by the exclusion of non-tradable consumption goods.

Another interpretation of the differences in relative prices is related to differences in the technical rate of transformation between output and next-period capital across countries (or a two sector model). In particular, consider an economy in which one unit of output can be transformed into $\frac{1}{(1+\theta)}$ units of capital next period. As in our model, the price of investment relative to consumption is $(1 + \theta)$, and our measure of distortions remains consistent with this setup. The key difference is that in our interpretation distortions imply a redistribution of resources, since taxes are rebated to consumers as a lump-sum transfer, while under the alternative interpretation distortions imply resources wasted, changing the resource constraint. In other words, in our environment, distortions affect only the allocation decision between consumption and investment, but in the alternative environment distortions not only affect the allocation decision between investment and consumption, but also the total amount of resources that get actually allocated. Therefore, income disparity in our environment is lower than under the alternative.

3 Distortions, Investment Rates, and Income

In order to gain intuition about the role of investment distortions in the process of development we work with the steady state version of the model presented above. We show that investment rates and investment distortions closely match their theoretical steady state relation, and that high values of the capital share (implying a broad measure of capital) are needed to explain the level of income disparity in the data. We also show that changes in investment distortions are related to changes in the distribution of investment rates and income across countries over time. In particular, we analyze the cases of countries considered as miracles and disasters due to their growth experience over the period.

3.1 Steady State Analysis

We solve the recursive competitive equilibrium for the model described above by looking at the first order conditions for consumers and firms. Simplifying, we obtain the *Euler equation*:

$$(1+g)(1+n)\left(\frac{c}{c'}\right)^{-\sigma} = \tilde{\beta}\left[\frac{\alpha(k')^{\alpha-1}}{(1+\theta)} + (1-\delta)\right] \tag{8}$$

and combining the law of motion for capital and the resource constraint:

$$(1+g)(1+n)k' = k^{\alpha} + (1-\delta)k - c \tag{9}$$

The dynamical system (8) and (9) can be used to derive the predictions of the model about the relation between the level of investment distortions θ and other variables in the model. In steady state, where $c = c'$, we can solve (8) for the stock of capital per effective units of labor k, obtaining:

$$k = \left[\frac{1+\theta}{\alpha}\left(\frac{1}{\tilde{\beta}}(1+g)(1+n) - (1-\delta)\right)\right]^{\frac{1}{\alpha-1}} \tag{10}$$

and since, from (9), $y = k^{\alpha}$ and $x = [(1+g)(1+n) - (1-\delta)]\,k$, we get the following expressions for income per effective units of labor and the investment rate :

$$y = \left[\frac{1+\theta}{\alpha}\left(\frac{1}{\tilde{\beta}}(1+g)(1+n) - (1-\delta)\right)\right]^{\frac{\alpha}{\alpha-1}} \tag{11}$$

$$\frac{x}{y} = \frac{X}{Y} = \frac{\alpha\left[(1+g)(1+n) - (1-\delta)\right]}{(1+\theta)\left[\frac{1}{\tilde{\beta}}(1+g)(1+n) - (1-\delta)\right]} \tag{12}$$

depending on the exogenous growth rates of technology and population, the discount factor, technology parameters, depreciation rate and the level of distortions θ.

To make international comparisons, we assume that each country is a closed economy as defined above, with the same depreciation rates, preferences, technology and population growth. Then, (11) and (12) can be written in relative terms, relative to the US levels, as follows:

$$\frac{\left(\frac{Y}{L}\right)_j}{\left(\frac{Y}{L}\right)_{us}} = \frac{y_j}{y_{us}} = \left[\frac{1+\theta_j}{1+\theta_{us}}\right]^{-\frac{\alpha}{1-\alpha}} \tag{13}$$

$$\frac{\left(\frac{X}{Y}\right)_j}{\left(\frac{X}{Y}\right)_{us}} = \left[\frac{1+\theta_j}{1+\theta_{us}}\right]^{-1} \tag{14}$$

showing that, in steady state, countries with higher distortions will have lower levels of income and lower investment rates.

3.2 Distortions and Relative Investment Rates

The relation between relative distortions and relative investment rates given by (14) can be formulated, taking logs to both sides, as:

$$\log\left[\frac{\left(\frac{X}{Y}\right)_j}{\left(\frac{X}{Y}\right)_{us}}\right] = -\log\left[\frac{1+\theta_j}{1+\theta_{us}}\right] \tag{15}$$

To confront this relation with the data, note that the right hand side corresponds to the log of RDIST. The measure of relative investment rates that we use for the left hand side is provided by Summers and Heston. We take their share of investment in GDP for each country, at 1985 international prices, and divide it over the one for the US. We call this variable RINV.

Why using Summers and Heston's investment share instead of, for example, the one obtained from National Income and Product Accounts (NIPA)? The reason is that, by using a common set of international prices, Summers and Heston are able to measure the fraction of resources actually transformed into capital, as opposed to the fraction of resources devoted to capital investment. The distinction is crucial since the differences in relative prices indicate that a lot more resources are needed in poor countries to generate comparable amounts of capital. Figure 3 shows that investment-output ratios at domestic prices from national accounts (reported by the IMF) do not vary much across countries. The mean investment/GDP ratio at domestic prices is 0.22, and the correlation with relative GDP at international prices (taking logs) is 0.27. Investment-output ratios measured at international prices show a lot more variability across countries and a higher correlation with relative income, as Figure 4 shows. The correlation between the two variables (also taking logs) is in this case 0.6.

Figure 5 is a scatter plot of the log of RINV against the log of RDIST, for 1985. The relation implied by the model in (15) is represented by the solid line. The figure shows that this relation closely matches the data. Moreover, Table 6 reports the results of the following regression:

$$\log RINV = \beta_0 + \beta_1 \log RDIST + \varepsilon$$

for selected years, using in each case the full sample of 125 countries. Again, the model fits well the pattern of the data and the estimated values for the parameter β_1 are very close to minus one, as predicted by the model.

Therefore, using a very simple steady state version of the growth model, and distortions constructed in a systematic way, we are able to generate endogenously differences in investment rates similar to those observed in the data. A very simple mechanism of inter-temporal substitution of consumption makes agents in different countries to allocate a different fraction of total resources to investment in reaction to the differences in incentives generated by distortions. What is striking about the previous results is how well the model does from a quantitative point of view.

Finally, note that the model is also consistent with the low variability observed in investment rates measured at domestic prices (from NIPA) across countries. The corresponding expression in the model for such variables that do not correct for differences in relative prices across countries is:

$$\left(\widehat{\frac{X}{Y}}\right) = \frac{(1+\theta)\,X}{Y+\theta X} = \frac{(1+\theta)\,\frac{X}{Y}}{1+\theta\frac{X}{Y}}$$

where $\widehat{\frac{X}{Y}}$ is the investment rate at domestic prices, and $\frac{X}{Y}$ the investment rate from the model. Using the steady state expression for investment-output ratio in the model, this expression is negatively related to θ but the correlation is small. Intuitively, since countries with lower investment rates $\frac{X}{Y}$ are associated with higher distortions θ, the corresponding investment rate at domestic prices reverts to the mean level.

3.3 Distortions and Relative Income

We want to extend the relationship between distortions and relative investment rates to distortions and relative income. The steady state relation (14) can be formulated as:

$$\log\left[\frac{y_j}{y_{us}}\right] = -\left(\frac{\alpha}{1-\alpha}\right)\log\left[\frac{1+\theta_j}{1+\theta_{us}}\right] \tag{16}$$

showing that the value of the capital share α determines the amount of disparity in income that we can obtain for a given disparity in investment distortions. As we show before, differences in relative distortions reach factors of between 5 and 8. That means that, with the usual capital share of $\alpha \approx 1/3$, we can get differences in income of around 2 or 3, well below the observed disparity in the data.

The result is not surprising. In a steady state version of the Solow model, Mankiw, Romer and Weil (1992) show that the observed differences in investment rates are unable to account for the disparity in income per worker across countries. They claim that the model does a lot better by including an additional factor, namely human capital, that increases the share of accumulable factors in the production function. Parente and Prescott (1994) reach a similar conclusion, although in their view what is missing is some sort of technological or business capital. Note that in the two cases it is key that the additional factor is not included in the measurement of income, so we will refer to it as *unmeasured capital.*

How much can we amplify the effect of differences in investment distortions over differences in income by including some unmeasured capital? We try to answer this question in the remaining part of the section. For this, assume a production function of the form:

$$Y_t = K_t^{\alpha_k} Z_t^{\alpha_z} (A_t L_t)^{1-\alpha_k-\alpha_z}$$

where Z_t represents the stock of unmeasured capital. As before, Z_t evolves over time according to:

$$Z_{t+1} = (1-\delta) Z_t + X_t^z$$

and X_t^z represents units of the (only) final good devoted to investment in unmeasured capital. The resource constraint is then:

$$Y_t = C_t + X_t^k + X_t^z$$

however, what we call measured output and compare with the data is:

$$Y_t^M = C_t + X_t^k$$

The key assumption is about investment distortions. Should investment in unmeasured capital be also affected by distortions that increase the relative price of investment, or not? It seems reasonable to think that countries that distort investment decisions in physical capital are also distorting investment in other types of capital, specially those that are closely tied to physical capital investments. However, there is simply no data available to support this claim. We will explore two extreme assumptions: (i) that investment distortions do not affect investment in unmeasured capital; and (ii) that distortions affect equally investment in physical and unmeasured capital. A more realistic assumption should of course lie between (i) and (ii).

In the first case, only physical capital is affected directly by distortions. However, investment in unmeasured capital is affected indirectly, since a lower stock of physical capital reduces its rate of return. The corresponding steady state formulas for total and measured relative incomes are:

$$\begin{aligned}
\frac{y_j}{y_{us}} &= \left[\frac{1+\theta_j}{1+\theta_{us}}\right]^{-\frac{\alpha_k}{1-\alpha_k-\alpha_z}} \\
\frac{y_j^M}{y_{us}^M} &= \frac{1-\left(\frac{X^z}{y}\right)_j}{1-\left(\frac{X^z}{y}\right)_{us}}\left(\frac{y_j}{y_{us}}\right) = \left[\frac{1+\theta_j}{1+\theta_{us}}\right]^{-\frac{\alpha_k}{1-\alpha_k-\alpha_z}}
\end{aligned}$$

since distortions do not affect the ratio $\frac{X^z}{Y}$, so it is the same across countries. Taking logs, we obtain:

$$\log\left[\frac{y_j^M}{y_{us}^M}\right] = -\left(\frac{\alpha_k}{1-\alpha_k-\alpha_z}\right)\log\left[\frac{1+\theta_j}{1+\theta_{us}}\right] \tag{17}$$

a formula similar to (16) but with a bigger amplifier effect $\frac{\alpha_k}{1-\alpha_k-\alpha_z}$.

In the second case, distortions affect equally physical and unmeasured capital accumulation. We have in steady state:

$$\begin{aligned}
\frac{y_j}{y_{us}} &= \left[\frac{1+\theta_j}{1+\theta_{us}}\right]^{-\frac{\alpha_k+\alpha_z}{1-\alpha_k-\alpha_z}} \\
\frac{y_j^M}{y_{us}^M} &= \left(\frac{1-\phi\left(1+\theta_j\right)^{-1}}{1-\phi\left(1+\theta_{us}\right)^{-1}}\right)\left[\frac{1+\theta_j}{1+\theta_{us}}\right]^{-\frac{\alpha_k+\alpha_z}{1-\alpha_k-\alpha_z}}
\end{aligned}$$

where $\left(\frac{X^z}{Y}\right)_j = \phi\left(1+\theta_j\right)^{-1}$ and:

$$\phi = \frac{\alpha_z\left[(1+g)(1+n)-(1-\delta)\right]}{\frac{1}{\beta}(1+g)(1+n)-(1-\delta)}$$

Taking logs, we obtain:

$$\log\left[\frac{y_j^M}{y_{us}^M}\right] = -\left(\frac{\alpha_k+\alpha_z}{1-\alpha_k-\alpha_z}\right)\log\left[\frac{1+\theta_j}{1+\theta_{us}}\right] + \log\left(\frac{1-\phi\left(1+\theta_j\right)^{-1}}{1-\phi\left(1+\theta_{us}\right)^{-1}}\right) \tag{18}$$

a formula similar to (16), but with a broader capital share $\alpha = \alpha_k + \alpha_z$ and an additional term reflecting the adjustment for unmeasured output that depends on the values of most of the parameters of the model.

Figure 6 is a scatter plot of the log of RINC (GDP per worker measured at 1985 international prices, from Summers and Heston) against the log of RDIST, for 1985. The relation implied by the model without unmeasured inputs (16) is represented by a dotted line. The relation implied by the model in which distortions affect only investment in physical capital

(17) is represented by a dashed line, while the one implied by the model with distortions affecting both types of capital (18) is represented by a solid line. In this figure, we assume $\alpha_k = \alpha_h = 1/3$, and for the last case we use the values for the remaining parameters reported in Table 7 and discussed in the next section (these numbers imply $\phi = 0.22$).

Figure 6 shows, as expected, that the model without unmeasured capital is unable to reproduce the range of disparity in income per worker across countries. The model with unmeasured inputs but in which distortions affect only physical capital accumulation increases the amount of disparity generated by the model, but it is still far off the numbers in the data. Finally, the model with unmeasured inputs and distortions affecting equally both types of capital matches a lot better the data and generates enough disparity in income, given the differences in distortions. In our view, more research is needed in order to understand how distortions affect different types of capital accumulation before postulating this model as a theory of development.

3.4 Mobility

The steady state relations (15) and (16) can be used also to give some intuition about changes in investment rates and income per worker over time. We know from the previous section that there is a lot of mobility in our panel of investment distortions, as shown in Table 3. Are those movements related to changes in investment rates and income? We evaluate now this question.

Table 4 contains a cell by cell characterization of the mobility matrix for distortions (RDIST) using the gross growth rate of relative investment rates (RINV). For example, looking at countries starting in bin 3 in 1960 and ending in bin 2 in 1985 in the distribution of investment distortions, their average ratio of RINV in 1985 over 1960 is 1.06, showing an increase in their relative investment rates between those years.

We observe in this table that the growth rate of relative investment rates is consistently higher in the cells below the main diagonal than for the ones above it. With only some exceptions, this ratio is bigger than one below the main diagonal and less than one above it. Moreover, this ratio is decreasing as we move in each row to the right. That is, countries that increase (decrease) relatively more their investment distortions deteriorate (improve) more their position in the distribution of relative investment rates, as predicted by the model.

A similar exercise is conducted for relative income per worker (RINC), as shown in Table 5. Again, we observe that changes in investment distortions are related to changes in the distribution of relative income. Countries that reduce in relative terms their investment distortions improve their position in the distribution of relative income, although the opposite is less clear.

We realize that the use of the steady state version of the model to explain mobility is contradictory. The previous results should be taken only as a first approximation before a fully dynamic version of the model is simulated. We perform this simulation in Section 4.

3.5 Miracles and Disasters

One striking observation in economic development is the existence of miracles and disasters, that is, countries that increase (decrease) their income per worker at rates well above (below) the world average. A natural explanation in the context of the model goes as follows. Some countries reduce their relative level of distortions; as a result, their investment rates increase in relative terms, they grow at faster rates and at the end are considered as miracles. The opposite story also holds; countries considered as disasters would be the ones with relatively higher levels of distortions and low investment rates.

Figure 7 plots the evolution over time of the average level (in logs) of relative investment rates (RINV) for three groups of countries: miracles, disasters and rest of the world. By miracles, we consider the ten countries with higher growth rates of income per worker over the period. Similarly, we take the ten countries with lower growth rates and call them disasters. As we can see, the relative investment rate for the miracles is between 1960 and 1965 similar than for the rest of the world, but after that it increases. On the other hand, relative investment rates for the disasters are lower than for the rest of the world during the entire period.

To continue with the story, Figure 8 plots the evolution of the average level (in logs) of relative investment distortions (RDIST) for the same three groups of countries. We observe that investment distortions for the miracles were not different from the rest of the world until 1965, where they begin to decrease, while RDIST is consistently higher for the disasters during the entire period.

Comparing the two figures, it seems that a decrease in investment distortions (occurring during the early sixties), consistent with an increase in investment rates, explains the good performance of the miracles, while permanently high levels of investment distortions, associated with low investment rates, are the main reason for the existence of disasters.

4 A Quantitative Experiment

In this section we simulate a stochastic version of the model, in which investment distortions follow a Markov process. We simulate this model for 125 countries and 26 periods, where countries are closed economies with the same parameter values and the same stochastic process for distortions. The result is a panel of simulated statistics for the model, that we compare with Summers and Heston's data in several dimensions. This experiment is a simple version of Chari, Kehoe and McGrattan (1996), that simulate a model with stochastic taxes and changes of regime.

4.1 Description of the Experiment

Consider an economy as the one described in Section 2, but in which the tax level θ is a random variable that takes values on the finite set Ω and follows a stationary first-order Markov process with transition matrix Π. The intuition behind this stochastic formulation is that agents in this economy don't know the future path of distortions, but may formulate probabilistic inferences about it based on the current level. A country will be identified by a pair of initial conditions (k_0, θ_0). In particular, we assume that the US is the undistorted baseline economy ($\theta = 0$) that remains always in steady state.

To simulate the model we need first to pick values for the parameters. The calibration exercise is standard except for the values of the states θ, probabilities in the Markov Chain

Π, and the capital share α. The complete list of parameter values is presented in Table 7. We assume a yearly depreciation rate δ of 6%. Then, we choose β to match a capital-output ratio of 3, as calculated for the US economy. The parameters g and n correspond to the growth rates of population and productivity, also for the US economy. As in most of the literature of Real Business Cycles, we set the relative risk-aversion coefficient σ equal to 1.5.

We simulate the model with a value for α equal to 2/3. This is equivalent to a model with unmeasured capital in which both types of capital are equally affected by distortions, with $\alpha_k = \alpha_z = 1/3$. As we saw in the previous section, this specification has the best chance to replicate the disparity in income per worker observed in the data. We carry on this exercise having in mind that the results in terms of income disparity represent an upper bound to the explanatory power of the model. Nevertheless, we emphasize that the results about investment rates are not affected by our assumption about the size of the capital share.

We describe now the parameterization of the stochastic process for investment distortions. We choose five states, and we pick values for the 20 elements of the transition matrix Π using the following procedure: (i) raise the mobility matrix in Table 3 to the power 1/21; (ii) eliminate negative elements and round the resulting matrix to three decimal places; and (iii) make the necessary adjustments to get a row stochastic matrix. This procedure is closely related to Maximum Likelihood estimation.

The resulting matrix is presented in Table 8. This matrix multiplied by itself 21 times is fairly close to the one reported in Table 3. Therefore, we obtain a yearly transition matrix that generates the mobility in investment distortions observed in the data.[3] We use this matrix Π, and the following values for the states $(1+\theta)$:

$$\Omega = \{0.8, 1.2, 1.8, 3.2, 6.3\} \tag{19}$$

corresponding to the average value of RDIST for countries in each bin during 1960-64.

The next step in the experiment is to compute numerical solutions for the model. For this, we apply the Finite Element Method with penalty functions (in order to impose non-negativity on investment) to the dynamical system given by the stochastic version of (8) and (9). This method is explained in great detail in McGrattan (1996).

Once we compute decision functions for consumption, investment, and capital next period, we simulate the model. The procedure is the following: (i) initialize the state pairs (k_0, θ_0) for each of the 125 countries, using their 1960 level of investment distortions, income and investment rates; (ii) simulate the model for 26 periods, drawing each period and for each country (except the US) a distortion shock θ from the Markov process specified above; and (iii) compute statistics for the variables simulated in the model and compare them with the corresponding statistics from the data.

4.2 Results about Disparity

The results of the experiment are summarized in Tables 9 and 10. In the bottom panels of those tables we report statistics about relative investment rates and relative income per

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[3] An implicit assumption is the stationarity of the Markov process driving investment distortions. To justify this assumption we run a test of stationarity as in Anderson and Goodman (1957). We estimate yearly transition matrices using Maximum Likelihood (from the panel data information) with and without the constraint that these matrices are equal. The log likelihood test couldn't reject stationarity.

worker from Summers and Heston (the same variables RINV and RINC used before), and in the top panels the statistics for the same variables in the model (properly adjusted to account for unmeasured output, as in equation (18)). Since the statistics for the model are random numbers (they depend on the particular realization of the distortion shock), we perform a large number of simulations and report their average.

In Table 9 we focus on the distribution of relative investment rates across countries. The model reproduces fairly well the range and mean of the distribution, although it generates a Gini coefficient slightly lower than in the data. Moreover, in the model, as well as in the data, there is a decrease in the disparity in investment rates from 1960 to 1985, due to the decrease in the disparity of investment distortions. In fact, as Figure 9 shows, the model reproduces almost exactly the final distribution of investment rates across countries observed from the 1985 data.

Table 10 reports the same statistics for the distribution of relative income across countries. The range of the distribution (the bottom and top ten percent of the sample) generated by the model is very close to the one in the data, although the average of the bottom ten percent is slightly higher in the model. The means of the distribution are also very close in the model and the data. In terms of disparity, the Gini coefficients are almost equal in 1960 in the model and the data (because we start simulated economies at initial levels that resemble real countries situation in 1960). However, at the end of the 26 periods of simulation the ratio between these two coefficients is around 80%, again as a result of the decrease in the disparity in investment distortions.

To quantify the proportion of the disparity in these variables accounted for by the model, we compute the mean and standard errors across 100 simulations and the ratio between the Gini coefficient in the model and the one in the data. Looking at Table 11, the model accounts for 90% of the observed disparity in investment rates and 80% of the observed disparity in income.

Considering the steady state analysis in Section 3, it is not surprising that the model fits better the disparity in investment rates than the disparity in income. In particular, Figure 10 shows that the disparity in relative investment rates and relative distortions fall over time, while the disparity in income is roughly constant or slightly decreasing during the sample period. This suggest that there are other important features of real economies that our basic model is abstracting from. The accounting exercise pursued in O'Neill (1995) suggests that considering skill biased technological change could potentially reconcile the patterns of disparity between the model and the data, but this is beyond the objective of this paper.

4.3 Results about Mobility

Table 12 shows the mobility matrix of relative investment rates for the model and the data.[4] The model reproduces fairly well the numbers in the whole matrix, in particular those in the main diagonal that represent the degree of persistence. If anything, the model produces more mobility from countries with low investment rates to very high rates (number in the

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[4] The mobility matrices are calculated from 1960 to 1985. The range of the bins are 1=[0, 1/8], 2=[1/8, 1/4], 3=[1/4, 1/2], 4=[1/2, 1], and 5=[1, 2].

upper right cells in the matrix), but the overall results seem to be promising.

On the other hand, Table 13 shows the mobility matrix of relative income for the model and the data.[5] Looking at the main diagonal, the size of the numbers is smaller in the model, showing less persistence than in the data. Moreover, the numbers are even smaller at the extremes (specially the first bin corresponding to the poorest countries in the distribution), being consistent with the decrease in disparity and the convergence to the middle generated by the model. Again, we conclude that other important sources of variation in income across countries are missing in our model.

5 Conclusions

Differences in the relative price of investment over consumption goods across countries are big, and this conclusion is not affected by excluding non-tradable consumption goods. We interpret these differences as arising from differences in a wide range of policies that increase the cost of investment. Under this interpretation, we show that investment distortions are negatively correlated with investment rates and income per worker in a cross section of countries. The story behind this observation is simple: Poor countries invest a smaller fraction of their income because agents face higher investment distortions.

The standard growth model is a natural framework to test quantitatively the previous hypothesis. We show that the steady state relation between relative investment distortions and relative investment rates predicted by the model closely resembles what we observe in the data in terms of disparity and mobility. Moreover, we simulate a calibrated version of the model in which distortions follow a stochastic process common to all countries and obtain statistics for investment rates that match surprisingly well the data. In particular, the model accounts for around 90% of the final disparity in relative investment rates.

We think that this result is important by itself and summarizes the main contribution of the paper. We have been able to generate endogenously the differences in investment rates used in most exercises of development accounting (as in Mankiw, Romer and Weil (1992)) using a simple growth model with distortions, measuring these distortions from the data, and comparing the implications of the model with the data in a systematic way.

The model, however, does not do such a good job in accounting for the income disparity across countries and its evolution over time. The steady state relation between investment distortions and income per worker can only come close to the data by increasing the capital share in the production function to around 2/3. That would imply to assume that there is accumulation of some unmeasured capital facing the same distortions as physical capital, an assumption that we believe to be extreme. But even in this case the model cannot reproduce the observed mobility in the distribution of relative income.

This failure of the model as a theory of development comes at least from two sources. First, it is a well known fact that the connection between investment rates and income per worker is weak in the standard growth model. We need a lot more than the observed differences in investment rates to explain the wide disparity in income across countries. Models that extend the features of the simple standard growth model may have a better chance

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[5] Again. the mobility matrices are calculated from 1960 to 1985. The range of the bins are now 1=[0, 1/8], 2=[1/8, 1/4], 3=[1/4, 1/2] and 4=[1/2, 1].

in accounting for the disparity in the data. For example, Parente, Rogerson, and Wright (1997) and Restuccia (1998) consider additional features to the standard neoclassical model that prove to be quantitatively important in amplifying the income effects of distortionary policies. Second, the disparity in investment distortions and investment rates are falling over the sample period, while the disparity in income per worker is roughly constant or slightly decreasing at the end of the period. We argue that a version of our model with skill biased technical change can at least qualitatively reconcile the time pattern predictions of income disparity between the model and the data.

References

[1] Anderson, T. and L. Goodman. "Statistical Inference about Markov Chains." *Annuals of Mathematical Statistics* vol. 28, 1957.

[2] Chari, V. V., P. Kehoe, and E. McGrattan. "The Poverty of Nations: A Quantitative Exploration." Staff Report 204. Federal Reserve Bank of Minneapolis, 1996.

[3] De Long, B. and L. Summers. "How Strongly do Developing Economies Benefit from Equipment Investment?" *Journal of Monetary Economics* vol. 32, 1993.

[4] Holmes, T. and J. Schmitz. "Resistance to New Technology and Trade between Areas." *Federal Reserve Bank of Minneapolis, Quarterly Review* vol. 19, 1995.

[5] Jones, C. "Economic Growth and the Relative Price of Capital." *Journal of Monetary Economics* vol. 34, 1994.

[6] Jones, L. and R. Manuelli. "A Convex Model of Equilibrium Growth: Theory and Policy Implications." *Journal of Political Economy* vol. 98, 1990.

[7] King, R. and S. Rebelo. "Public Policy and Economic Growth: Developing Neoclassical Implications." *Journal of Political Economy* vol. 98, 1990.

[8] Kravis, I., R. Heston, and R. Summers. *World Product and Income: International Comparisons of Real Gross Product*. Johns Hopkins, 1982.

[9] Mankiw, G., D. Romer, and D. Weil. "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics* vol. 107, 1992.

[10] McGrattan, E. "Solving the Stochastic Growth Model with a Finite Element Method." *Journal of Economic Dynamics and Control* vol. 20, 1996.

[11] O'Neill, D. "Education and Income Growth: Implications for Cross-Country Inequality." *Journal of Political Economy*. 1995. Vol. 103(6): 1289-1301.

[12] Parente, S. and E. C. Prescott. "Changes in the Wealth of Nations." *Federal Reserve Bank of Minneapolis Quarterly Review* vol. 17, 1993.

[13] Parente, S, R. Rogerson, and R. Wright. "Homework in Development Economics: Household Production and the Wealth of Nations." Mimeo. Department of Economics. University of Pennsylvania. 1997.

[14] Parente, S. and E. C. Prescott. "Barriers to Technology Adoption and Development." *Journal of Political Economy* vol. 102, 1994.

[15] Restuccia, D. "Technology Adoption and Schooling: Amplifier Income Effects of Policies Across Countries ". University of Minnesota. Mimeo, 1998.

[16] Sarel, M. "Relative Prices, Economic Growth, and Tax Policy." Working Paper 113. International Monetary Fund, 1995.

[17] Summers, R. and A. Heston. "The Penn World Table (Mark 5): and Expanded Set of International Comparisons, 1950-1988." *Quarterly Journal of Economics,* 1991.

Table 1: Summary Statistics: Investment Distortions (RDIST)

year	Min5	Max5	Ratio	Mean	Gini
60	0.67	7.62	11.3	2.11	0.35
65	0.79	7.30	9.3	2.07	0.33
70	0.86	7.26	8.5	2.07	0.33
75	0.84	6.14	7.4	1.95	0.29
80	0.84	6.61	7.9	1.93	0.29
85	0.91	5.88	6.5	1.97	0.26

Table 2: Disparity in Investment Distortions (RDIST)

Sample: (N=size)	Max.	Min.	Ratio
S-H data (N=152)	8.4	0.77	11.0
R-U (N=125)	8.4	0.85	9.9
S-H Benchm. (N=64)	8.4	0.88	9.5
S-H Benchm. $\frac{P_I}{P_{C(tradables)}}$	6.8	0.62	11.0

Table 3: 21 years Mobility Matrix for RDIST

		1981-85				
	bin	1	2	3	4	5
1960 -64	1	0.3750	0.5000	0.1250		
	2	0.1316	0.4737	0.3421	0.0526	
	3	0.0270	0.1892	0.6216	0.1622	
	4		0.0833	0.4583	0.4167	0.0417
	5			0.2000	0.3000	0.5000

Table 4: Cell-by Cell Changes in Relative Investment Rates

bin	1	2	3	4	5
1	0.8992	0.7777	0.9746		
2	0.9599	1.1822	0.8730	0.4834	
3	1.0818	1.7026	1.5735	0.8718	
4		2.0753	2.4078	1.8888	0.8590
5			3.6784	2.1832	0.9126

Table 5: Cell-by Cell Changes in Relative Income

bin	1	2	3	4	5
1	1.3393	1.6729	1.1034		
2	1.2974	1.4246	1.4076	1.0112	
3	2.3023	1.7457	1.5013	1.1303	
4		1.1230	1.2528	1.2360	1.9896
5			1.1003	0.9926	0.9235

Table 6: Regression Results

(Standard Errors in Parenthesis)

Year	β_0	β_1	R^2
60	0.02	-1.09	0.50
	(0.077)	*(0.0096)*	
65	-0.01	-1.10	0.53
	(0.072)	*(0.0093)*	
70	0.27	-1.18	0.61
	(0.065)	*(0.0085)*	
75	0.35	-1.08	0.51
	(0.068)	*(0.0094)*	
80	0.22	-0.98	0.47
	(0.064)	*(0.0091)*	
85	0.22	-1.36	0.69
	(0.058)	*(0.0081)*	

Table 7: Parameter Values

Param	Value
σ	1.50
β	0.94
α	0.70
δ	0.06
g	0.019
n	0.023

Table 8: Estimated Yearly Transition Matrix for Investment Distortions

$1+\theta$	0.8	1.2	1.8	3.2	6.3
0.8	0.9348	0.0652			
1.2	0.0170	0.9485	0.0345		
1.8		0.0182	0.9650	0.0168	
3.2		0.0013	0.0463	0.9476	0.0048
6.3			0.0058	0.0310	0.9632

(raised to the 21^{st} power)

$1+\theta$	0.8	1.2	1.8	3.2	6.3
0.8	0.3181	0.4689	0.1920	0.0206	0.0005
1.2	0.1222	0.4706	0.3517	0.0537	0.0017
1.8	0.0266	0.1875	0.6166	0.1613	0.0080
3.2	0.0095	0.0897	0.4513	0.4061	0.0434
6.3	0.0026	0.0308	0.2074	0.2896	0.4696

Table 9: Statistics for Relative Investment Rate

Generated by the model - Average of 100 simulations

year	Min10	Max10	Ratio	Mean	Gini
60	0.09	1.77	17.9	0.82	0.32
65	0.12	1.73	14.5	0.81	0.30
70	0.14	1.68	12.1	0.79	0.29
75	0.16	1.64	10.9	0.78	0.28
80	0.17	1.61	9.9	0.77	0.27
85	0.17	1.57	9.3	0.76	0.27

From Summers and Heston Data

year	Min10	Max10	Ratio	Mean	Gini
60	0.09	1.64	18.7	0.74	0.37
65	0.10	1.44	14.4	0.69	0.35
70	0.13	1.71	12.7	0.87	0.34
75	0.18	1.96	10.9	0.98	0.31
80	0.17	1.61	9.7	0.89	0.28
85	0.13	1.37	10.5	0.69	0.30

Table 10: Statistics for Relative Income

Generated by the model - Average of 100 simulations

year	Min10	Max10	Ratio	Mean	Gini
60	0.03	0.79	27.1	0.24	0.50
65	0.05	0.83	17.3	0.28	0.46
70	0.05	0.88	16.9	0.32	0.43
75	0.05	0.94	17.8	0.36	0.41
80	0.05	0.99	18.3	0.39	0.40
85	0.06	1.05	18.6	0.43	0.39

From Summers and Heston Data

year	Min10	Max10	Ratio	Mean	Gini
60	0.03	0.77	24.5	0.24	0.49
65	0.03	0.79	26.7	0.25	0.50
70	0.03	0.83	27.1	0.27	0.49
75	0.04	0.91	26.0	0.31	0.49
80	0.03	0.95	27.9	0.33	0.48
85	0.03	0.86	26.2	0.31	0.48

Table 11: Gini Coefficient - 100 Simulations

Relative Income

year	Mean	Std	Data	Ratio
60	0.50	0.00	0.49	1.02
65	0.46	0.00	0.50	0.92
70	0.43	0.00	0.49	0.88
75	0.41	0.01	0.49	0.84
80	0.40	0.01	0.48	0.83
85	0.39	0.01	0.48	0.81

Relative Investment Rate

year	Mean	Std	Data	Ratio
60	0.32	0.00	0.37	0.87
65	0.30	0.01	0.35	0.86
70	0.29	0.01	0.34	0.85
75	0.28	0.02	0.31	0.85
80	0.27	0.02	0.28	0.96
85	0.27	0.02	0.30	0.90

Table 12: Mobility Matrices for Relative Investment Rates

Generated by the Model

bin	1	2	3	4	5
1	0.3000		0.5000	0.1000	0.1000
2				0.6667	0.3333
3		0.0526	0.3684	0.4737	0.1053
4		0.0294	0.1471	0.5588	0.2647
5		0.0893		0.4107	0.5000

From Summers and Heston Data

bin	1	2	3	4	5
1	0.3077		0.4615	0.2308	
2		0.3333	0.3333	0.3333	
3		0.1154	0.3462	0.4615	0.0769
4		0.0769	0.1282	0.6154	0.1795
5			0.0526	0.4211	0.5263

Table 13: Mobility Matrices for Relative Income

Generated by the Model

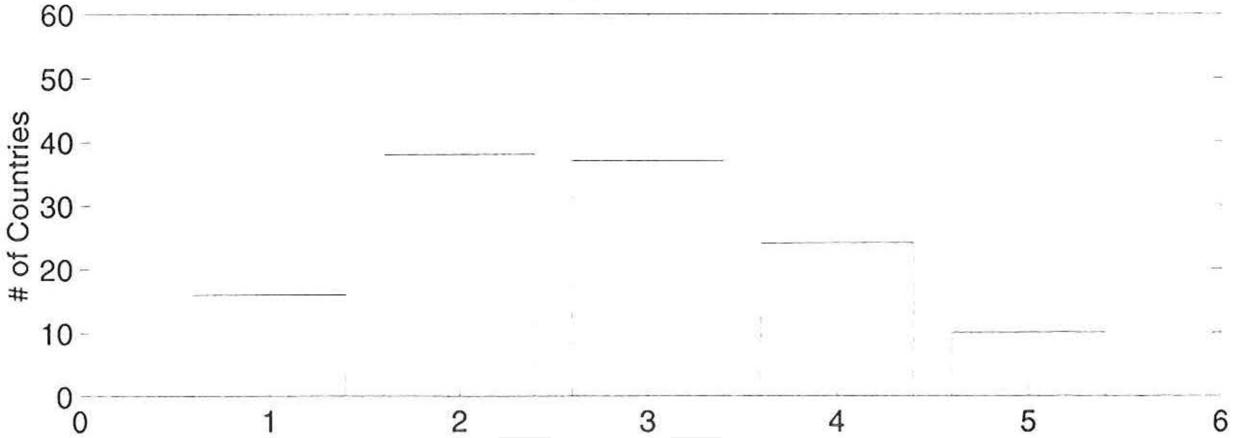
bin	1	2	3	4
1	0.3137	0.2745	0.3922	0.0196
2	0.0571	0.1429	0.4000	0.4000
3	0.0500	0.0500	0.4000	0.3500
4		0.0526	0.2105	0.6316

From Summers and Heston Data

bin	1	2	3	4
1	0.7736	0.2075	0.0189	
2	0.0294	0.3824	0.5000	0.0882
3		0.0526	0.5263	0.4211
4			0.0526	0.9474

Figure 1: Distribution of Relative Distortions

(a) 1960–64



(b) 1981–85

Figure 2: Persistence of Changes in Investment Distortions

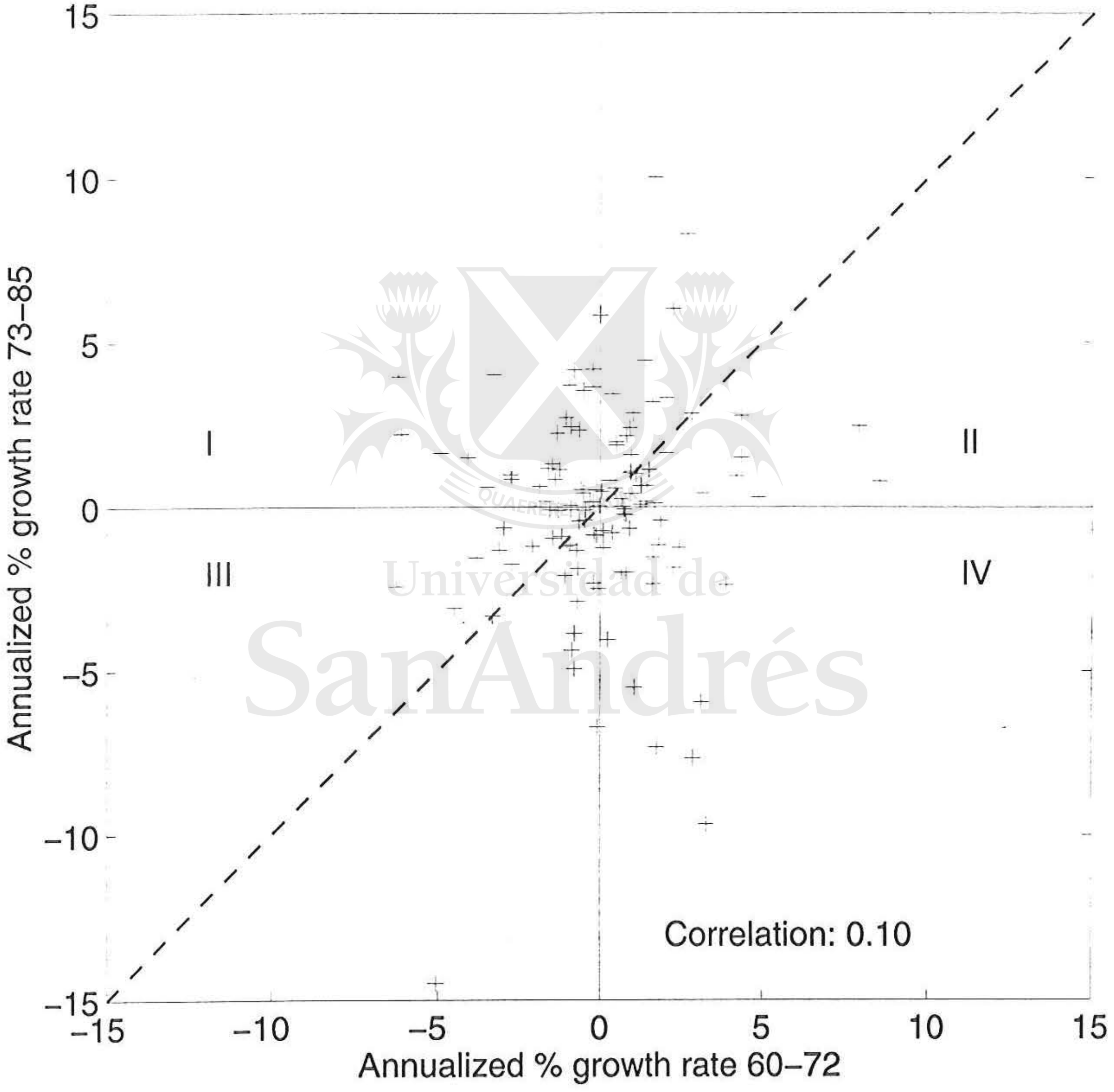


Figure 3: Investment/GDP at Domestic Prices and Relative Income

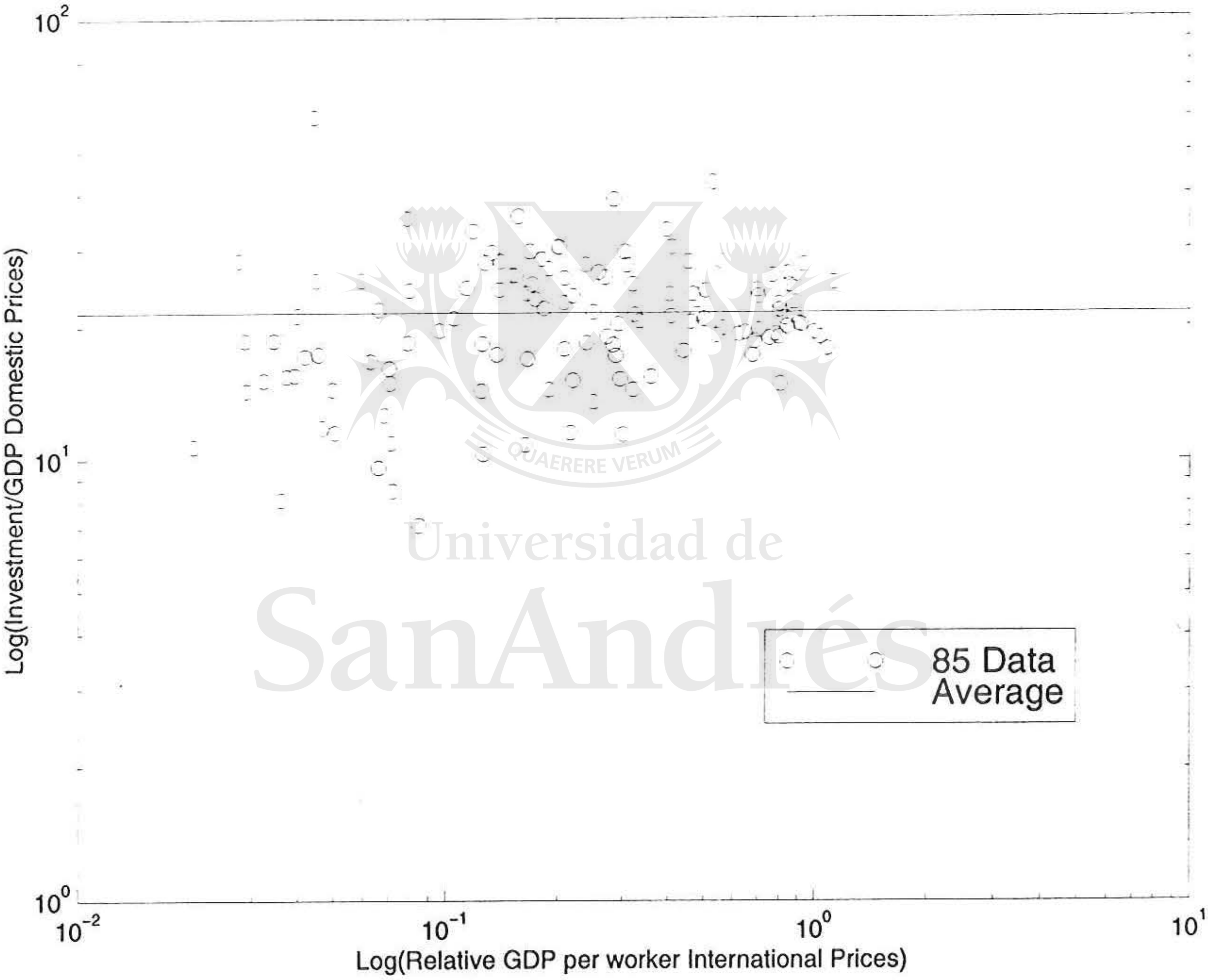


Figure 4: Investment/GDP at International Prices and Relative Income

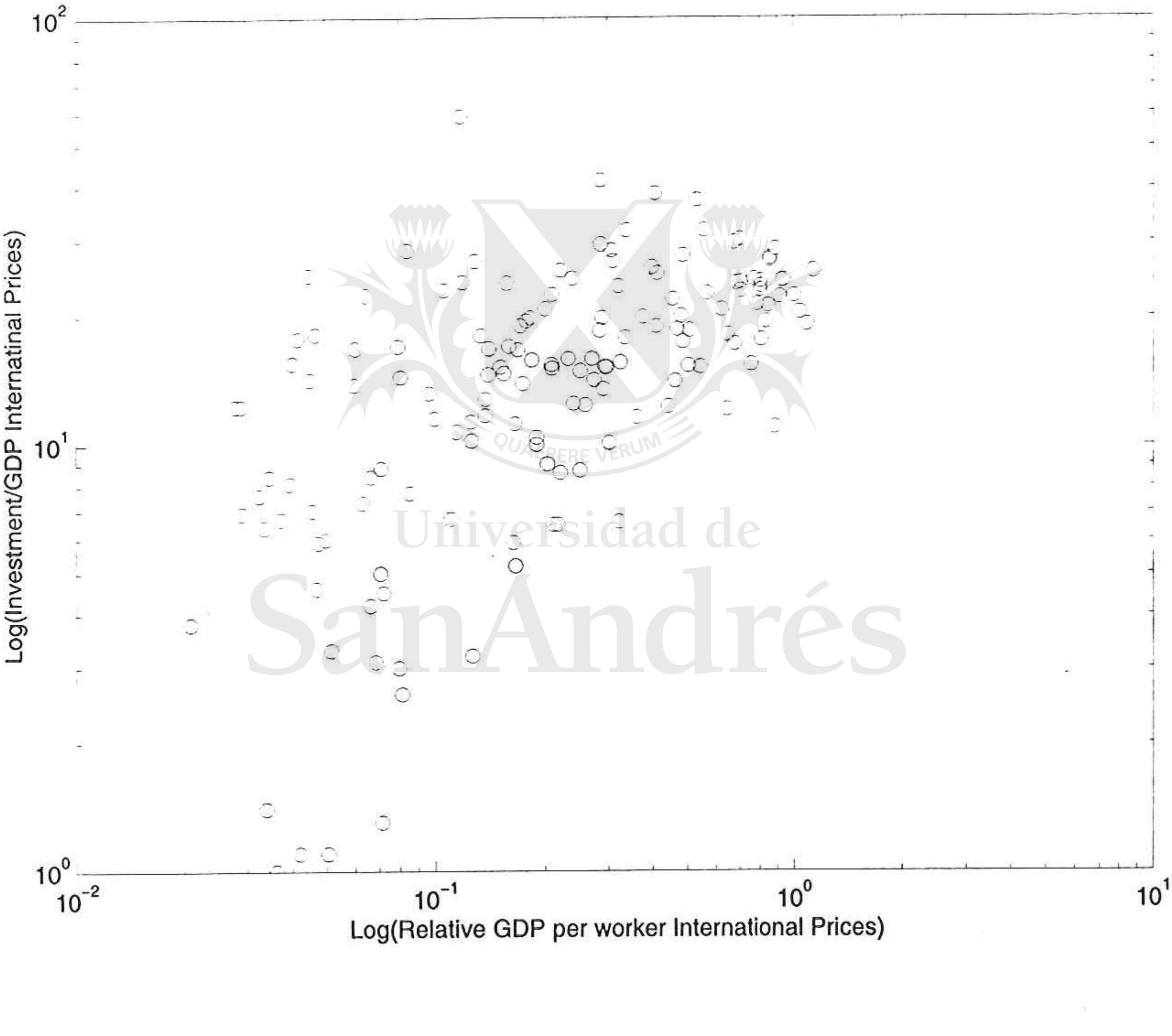


Figure 5: Distortions and Relative Investment Rates

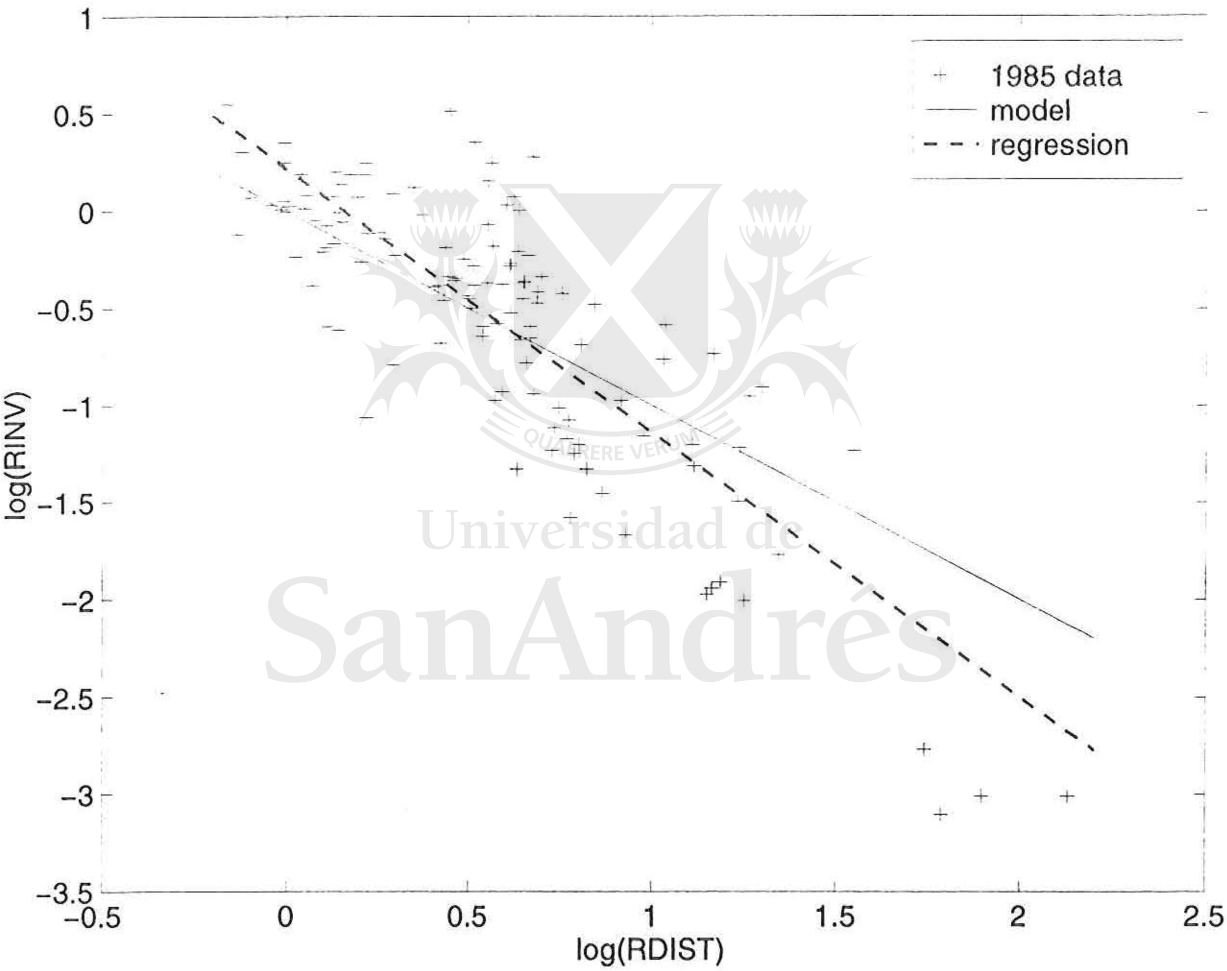


Figure 6: Distortions and Relative Income

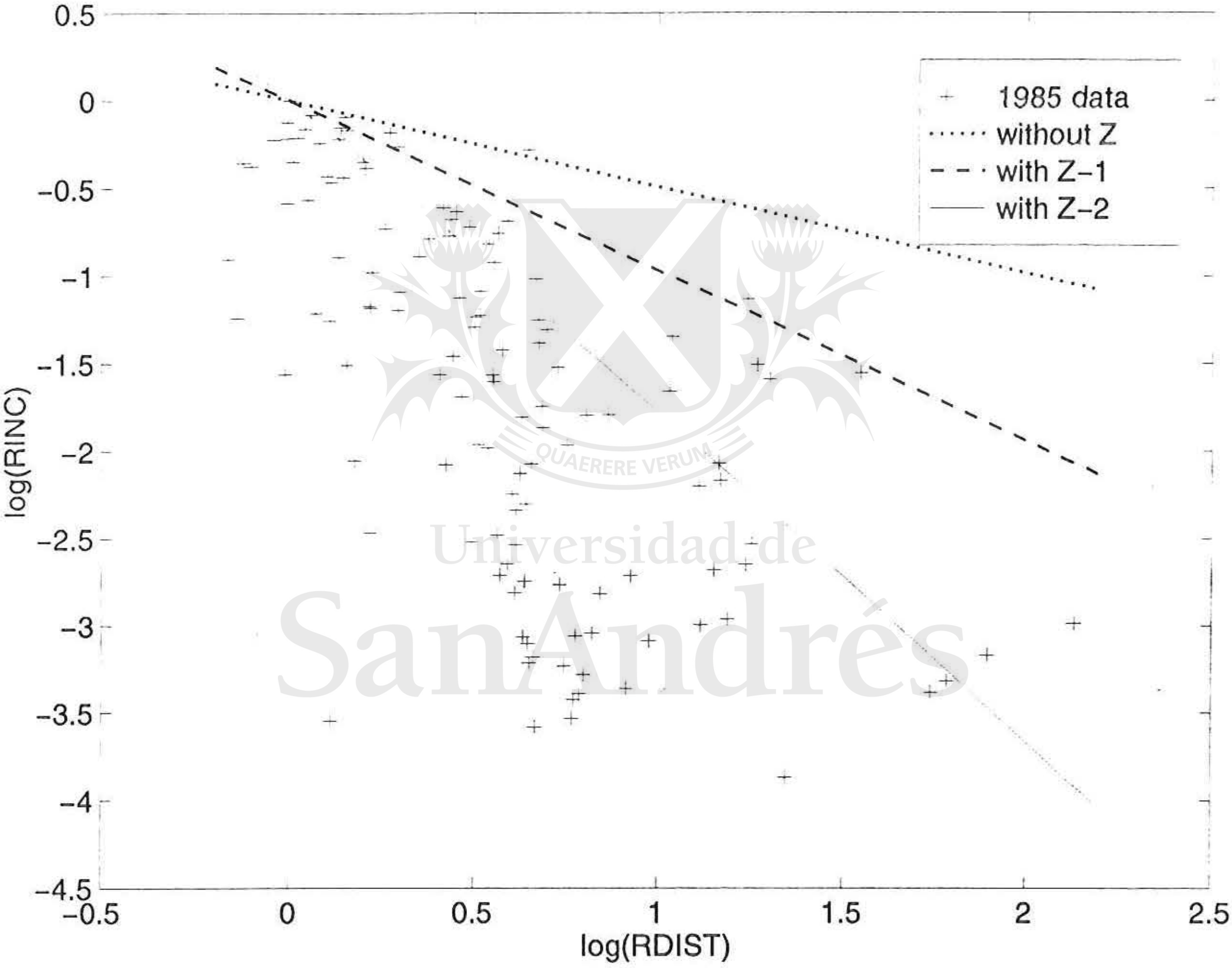


Figure 7: Evolution of Relative Investment Rates

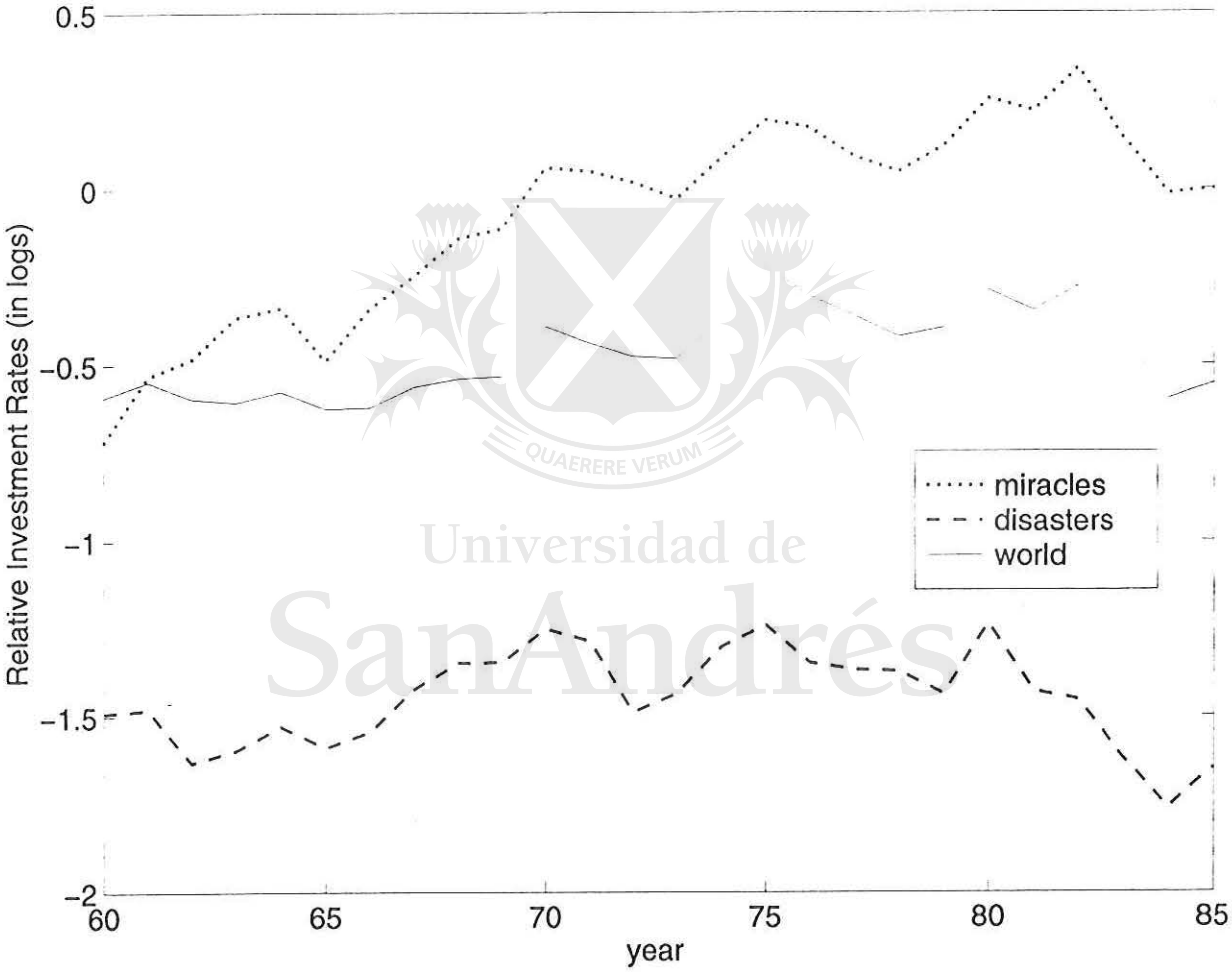


Figure 8: Evolution of Relative Investment Distortions

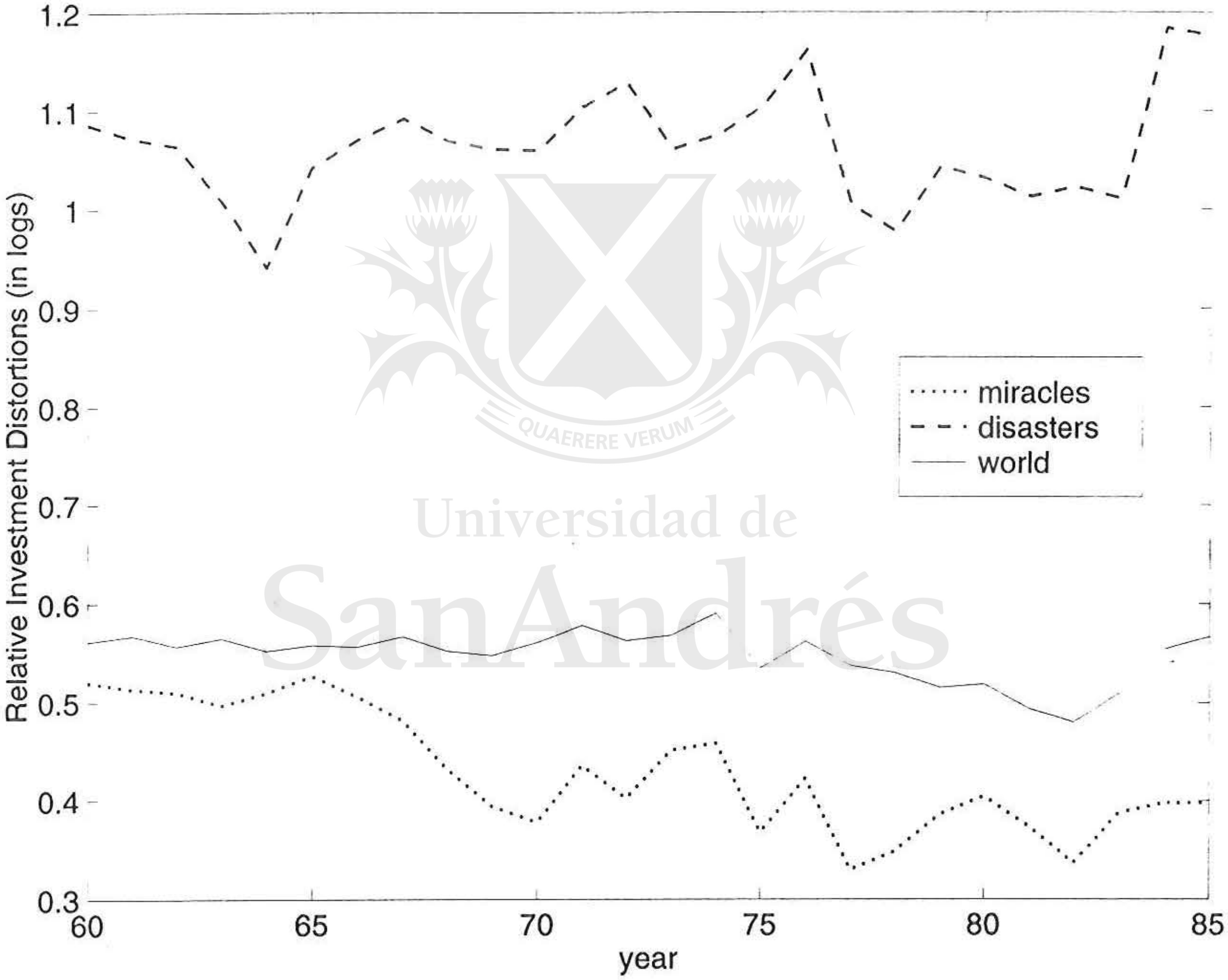
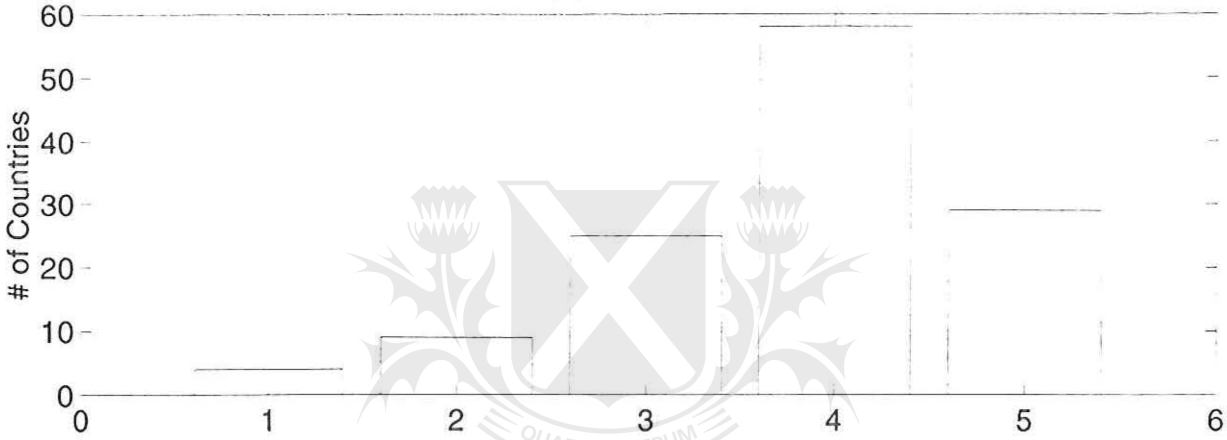


Figure 9: Final Distribution of Relative Investment Rates

(a) in SH Data



(b) in the Model

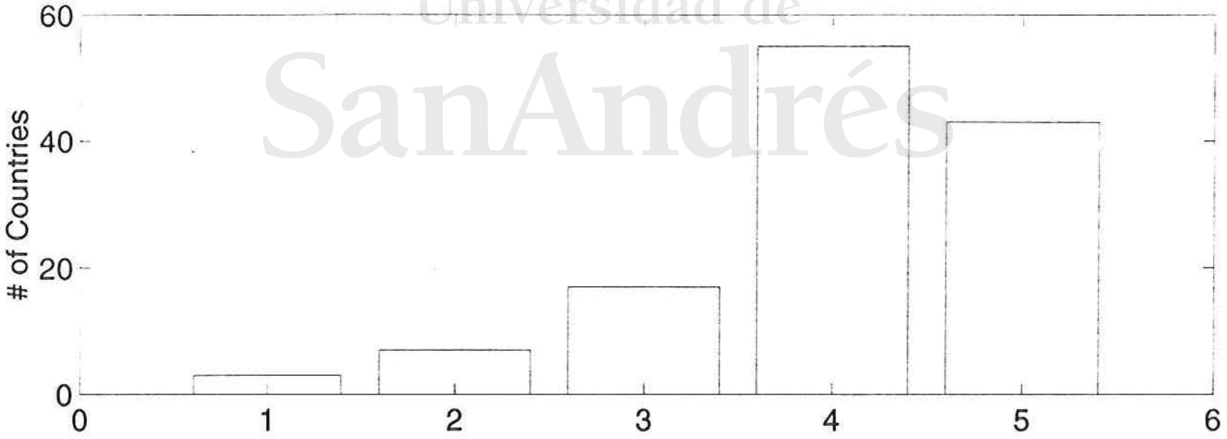


Figure 10: Evolution of the Disparity in the Data