Relative Prices and Relative Prosperity

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The positive correlation between real investment rates and real income levels across countries is driven largely by differences in the price of investment relative to output. The high relative price of investment in poor countries is due to the low price of consumption goods in those countries. Investment prices are no higher in poor countries. Thus, the low real investment rates in poor countries are not driven by high tax or tariff rates on investment. Poor countries, instead, appear to be plagued by low efficiency in producing investment goods and in producing consumer goods to trade for them. (*JEL* E22, E23, O16, O47)

One of the strongest relationships established in the empirical growth literature is the positive correlation between the investment rate in physical capital and the level of output per worker. As illustrated by Figure 1, a well-known stylized fact is that the real investment rate of wealthy countries such as Norway and the United States is roughly two to three times higher than that of poor countries such as Mali and Kenya. This positive correlation also holds when considering the growth rate, rather than the level, of output per worker.[1] Based on this evidence, empirical work accounting for why some countries are rich and others are poor has assigned an important role to differences in physical capital intensity.[2]

Two broad sets of explanations have been proposed for the low real investment rates in poor countries. The first set of explanations operates through savings rates (combined with limited international capital mobility). Prime examples are theories in which poor countries have low savings because of institutions and policies that result in high effective tax rates on capital income (e.g., financial repression).[3] Other authors have argued that poor countries are stuck in low-savings traps because of subsistence consumption needs.[4] Regardless of the underlying mechanism, the notion that poor countries have low savings was central to the way development economists in the 1950s and 1960s thought about the problem of development, and was an important intellectual foundation for the lending work of institutions like the World Bank.

A second set of explanations focuses on forces directly affecting investment. A number of recent papers argue that poor countries have policies that drive up the cost of capital. According to this view, poor countries have low real investment rates because they tax capital goods, have barriers to capital goods imports, or grant monopoly rights to domestic capital goods pro-

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[1] Ross Levine and David Renelt (1992) single out the investment rate as the lone robust correlate with growth in income per person. Xavier Sala-i-Martin (1997) finds the investment rate to be significantly correlated with growth in 99.97 percent of the 32,509 cross-country regressions he ran with investment alongside other regressors.

[2] See N. Gregory Mankiw, David Romer, and David N. Weil (1992), Klenow and Andrés Rodríguez-Clare (1997), and Robert E. Hall and Charles I. Jones (1999).

[3] See Ronald I. McKinnon (1973). Poor countries have also been hypothesized to have low savings rates because of high dependency ratios (Matthew Higgins and Jeffrey G. Williamson 1997), high discount rates (Christopher D. Carroll, Byung-Kun Rhee, and Chang-Yong Rhee 1994), and high explicit tax rates on capital income (William Easterly and Sergio Rebelo 1993).

[4] The earliest papers were by Richard R. Nelson (1956) and Robert M. Solow (1956). More recent papers include Mark Gersovitz (1983), Kiminori Matsuyama (1992), and Dan Ben-David (1998).

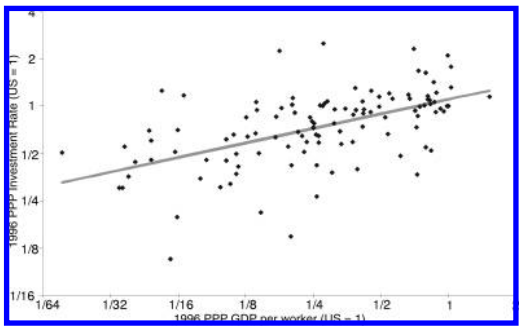

FIGURE 1. INVESTMENT RATES AT *INTERNATIONAL* PRICES

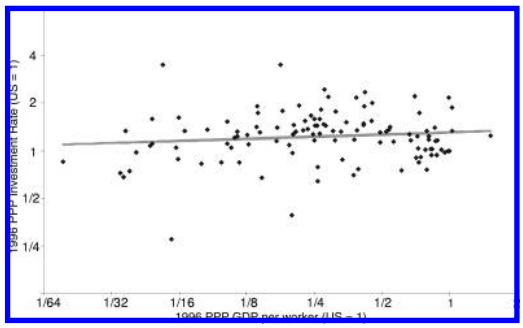

FIGURE 2. INVESTMENT RATES AT *DOMESTIC* PRICES

ducers. Advocates typically point to the fact that the relative price of capital is two to three times higher in a poor country than in a rich country.[5] Investment distortions have also played a prominent role in historical accounts of countries that have experienced dramatic reversals of fortune.[6]

In this paper, we present a series of facts to shed light on the underlying causes of differences in real investment rates across rich and poor countries. The first fact involves the rate of investment at international prices versus at domestic prices. When evaluated at domestic prices, richer countries have only modestly higher investment rates than poorer countries do.[7] Figure 2 illustrates this for 114 countries in 1996. Whereas the correlation between the purchasing power parity (PPP) investment rate and PPP income is 0.50, that between the domestic-price investment rate and PPP income is only 0.05. At domestic prices, poor countries do not invest much less than rich countries do. This evidence suggests that explanations involving discount rates, subsistence consumption, low-savings traps, and the taxation of capital income can account for only a small part of the difference in capital intensity between rich and poor countries. Instead, the domestic relative price of investment—which accounts for the difference between investment rates at domestic prices versus at international prices—is much higher in poor countries.

The second stylized fact is that the high relative price of investment in poor countries is driven entirely by the denominator rather than the numerator. We find that investment goods tend to be no more expensive in poor countries than in rich countries, whereas consumption prices tend to be lower in poor countries. This contradicts the hypothesis that investment goods are taxed more heavily in poorer countries, or are subject to high tariffs or transportation costs that make them expensive for poor countries.

To be sure, none of these facts is new. The positive correlation between investment rates (measured in PPP prices) and income and the negative correlation between the relative price of capital and income are two of the most

[5] See Jones (1994), Jong-Wha Lee (1995), V. V. Chari, Patrick J. Kehoe, and Ellen R. McGrattan (1996), McGrattan and James A. Schmitz (1999), William Collins and Williamson (2001), Jonathan Eaton and Samuel Kortum (2001), and Diego Restuccia and Carlos Urrutia (2001).

[6] See Carlos Diaz-Alejandro (1970) and Alan M. Taylor (1998a, 1998b) for the role of investment distortions in Argentina.

[7] We focus on data from 1980, 1985, and 1996 because the Penn World Tables (PWT) has benchmark price data for a large number of countries in these years. The data from nonbenchmark years still provide useful information, however. In particular, the income elasticity of investment rates was generally higher in the 1960s than in recent decades. And, although Stephen L. Parente and Edward C. Prescott (2000, 39) find savings rates to be modestly correlated with income, they are more highly correlated with income than are domestic-price investment rates: 0.43 versus 0.05 in 1996, 0.55 versus 0.17 in 1985, and 0.53 versus 0.23 in 1980. Interestingly, the correlation of savings rates with income has remained unchanged since the 1960s. Since domestic-price investment rates have become much less correlated with income in recent decades, capital flows from rich countries to poor countries must have increased since the 1960s. Clearly, understanding why the investment rates were more highly correlated with income in the past and understanding the distinction between savings and investment rates at domestic prices are important topics for future research.

widely cited stylized facts in the growth literature, starting with Robert J. Barro (1991). Similarly, the low price of consumption goods in poor countries is a well-established fact, known as the "Balassa-Samuelson effect."[8] The last two facts—that investment rates measured in domestic prices are no lower in poor countries and prices of capital goods are no more expensive in poor countries—may not be as well known.[9] It is useful, however, to think about the investment rate measured in domestic prices as the product of the investment rate measured in PPP prices and the relative price of capital, and the price of capital as the product of the relative price of capital and the price of consumption. It should therefore not be surprising that the product of a variable positively correlated with income (investment rate in PPP prices or price of consumption) and a variable negatively correlated with income (the relative price of capital) is only weakly correlated with country income.

While these facts are all individually known, our contribution is to provide a unified explanation for them. Taken together, the facts suggest that savings and investment distortions can account for only a small part of the differences in physical capital intensity across countries. Instead, the facts point to important differences in sectoral productivity across countries. Poor countries appear to have low investment rates in PPP terms primarily because they have either low productivity in producing investment goods or low productivity in producing tradables to exchange for investment goods. This interpretation does not require investment goods to be entirely tradable, but does require that the share of nontraded services be larger in consumption goods than in investment goods. To the extent investment goods are easier to trade than are consumption goods, however, this is a corollary to the Balassa-Samuelson hypothesis that poor countries have low productivity in tradables relative to nontradables.

Eaton and Kortum (2001) provide an alternative interpretation for the high relative price of capital and low price of consumption in poor countries. In their framework, both consumption and investment goods are tradable, but transportation costs prevent prices from equalizing across countries. In addition, they assume that poor countries are completely specialized in producing consumption goods (and import investment goods from rich countries), while rich countries produce both consumption and investment goods (and import consumption goods from poor countries). Price differences across countries are determined by trade barriers and by a country's specialization in production. Consumption goods are therefore more expensive in rich countries simply because rich countries face barriers in importing consumption goods from poor countries. Similarly, the relative price of capital is higher in poor countries simply because poor countries face barriers in importing capital goods from rich countries, and because consumption goods are cheaper in poor countries. Eaton and Kortum's model thus captures the fact that consumption prices are cheaper in poor countries, but is inconsistent with the fact that the absolute price of capital does not appear to be any higher in poor countries.

Trade frictions play no role in our story. Instead, we argue that the high relative price of capital in poor countries is entirely due to poor countries' low productivity in producing investment goods and in producing tradable goods in exchange for investment goods (relative to their productivity in the nontradable service sector). This interpretation is consistent with the two key facts about the cross-country pattern in prices—that consumption good prices are lower in poor countries and that investment goods prices are no higher in poor countries.

Our results thus imply that the correlation of physical capital investment rates and income arises from a deeper productivity puzzle. The challenge is to explain not only low overall productivity in poor countries, but also low productivity in investment goods (or in providing consumption goods to trade for investment goods) relative to consumption goods.

The rest of this paper proceeds as follows. In Section I we present models in which a country's investment rate and income level are endogenous to its tax rate on capital income, its tax rate on producing and importing investment goods, and its productivity in producing investment and consumption goods. In Section II we

[8] See Bela Balassa (1964) and Paul A. Samuelson (1964), and also Jagdish N. Bhagwati (1984). Robert Summers and Alan Heston (1991) further document this phenomenon, using services as a proxy for nontradables. And see figure X in Barro (1991).

[9] But see figure XI in Barro (1991).

compare the predictions of the model to Penn World Trade (PWT) benchmark data on investment prices, consumption prices, income levels, and investment rates. In Section III, we discuss the impact of possible measurement error in the international price data. In Section IV we summarize.

I. Models with Endogenous Investment Rates and Income Levels

We begin by considering a simple model with two sectors and two taxes: a nontraded consumption sector, a tradable investment sector, a tax on retail sales of investment goods, and a tax on capital income. Aside from having separate consumption and investment sectors, it is a conventional neoclassical growth model. We use this simple model to illustrate how the two taxes and productivity levels affect a country's price of investment, price of consumption, PPP investment rate, and PPP income per worker. We then consider a more complicated model that introduces a tradable consumption sector and a nontradable investment sector. In this setup, countries with a comparative advantage in tradable investment goods (presumably rich countries) export capital goods in exchange for consumption goods produced by countries with a comparative advantage in tradable consumer goods (presumably poor countries).

A. *A Model with Tradable Investment and Nontraded Consumption*

We begin by laying out the simple two-sector model. The production technologies in the consumption and investment sectors in country j are

$$C^j = A_C^j (K_C^j)^\alpha (L_C^j)^{1-\alpha} \quad \text{and} \tag{1}$$

$$I^j = A_I^j (K_I^j)^\alpha (L_I^j)^{1-\alpha}. \tag{2}$$

The variables A_C^j and A_I^j are exogenous productivity indices that grow at the constant rate g_A across sectors and across countries. The parameter $\alpha \in (0, 1)$ is the elasticity of output with respect to physical capital, and $(1 - \alpha)$ that with respect to labor. For simplicity, we assume these elasticities are the same across countries and across sectors. We also assume that the aggregate endowment of labor is given by $L^j = L_C^j + L_I^j$ and the aggregate capital stock is given by $K^j = K_C^j + K_I^j$.

We will assume that consumption goods cannot be traded internationally, whereas investment goods are fully tradable. Empirically, some consumption is in fact tradable (e.g., clothing and cars) and even tradable investment goods have a nontradable component (e.g., some distribution and retail services). For expositional simplicity, we will first model the polar case of purely nontradable consumption and tradable investment. However, we will relax these assumptions in the next section by introducing nontradable investment goods and tradable consumption goods that can be exchanged for (traded) investment goods.

We model the investment distortion as a tax τ_I^j levied on sales of investment goods at the *retail* level. Specifically, we assume that all producers of investment goods sell their products at a fixed wholesale price determined in world markets. In turn, the wholesaler sells capital goods to firms wishing to invest, at which point the government in country j imposes a sales tax at rate τ_I^j. We thus denote the pre-tax wholesale price of investment goods by $P_I^j/(1 + \tau_I^j)$, where P_I^j represents the after-tax price of investment goods at the retail level.[10]

We assume that consumption and investment goods are produced by representative firms facing competitive output and input markets. The current profits of firms producing consumption and investment goods are, respectively:

$$\pi_C^j = P_C^j C^j - w^j L_C^j - R^j K_C^j; \tag{3}$$

$$\pi_I^j = \frac{P_I^j}{1 + \tau_I^j} I^j - w^j L_I^j - R^j K_I^j. \tag{4}$$

Here, P_C^j denotes the price of consumption goods, w^j denotes the wage, R^j represents the rental price of capital, and C^j and I^j are given by equations (1) and (2). Assuming that firms maximize profits, one can show that

$$R^j = \alpha \left(\frac{P_I^j}{1 + \tau_I^j} \right) A_I^j \left(\frac{K^j}{L^j} \right)^{\alpha - 1} \quad \text{and} \tag{5}$$

[10] We assume the wholesaler does not provide any services. In the next section we relax this assumption.

$$\frac{P_C^j}{P_I^j} = \frac{A_I^j}{A_C^j(1 + \tau_I^j)}. \tag{6}$$

Equation (5) equates the rental price of capital R to the marginal product of capital. Marginal products in the two sectors are equated to the common rental price. This implies a common capital-labor ratio in the two sectors equal to the economy-wide K/L. Expression (6) says the domestic price of consumption relative to investment is inversely related to relative total factor productivity (TFP) in the two sectors, and decreasing in the tax rate on producing and importing investment goods. The relative price does not depend on the wage or real interest rate because both sectors face the same factor prices and use factors with the same intensity.

Finally, we model the savings distortion as a tax τ_K on income from domestically located capital. Specifically, we assume that each worker supplies one unit of labor inelastically and chooses current consumption to maximize

$$\sum_{t=0}^{\infty} \beta^t \frac{[C^j(t)]^{1-(1/\sigma)}}{1 - (1/\sigma)}$$

subject to the constraints

$$K^j(t + 1) = (1 - \delta)K^j(t) + I^j(t), \tag{7}$$

$$P_C^j(t)C^j(t) + P_I^j(t)I^j(t) = w^j(t) + [R^j(t) - \tau_K^j(R^j(t) - \delta P_I^j(t))]K^j(t) + T^j(t),$$

$$\text{and} \qquad R^j(t) = \frac{r^j(t) + \delta - \delta\tau_K^j}{1 - \tau_K^j} P_I^j(t).$$

β is the discount factor, σ is the intertemporal elasticity of substitution, τ_K^j is the capital income tax, r^j is the real interest rate, and $T^j \equiv \tau_I^j P_I^j/(1 + \tau_I^j)I^j + \tau_K^j(R^j - \delta P_I^j)K^j$ are government transfers (lump-sum rebates of tax revenue).

The discount rate (β), intertemporal elasticity (σ), and depreciation rate (δ) are the same in all countries. Sectoral TFP grows at the constant rate g_A across sectors and across countries. What we allow to vary across countries are the tax rate on capital income (τ_K), the tax rate on producing and importing investment goods (τ_I), TFP in the investment sector (A_I), and TFP in the consumption sector (A_C). TFP ascends parallel paths, but can differ across countries and across sectors at a point in time.

Steady State.—Variation in τ_K, τ_I, A_I, and A_C generates cross-country variation in steady-state levels of the investment rate at domestic prices and in the domestic price of investment relative to consumption. Because capital income is taxed based on where the capital is located, there is no incentive for international capital flows. Real interest rates are the same in all countries:

$$r^j = (1 + g)^{1/\sigma}/\beta - 1. \tag{8}$$

Here $(1 + g) = (1 + g_A)^{1/(1-\alpha)}$. Expression (8) follows from the consumption Euler equation and the steady-state assumption. As no capital flows internationally, saving and investment rates (at domestic prices) are equal within countries, and countries own their domestic capital stocks.

We now solve for the steady-state values of the model. We use the following definitions:

$$\text{Domestic Price GDP} = P_C^j C^j + P_I^j I^j;$$

$$\text{PPP GDP} = Y^j = P_C C^j + P_I I^j;$$

$$\text{Domestic Price Investment Rate} = i_{\text{dom}}^j = \frac{P_I^j I^j}{P_C^j C^j + P_I^j I^j};$$

$$\text{PPP Investment Rate} = i^j = \frac{P_I I^j}{P_C C^j + P_I I^j}.$$

Here, P_C and P_I (no superscripts) denote the PPP price of consumption and investment. Although any common set of prices could be used as the PPP price, in practice the PPP price provided by the PWT is effectively the price prevailing in rich countries.[11]

[11] The PWT uses a Gheary-Khamis procedure to calculate PPP prices. Specifically, the PPP price of a good, say consumption (the individual goods are finer than this), would be defined as $P_c = \sum_j (P_C^j/E^j) \cdot (C^j/C^w)$, where P_C^j is the domestic currency price of consumption in country j, $C^w = \sum_j C^j$ is world consumption, and $E^j = (P_C^j C^j +$

To determine each country's steady-state path, we proceed as follows. We first solve for the share of labor (and capital) devoted to investment goods production:

$$(9)\quad L_I^j/L^j = \frac{(g+\delta)\alpha(1-\tau_K^j)}{(1+\tau_I^j)[(1+g)^{1/\sigma}/\beta - 1 + \delta(1-\tau_K^j)]}.$$

It is then straightforward to show that the steady-state investment rate at domestic prices is

$$(10)\qquad i_{\text{dom}}^j = \frac{(1+\tau_I^j)L_I^j/L^j}{1+\tau_I^j L_I^j/L^j}.$$

According to (9) and (10), nominal investment rates are affected by the two tax rates, but are unaffected by changes in sectoral TFP.

We can then express the real investment rate as a function of the nominal investment rate and the relative price of capital:[12]

$$(11)\quad i^j = i_{\text{dom}}^j\left[(1-i_{\text{dom}}^j)\frac{P_I^j/P_I}{P_C^j/P_C} + i_{\text{dom}}^j\right]^{-1};$$

$$= i_{\text{dom}}^j\left[(1-i_{\text{dom}}^j)\frac{A_C^j(1+\tau_I^j)}{A_I^j}\cdot\frac{P_C}{P_I} + i_{\text{dom}}^j\right]^{-1}.$$

The second line in (11) expresses the relative price of capital in terms of relative TFP (equation (6)). Intuitively, equation (11) expresses the real investment rate as the product of the nominal investment rate and the price of output relative to capital, where the latter is itself an inverse function of the price of capital relative to consumption.

Given that all of the parameter values lie between 0 and 1, (9), (10), and (11) imply that the investment rates at both domestic prices and at international prices are strictly decreasing in the capital income tax. To see why intuitively, we combine (5) and (7) to arrive at

$$(12)\quad \frac{r+\delta-\delta\tau_K^j}{1-\tau_K^j}(1+\tau_I^j) = \alpha A_I^j\left(\frac{K^j}{L^j}\right)^{\alpha-1}.$$

A higher capital income tax rate raises the left-hand side and the rental price of capital, so the right-hand side and the marginal product of capital must be higher. For a given level of TFP in the investment sector, a higher marginal product of capital requires a lower capital-labor ratio and therefore a lower nominal investment rate. The tax rate on capital income does not affect relative prices by (6), so the investment rate is lower at domestic as well as international prices.

The negative effect of the investment tax on the PPP investment rate follows similar logic. A higher tax rate on investment raises the rental price of capital, necessitating a higher marginal product of capital and a lower PPP investment rate. The negative effect on the investment rate at domestic prices is less transparent. A higher investment tax raises the relative price of investment goods in (6), a force for a higher investment rate at domestic prices. But the adverse effect on the quantity of investment is larger, leaving the domestic-price investment rate lower. From (9), (10), and $\alpha < 1$, the capital-labor ratio must fall proportionately more than the tax-induced increase in the price of investment. As the real capital-labor ratio is proportional to a country's real investment rate (controlling for TFP), the real investment rate must fall more than the price of investment rises, yielding a lower investment rate at domestic prices.[13]

Finally, the investment rate at domestic prices does not depend on sectoral TFP. TFP levels do not affect the investment rate at domestic prices because the quantities and prices of investment and consumption respond in precisely offsetting ways. In contrast, while the PPP investment rate is invariant to equiproportionate changes in sectoral TFP, low TFP in the investment sector *relative* to TFP in the consumption sector does depress a country's real investment rate. It makes investment expensive, just like high taxes on capital income or investment do. Because PPP prices of investment and

$P_I^j I^j)/(P_C C^j + P_I I^j)$ is the PPP exchange rate of country j. In addition, E^{US} is typically normalized to 1 so that the units are US dollars. Because the weights used to aggregate country prices are aggregate quantities, rich country prices are weighted more than poor country prices.

[12] We substitute the nominal and real investment rate definitions into $i^j = i_{\text{dom}}^j \cdot (i^j/i_{\text{dom}}^j)$ to obtain the first line in (11).

[13] For plausible parameter values, we find this negative effect (of the investment tax rate on the domestic price investment rate) to be small. We illustrate this in Figure 3 below.

consumption do not vary across countries, there is no offsetting relative price effect as operates on the investment rate at domestic prices. For the same reason, a higher investment tax rate lowers the PPP investment rate more than it lowers the domestic-price investment rate. In contrast, a higher capital income tax rate does not affect the relative price of investment and therefore has the same (negative) effect on investment rates at domestic and international prices.

How can we determine whether the high relative price of capital in poor countries is driven by high investment distortions or by low productivity in investment goods relative to consumption? This is where the assumption that capital goods are tradable is crucial. Specifically, because capital goods are assumed to be tradable goods, a standard arbitrage condition pins down the *absolute* after-tax price of capital as a function of the pre-tax wholesale price of capital in world markets (which we assume each country takes as beyond its control) and the country-specific tax on retail sales of investment goods:[14]

$$P_I^j = (1 + \tau_I^j). \tag{13}$$

We can then substitute (13) into (6) to obtain the following expression for the price of consumption:

$$P_C^j = \frac{A_I^j}{A_C^j}. \tag{14}$$

In short, the assumption that capital goods are traded implies that τ_I^j affects the relative price of capital only through the price of capital, and that country differences in relative productivity show up entirely as differences in the price of consumption.

Along steady-state paths, PPP output per worker in country j is

$$\frac{Y^j}{L^j} = \left[\frac{K^j}{Y^j}\right]^{\alpha/1-\alpha} [\text{TFP}^j]^{1/1-\alpha}, \tag{15}$$

where $(K^j/Y^j) = i^j/(g + \delta)$. Expression (15) is ready-made for development accounting. In this two-sector model, however, there is no clean demarcation of parameters into those affecting capital intensity versus those affecting aggregate TFP. Take the tax rate on investment goods: according to (9), a higher tax rate on investment goods lowers the share of labor devoted to investment goods production, and hence the PPP investment rate (11) and PPP capital intensity. Unless P_C and P_IA_I happen to be equal in the country, this higher tax rate also affects aggregate TFP. It does so by reallocating labor away from producing investment goods toward producing consumption goods. An easier way to see this is to express economy-wide TFP as

$$\text{TFP}^j = P_C A_C^j \left(1 - \frac{L_I^j}{L^j}\right) + P_I A_I^j \frac{L_I^j}{L^j}. \tag{16}$$

From this expression it is clear that reallocating labor away from investment goods production lowers aggregate TFP if $P_CA_C < P_IA_I$, and raises aggregate TFP if $P_CA_C > P_IA_I$. The use of PPP prices is crucial here. At domestic prices, the marginal product of labor is equated across sectors. At international prices this need not be so.

One can similarly show that sector TFP affects both aggregate TFP and capital intensity. Consider a drop in A_I, holding A_C fixed. This lowers aggregate TFP *and* the PPP investment rate. The lower PPP investment rate means lower PPP capital intensity. TFP in the investment sector matters more than the share of labor devoted to investment would suggest, as it affects capital intensity throughout the economy. That is, the effect of TFP in the investment sector is amplified through its effect on capital accumulation.[15] As we shall see, poor countries appear to have not only lower A_C and A_I than rich countries do (as one would expect), but especially lower A_I. Their low sectoral TFP contributes to their low aggregate TFP, and their low A_I/A_C ratios contribute to their low capital intensity in PPP terms.

In summary, although there are three poten-

[14] We normalize the pre-tax wholesale price of investment goods on world markets to one (i.e., it is our numeraire).

[15] Schmitz (2001) emphasizes this effect in a model with inefficient government production of investment goods.

tial explanations—high investment distortions, high capital income taxes, and low productivity in tradables relative to nontradables—behind the low real rates of investment in poor countries, each force will result in different patterns in the data. A higher capital income tax will lower both the nominal and the real investment rate by the same magnitude, but will have no effect on prices. Higher investment distortions and low TFP in investment relative to consumption will increase the relative price of capital and thus lower the real investment rate, but will either have no effect (in the case of relative TFP differences) or only a small effect on the nominal investment rate (in the case of investment distortions). Finally, although both investment distortions and differences in relative TFP will affect the relative price of capital, investment distortions will affect only the absolute price of capital while relative TFP differences will affect only the price of consumption.

B. *A Model with Both Tradable and Nontradable Consumption and Investment*

Thus far we have made the polar assumption that capital goods are perfectly tradable and that consumption goods are not. We now relax this assumption in three ways. First, we allow for two types of traded goods: consumption goods and producer durables. With this change, countries will now specialize in one of the two tradable sectors: countries with a comparative advantage in consumption goods will export these goods in exchange for imports of producer durables (and vice versa). Second, we allow for the fact that even tradable goods have a nontradable component at the retail level. Third, we assume that in addition to tradable producer durables, investment can also take the form of nontradable structures.

Model Setup.—We assume that every country produces two nontraded goods, services (S^j) and investment structures (I^j_N), and one of the two tradable goods, consumption goods (C^j_T) or producer durables (I^j_T). The production functions of these sectors are

$$C^j_T = A^j_{CT}(K^j_{CT})^{\alpha}(L^j_{CT})^{1-\alpha}; \tag{17}$$

$$S^j = A^j_S(K^j_S)^{\alpha}(L^j_S)^{1-\alpha}; \tag{18}$$

$$I^j_T = A^j_{IT}(K^j_{IT})^{\alpha}(L^j_{IT})^{1-\alpha}; \tag{19}$$

$$I^j_N = A^j_N(K^j_N)^{\alpha}(L^j_N)^{1-\alpha}. \tag{20}$$

We assume that countries are small enough so they produce only one of the two tradable goods (and import the other). Specifically, country j will export consumer goods and import producer durables if the world price of tradable consumption (relative to tradable investment) P_{CT} is greater than country j's TFP in tradable investment relative to its TFP in tradable consumption:[16]

$$\frac{A^j_{IT}}{A^j_{CT}} < P_{CT}.$$

These countries will use resources to produce tradable consumption, which it exchanges in world markets for tradable investment goods at the terms of trade P_{CT} prevailing in world markets. Therefore, country j's production of tradable consumption goods C^j_T has to be equal to the sum of these goods consumed at home $C^j_{T,Home}$ and the value of tradable investment goods used for domestic investment $I^j_{T,Home}$ expressed in units of tradable consumption: $C^j_T = C^j_{T,Home} + I^j_{T,Home}/P_{CT}$.

On the other hand, if country j's productivity in tradable investment relative to tradable consumption is greater than P_{CT}, then it will specialize in producer durables and export these goods in exchange for imports of tradable consumer goods. In this case, country j's production of tradable investment goods I^j_T has to be equal to the sum of tradable investment goods destined for domestic investment $I^j_{T,Home}$ and the value of tradable consumption goods purchased from abroad for domestic consumption $C^j_{T,Home}$ expressed in units of tradable investment: $I^j_T = I^j_{T,Home} + P_{CT}C^j_{T,Home}$.

We will denote the TFP of the tradable sector in country j by A^j_T, defined as

$$A^j_T \equiv \max\{A^j_{CT}P_{CT}, A^j_{IT}\}. \tag{21}$$

[16] Again, we normalize the pre-tax wholesale price of tradable investment in world markets to one.

For countries with a comparative advantage in tradable investment, A_T^j is simply TFP in the tradable investment sector. For countries with a comparative advantage in tradable consumption, A_T^j is the product of TFP in tradable consumption and the terms of trade it faces in world markets. In turn, the world price of tradable consumption is determined by the world supply and demand of tradable consumption goods (relative to world supply and demand of tradable investment goods). Therefore, for a country that exports consumption goods, A_T^j will increase not only when the country's productivity in producing tradable consumption increases, but also when general equilibrium requires a higher world price of tradable consumption goods. For example, an increase in the world demand for tradable consumption goods can have important effects on the relative price of capital in poor countries by improving the terms of trade they face.

We also assume that nontraded services have to be used to make both consumer goods and tradable investment goods available at the retail level. Specifically, consumer goods and producer durables at the retail level (we use a tilde to denote a tradable good at the retail level) are "produced" by combining a traded intermediate good with nontraded retail services:

$$\tilde{C}_T^j = (S_{CT}^j)^{\theta_C}(C_{T,Home}^j)^{1-\theta_C}; \tag{22}$$

$$\tilde{I}_T^j = (S_{IT}^j)^{\theta_I}(I_{T,Home}^j)^{1-\theta_I}. \tag{23}$$

Here, S_{CT} and S_{IT} denote nontraded services in the two sectors, and θ_C and θ_I the shares of nontraded services in the two sectors. Therefore, the following adding-up constraint has to hold:

$$S^j = S_{IT}^j + S_{CT}^j + C_N^j.$$

Here, C_N denotes services used as a final consumption good. The total endowment of labor is given by $L^j = L_{IT}^j + L_N^j + L_{CT}^j + L_S^j$ and the aggregate capital stock by $K^j = K_{IT}^j + K_N^j + K_{CT}^j + K_S^j$. The aggregate capital stock K^j is itself a Cobb-Douglas aggregate of tradable capital (KT^j) and structures (KN^j):

$$K^j = (KT^j)^{\gamma_j}(KN^j)^{1-\gamma_j}. \tag{24}$$

$\gamma_I^j \in (0, 1)$ is the elasticity of aggregate capital with respect to producer durables and $1 - \gamma_I^j$ is the elasticity with respect to structures (we allow these elasticities to vary across countries).

Finally, to close the model, we assume that representative households maximize

$$\sum_{t=0}^{\infty} \beta^t \frac{([\tilde{C}_T^j(t)]^{\gamma_C^j}[C_N^j(t)]^{1-\gamma_C^j})^{1-1/\sigma}}{1-1/\sigma}$$

subject to the transition equations for the two types of capital (producer durables and structures):

$$KT^j(t+1) = (1-\delta)KT^j(t) + \tilde{I}_T^j(t);$$

$$KN^j(t+1) = (1-\delta)KN^j(t) + I_N^j(t);$$

and the standard lifetime budget constraint.

We begin by solving for the key prices. First, as before, the price of traded intermediate investment good is pinned down by the investment distortion

$$P_{IT}^j = 1 + \tau_I^j. \tag{25}$$

Second, the price of the nontraded goods is derived from equating the marginal revenue product of the factors of production in all sectors:

$$P_S^j = \frac{A_T^j}{A_S^j}; \tag{26}$$

$$P_N^j = \frac{A_T^j}{A_N^j}. \tag{27}$$

Third, we obtain the retail price of consumer goods and producer durables by substituting the prices in (25) and (26) into the dual cost functions of the production functions in (22) and (23):

$$\tilde{P}_{CT}^j = \left(\frac{A_T^j}{A_S^j}\right)^{\theta_C} P_{CT}^{1-\theta_C} \Big/ [\theta_C^{\theta_C}(1-\theta_C)^{1-\theta_C}]; \tag{28}$$

$$\tilde{P}_{IT}^j = \left(\frac{A_T^j}{A_S^j}\right)^{\theta_I} (1+\tau_I^j)^{1-\theta_I} \Big/ [\theta_I^{\theta_I}(1-\theta_I)^{1-\theta_I}]. \tag{29}$$

Steady State.—We now solve for the steady state of the model. We proceed in the same manner as we did for the two sector models. First, the key labor share is now either the share of workers producing consumption goods for export (for countries that export consumption goods and import investment goods) or the share of workers producing tradable investment goods for domestic investment (for countries that specialize in producing machinery and equipment):

$$(30)\quad \frac{L_T^j}{L^j} = \frac{(g+\delta)\alpha(1-\tau_K^j)}{(1+\tau_I^j)[(1+g)^{1/\sigma}/\beta - 1 + \delta(1-\tau_K^j)]} \times (1-\theta_I)\gamma_I^j.$$

We then solve for the domestic-price investment rate as a function of this share:

$$(31)\quad i_{\text{dom}}^j = \left(\frac{\frac{L_T^j}{L^j}(1+\tau_I^j)}{1+\tau_I^j\frac{L_T^j}{L^j}}\right)\cdot\frac{1}{(1-\theta_I)\gamma_I^j}.$$

From comparing (30) and (31) with the expressions defining the nominal investment rate in the two-sector model (equations (9) and (10)), it is clear that the only additional factor that potentially drives country differences in nominal investment rates (and only when $\tau_I^j > 0$) is the share of producer durables in aggregate investment.

The real investment rate is still given by the product of the nominal investment rate and an inverse function of the relative price of capital, with the only difference being that P_C^j/P_C and P_I^j/P_I now refer to the *aggregate* price indices of consumption and investment:

$$(32)\quad i^j = i_{\text{dom}}^j\left[(1-i_{\text{dom}}^j)\frac{P_I^j/P_I}{P_C^j/P_C} + i_{\text{dom}}^j\right]^{-1}$$

where

$$\frac{P_I^j/P_I}{P_C^j/P_C} = \frac{\gamma_C^j\tilde{P}_{CT}\left(\frac{1-\theta_C}{P_{CT}}\right)^{1-\theta_C}\left(\frac{A_S^j}{A_T^j}\theta_C\right)^{\theta_C} + (1-\gamma_C^j)P_S\frac{A_S^j}{A_T^j}}{\gamma_I^j\tilde{P}_{IT}\left(\frac{1-\theta_I}{1+\tau_I^j}\right)^{1-\theta_C}\left(\frac{A_S^j}{A_T^j}\theta_I\right)^{\theta_I} + (1-\gamma_I^j)P_N\frac{A_N^j}{A_T^j}}.$$

The second line in (32) expresses P_I^j/P_I as a weighted average of the price of producer durables and the price of structures, and P_C^j/P_C is expressed as a weighted average of the price of tradable consumption and the price of nontraded services.

As in the simple two-sector model, low productivity in traded goods relative to nontraded services in a country that exports tradable investment goods results in a low price of nontraded services (relative to the price of the traded investment good) and a low real investment rate. In this setup, however, some countries specialize in tradable consumption goods, which they export in exchange for tradable investment goods. For these countries, low productivity in producing tradable consumption goods has exactly the same effect on the price of nontraded services (again, relative to the price of the traded investment good). In all countries, as long as services are used more intensively in consumption than in investment, cheap services (relative to producer durables) lower the aggregate price of consumption by more than the price of investment, and thus lower the real investment rate (for a given nominal investment rate).

The effect of low TFP in investment structures relative to TFP in nontraded services on the relative price of capital follows a similar logic. From (26) and (27), low TFP in structures relative to nontraded services makes structures expensive relative to the price of consumer services. Since the aggregate price of investment is a weighted average of the price of producer durables and investment structures, low A_{IN}^j/A_S^j will increase the aggregate price of capital relative to the price of consumption and thus lower the real investment rate.

Finally, the shares of tradables in aggregate consumption and aggregate investment will also potentially affect the relative price of capital. A decline in the share of tradables in consumption γ_C^j will lower the aggregate price of consumption (and thus increase the aggregate relative price of capital) when $\tilde{P}_{CT}^j/\tilde{P}_{CT} > P_S^j/\tilde{P}_S$. Similarly, an increase in the share of tradables in investment γ_I^j will raise the absolute and relative price of capital if the price index of producer durables is larger than the price index of investment structures.

For completeness, steady-state PPP output per worker can be expressed as a function of the

capital output ratio and aggregate TFP (equation (15)), where aggregate TFP is now

$$(33)\qquad TFP_j = A_T^j \cdot \frac{L_T^j}{L^j} \cdot \frac{(1+\tau_I^j)}{\gamma_I^j(1-\theta_I)} \times \left(\gamma_I^j \frac{\tilde{P}_{IT}}{\tilde{P}_{IT}^j} + (1-\gamma_I^j) \frac{P_{IN}}{P_{IN}^j} \right) + A_T^j \times \left(1 - \frac{L_T^j}{L^j} \left[1 + \frac{1+\tau_I^j}{1-\theta_I} \left(\theta_I + \frac{1-\gamma_I^j}{\gamma_I^j} \right) \right] \right) \times \left(\gamma_C^j \frac{\tilde{P}_{CT}}{\tilde{P}_{CT}^j} + (1-\gamma_C^j) \frac{P_S}{P_S^j} \right).$$

Here, L_T^j/L^j is given by (30), $\tilde{P}_{IT}^j$ by (29), P_{IN}^j by (27), $\tilde{P}_{CT}^j$ by (28), and P_S^j by (26). As before, aggregate TFP is a function of sectoral TFP and the allocation of resources between domestic consumption and investment. What is new is that the allocation of resources between tradables and nontradables *within* the consumption and investment sectors will also potentially affect aggregate TFP. In particular, a higher share of services in consumption *lowers* aggregate TFP if $P_S^j/P_S > \tilde{P}_{CT}^j/\tilde{P}_{CT}$, and raises aggregate TFP if $P_S^j/P_S < \tilde{P}_{CT}^j/\tilde{P}_{CT}$.

Figures 3A and 3B illustrate the quantitative predictions of the model.[17] In the first two panels of Figure 3A, tax rates are shown to materially discourage PPP investment and income. In Figure 3B, TFP in one sector relative to the others is likewise shown to influence PPP investment rates and PPP incomes. In all cases, the qualitative results of the simpler model in Section IA are shown to carry through to the model in this section. A proportional increase in TFP in all sectors has no effect on investment rates. Rising TFP in tradables (or investment more broadly) relative to services drives up the PPP investment rate while leaving the domestic price investment rate unchanged. In the next section we will use data on the endogenous variables to infer the underlying causes of higher PPP investment rates in richer countries.

II. Cross-Country Facts about Investment Rates and Income Levels

The United Nations International Comparison Program (ICP) collects data on the prices of between 500 and 1,500 individual goods and services in selected countries and years. The countries for which the ICP has price data in a given year are "benchmark" countries for the PWT. The PWT uses the benchmark price data to convert each country's expenditures at domestic prices into expenditures at a common set of international prices. For nonbenchmark country-years, prices and therefore PPP values are inferred from fitted values of price regressions run on benchmark data. Because price differences across countries are at the crux of our investigation, we concentrate on the benchmark country-years for which actual price data were collected. Benchmark data currently exist for 1970 (16 countries), 1975 (34 countries), 1980 (61 countries), 1985 (64 countries), 1990 (24 countries), and 1996 (115 countries). We focus on 1980, 1985, and 1996, the years with broad cross sections of countries.[18]

We examine simple univariate regressions of observables on country log PPP income per worker. We do not consider other regressors because we are interested simply in how the dependent variables co-vary with income. Our first dependent variable is the log PPP fixed investment rate (expressed in percentages). Fixed investment

[17] For Figure 3 we set capital's share $\alpha = 1/3$, the depreciation rate $\delta = 0.07$, the annual growth of income per worker $g = 0.02$, the intertemporal elasticity $\sigma = 1$, and the discount factor $\beta = 0.97$. We set the world prices of tradable consumption and tradable investment to one, and did the same for the PPP prices of services and nontradable investment. Finally, we set the PPP prices of the retail versions of tradable consumption and investment consistent with (28) and (29) and the other PPP prices (based on the starting TFP values of one). We do not plot the effects of γ_C^j or γ_I^j because they do not affect the PPP investment rate at these parameter values. In our empirical Section III, we show that γ_C^j does affect the PPP investment rate, but not to an economically significant degree.

[18] We obtained the benchmark data from the PWT Web site (http://pwt.econ.upenn.edu). See Summers and Heston (1991) and Heston, Summers, and Bettina Aten (2002) for a fuller description of PPP methodology. We made two minor changes to the 1996 benchmark sample. First, we excluded Mongolia because its prices and quantities are zero for machinery and equipment. Second, for Antigua and Barbuda, St. Kitts and Nevis, and St. Lucia, we imputed missing employment as 0.5*(adult equivalents). For the other benchmark countries, 0.5 is the average ratio of employment to "adult equivalents" (which the PWT defines as population over 15 plus one half of the population 15 and under).

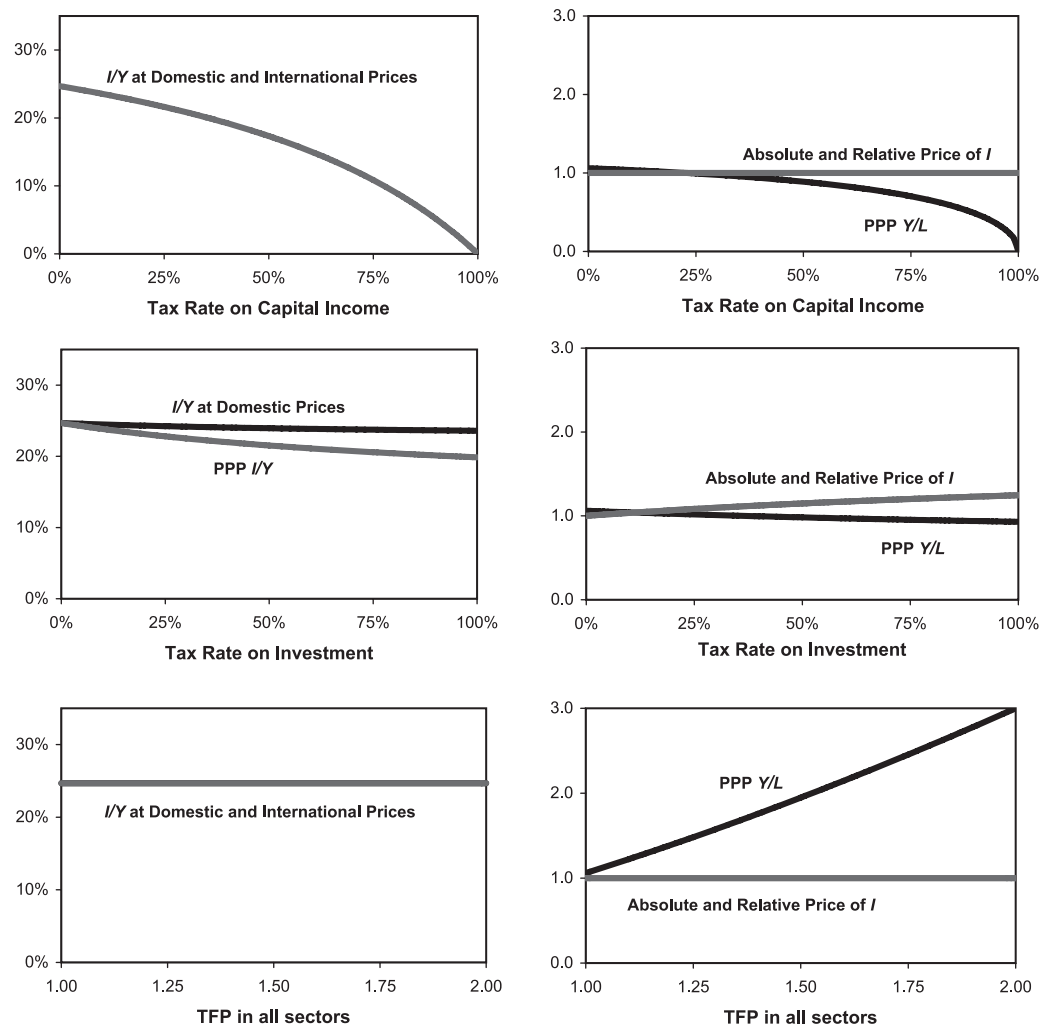

FIGURE 3A

excludes inventory investment and includes both public and private investment. We exclude inventory investment because some inventories are for consumer goods. The PWT does not contain separate data on public and private investment rates.[19] Table 1 provides results from regressing the log PPP fixed investment rate on log PPP income per worker. An additional log point of income is associated with about an additional 0.3 log point PPP investment rate in the 1980 and 1996 cross sections and a 0.5 log point increase in the PPP investment rate in the 1985 cross section. Across the 114 benchmark countries in 1996, the mean of the log fixed investment rate is 2.7 log points and PPP income per worker varies by 4.4 log points. The estimated comovement of the PPP fixed investment rate with PPP income is therefore significant relative to the mean investment rate.

[19] Lant Pritchett (2000) argues that public investment should be distinguished from private investment, where possible, because public investment is less likely to create economically viable capital.

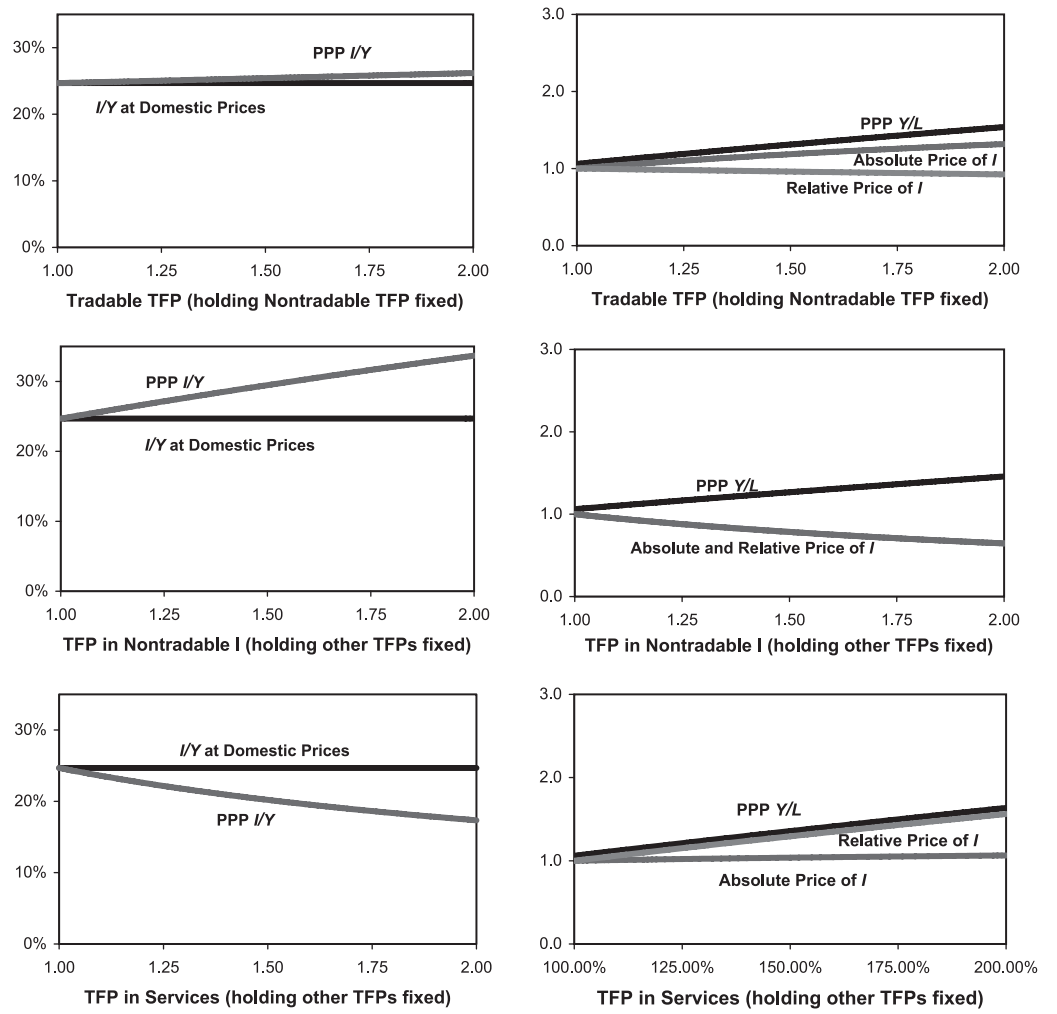

FIGURE 3B

Table 1 also presents results for investment in producer durables, which includes machinery, equipment, and vehicles, and investment in structures. Producer durables are arguably the most tradable components of fixed investment (in contrast to construction). Moreover, J. Bradford DeLong and Lawrence H. Summers (1991) presented evidence that the investment rate in producer durables was most strongly related to growth and development. Using the log PPP investment rate in producer durables, the coefficients on country income remain highly significant.

We next examine the log investment rate at domestic prices. Table 1 documents that, in all three years, coefficients on PPP income per worker fall by two-thirds or more when the fixed investment rates are evaluated at domestic prices rather than at international prices. Eaton and Kortum (2001) and Restuccia and Urrutia (2001) also note this low correlation between domestic-price investment rates and PPP incomes across countries. In addition, this correlation between the fixed investment rate at domestic prices and income appears to be driven by the correlation between investment in

TABLE 1—PPP INVESTMENT RATES VS. INVESTMENT RATES AT DOMESTIC PRICES
(*Independent variable = PPP GDP per worker*)

	PPP investment rates			Investment rates at domestic prices		
Dependent variable	1980	1985	1996	1980	1985	1996
Fixed investment	**0.30**	**0.52**	**0.31**	**0.09**	**0.11**	0.06
	(0.06)	(0.05)	(0.04)	(0.04)	(0.03)	(0.04)
	$R^2 = 0.37$	$R^2 = 0.60$	$R^2 = 0.32$	$R^2 = 0.10$	$R^2 = 0.15$	$R^2 = 0.02$
Producer durables	**0.28**	**0.58**	**0.43**	0.04	**0.10**	0.04
	(0.07)	(0.06)	(0.08)	(0.05)	(0.04)	(0.06)
	$R^2 = 0.24$	$R^2 = 0.60$	$R^2 = 0.28$	$R^2 = 0.02$	$R^2 = 0.08$	$R^2 = 0.01$
Structures	**0.34**	**0.49**	**0.36**	**0.13**	**0.13**	**0.26**
	(0.07)	(0.06)	(0.09)	(0.04)	(0.04)	(0.09)
	$R^2 = 0.32$	$R^2 = 0.51$	$R^2 = 0.16$	$R^2 = 0.14$	$R^2 = 0.18$	$R^2 = 0.13$
Number of benchmark countries	61	64	114	61	64	114

Notes: All variables are in logs. Each entry is a coefficient from a single regression. Robust standard errors are in parentheses. Bold coefficients are significant at the 5 percent level. Fixed investment includes producer durables and structures, and excludes inventory investment. Producer durables include machinery, equipment, and vehicles.

structures and income rather than by investment in producer durables. The point estimate of the elasticity of the log nominal investment rate in producer durables with income is essentially zero in 1980 and 1996 and small and marginally significant in 1985.

The results in the right half of Table 1 contrast sharply with those of Levine and Renelt (1992) and Sala-i-Martin (1997), who identified the investment rate as an indomitable correlate of income. When evaluated at domestic prices, the fixed investment rate is rendered insignificant for the broadest set of countries (the 1996 sample). The most tradable portion of investment (producer durables) is uncorrelated with PPP incomes in all years. Note that no conditioning variables are included in these regressions. The distinction between domestic prices and international prices is evidently crucial to the connection between investment rates and income levels. We now investigate price differences across the benchmark countries.

Many studies have noted the high relative price of investment in poor countries, and used it to help explain differences in country incomes. Examples include Jones (1994), Lee (1995), Chari, Kehoe, and McGrattan (1996), McGrattan and Schmitz (1999), Jovanovic and Rob (1999), and Eaton and Kortum (2001). A common theme in these papers is that the price of investment in poor countries is high relative to the price of investment prevailing in rich countries. A simple way to test this hypothesis is to compare prices of investment goods in rich and poor countries after appropriate conversion into a common currency.

Table 2 presents regressions of log investment prices on log PPP GDP per worker. We obtained these prices by converting PWT benchmark prices in national currency units into US dollar prices. We did this in two different ways: using official exchange rates from the PWT (whose source is the International Monetary Fund (IMF)), and using black market exchange rates from the World Currency Yearbook.[20] Although the official exchange rate may accurately reflect the market exchange rate in many country-years, black market premia are well documented in others. Our logic for presenting results using official exchange rates as well as black market exchange rates is as follows. First, countries may allow preferential access to the official exchange rate for trade (as opposed to purely capital account transactions). Second, countries may allow preferential access to the official exchange rate for imports of equipment (as opposed to consumer goods). Finally, and most important, to the extent that a good is imported at a devalued exchange rate relative to the official one, this should show up as a high dollar price when domestic

[20] For 1996 we use black market exchange rates collected by the IMF, since the World Currency Yearbook ceased publication after 1995. We thank Carmen Reinhart and Kenneth Rogoff for providing these data. See Reinhart and Rogoff (2004) for documentation.

TABLE 2—THE PRICE OF INVESTMENT GOODS
(*Independent variable = PPP GDP per worker*)

	At *official* exchange rates			At *black market* exchange rates		
Dependent variable	1980	1985	1996	1980	1985	1996
Fixed investment	0.024	−0.038	**0.183**	**0.190**	0.096	**0.245**
	(0.049)	(0.048)	(0.047)	(0.053)	(0.050)	(0.043)
	$R^2 = 0.00$	$R^2 = 0.01$	$R^2 = 0.13$	$R^2 = 0.14$	$R^2 = 0.03$	$R^2 = 0.19$
Producer durables	−0.006	**−0.142**	0.052	**0.055**	**−0.085**	**0.113**
	(0.034)	(0.035)	(0.032)	(0.039)	(0.035)	(0.030)
	$R^2 = 0.00$	$R^2 = 0.14$	$R^2 = 0.02$	$R^2 = 0.03$	$R^2 = 0.05$	$R^2 = 0.08$
Structures	0.016	−0.029	**0.339**	**0.181**	0.105	**0.401**
	(0.068)	(0.061)	(0.060)	(0.067)	(0.066)	(0.055)
	$R^2 = 0.00$	$R^2 = 0.00$	$R^2 = 0.18$	$R^2 = 0.09$	$R^2 = 0.03$	$R^2 = 0.23$
Number of benchmark countries	61	64	114	61	64	114

Notes: All variables are in logs. Each entry is a coefficient from a single regression. Robust standard errors are in parentheses. Bold coefficients are significant at the 5 percent level. The dependent variable is the log investment price expressed in dollars (converted from national currencies at official or black market exchange rates).

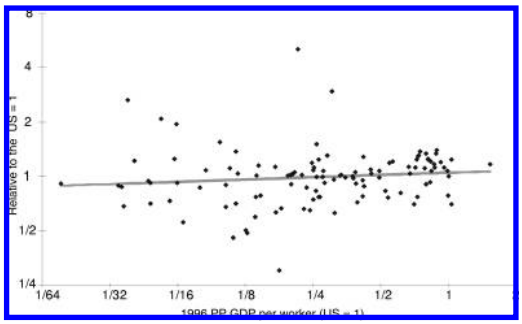

FIGURE 4. 1996 PRICE OF PRODUCER DURABLES

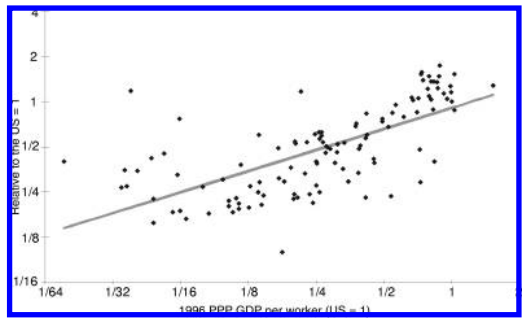

FIGURE 5. 1996 PRICE OF CONSUMPTION

prices are converted to dollars at the official exchange rate. Using official exchange rates is most favorable to the conventional view that investment goods are expensive in poor countries.

As documented in Table 2, none of the prices of fixed investment, producer durables, or the structures is negatively related to PPP income per worker. This is true when prices are converted at official exchange rates as well as at black market exchange rates. In several cases, investment goods, particularly investment structures in 1996, actually appear more expensive in richer countries. Figure 4 illustrates the case of 1996 prices of producer durables, converted into dollars at official exchange rates. As the figure reveals, the price of producer durables does vary across countries, especially outside the richest countries. But prices of producer durables look no higher in poor countries overall than in rich countries.

If the high relative price of investment in poor countries does not stem from a high price of investment, it must reflect a low price of consumption. Figure 5 shows consumption prices across countries in 1996. Table 3 provides elasticities with respect to country income. A doubling of income goes along with 20 to 50 percent higher consumption prices. Table 3 also provides separate elasticities for "nontradable" and "tradable" consumption. Following Heston et al. (1995), services are nontradables (housing, medical care, purchased transportation, communications, recreation, education, and personal services) and goods are tradables (food, beverages, tobacco, clothing, footwear, fuel, house furnishings, vehicles, and personal care items). The elasticities for nontradable consumption prices with respect to PPP in-

TABLE 3—THE PRICE OF CONSUMPTION
(*Independent variable = PPP GDP per worker*)

	At *official* exchange rates			At *black market* exchange rates		
Dependent variable	1980	1985	1996	1980	1985	1996
All consumption	**0.221**	**0.286**	**0.446**	**0.387**	**0.420**	**0.507**
	(0.053)	(0.049)	(0.057)	(0.048)	(0.039)	(0.056)
	$R^2 = 0.25$	$R^2 = 0.41$	$R^2 = 0.43$	$R^2 = 0.43$	$R^2 = 0.46$	$R^2 = 0.46$
Consumption services	**0.377**	**0.415**	**0.660**	**0.542**	**0.549**	**0.721**
	(0.064)	(0.050)	(0.070)	(0.062)	(0.050)	(0.073)
	$R^2 = 0.38$	$R^2 = 0.51$	$R^2 = 0.48$	$R^2 = 0.49$	$R^2 = 0.53$	$R^2 = 0.52$
Consumption goods	**0.141**	**0.223**	**0.310**	**0.307**	**0.357**	**0.372**
	(0.047)	(0.049)	(0.048)	(0.045)	(0.034)	(0.044)
	$R^2 = 0.15$	$R^2 = 0.33$	$R^2 = 0.35$	$R^2 = 0.37$	$R^2 = 0.41$	$R^2 = 0.42$
Number of benchmark countries	61	64	114	61	64	114

Notes: All variables are in logs. The dependent variable is a log consumption price expressed in dollars (converted from national currencies at official or black market exchange rates). Nontradables are services; tradables are goods.

come per worker in Table 3 are around 40 to 70 percent. Figure 6 plots nontradable consumption prices in 1996, converted at official exchange rates. The elasticities for tradable consumption prices are also shown in Table 3; these are also positive, but markedly lower, ranging from 14 to 37 percent.[21]

In sum, real investment rates are lower in poor countries largely because the relative price of capital is high. In turn, the relative price of capital in poor countries is high because consumption goods are cheap, not because investment goods are more expensive. Why might consumption goods be cheaper in poor countries? From (32), there are two potential explanations. First, poor countries might have low TFP in tradables (in producing tradable consumption goods or tradable investment goods) relative to nontradable services. Second, if the price of nontradable services in poor countries is higher than the price of consumption goods (relative to the ratio of PPP prices), a low share of tradable goods in consumption would also lower the aggregate price of consumption. Table 4 shows that the share of tradable goods in consumption appears to be *higher* in poor countries. As we will document shortly, the price of nontradable services relative to the price of consumption goods is *lower* in poor countries. Therefore, the higher share of tradable consumption in poor countries would have the effect of *raising* the price of aggregate consumption.

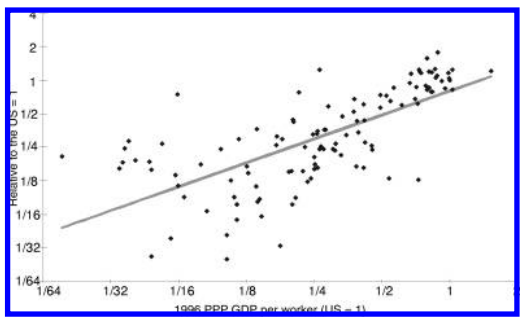

FIGURE 6. 1996 PRICE OF NONTRADABLE CONSUMPTION

If low consumption prices in poor countries are not due to a lower share of goods in consumption, the only remaining explanation must be low productivity in tradables relative to nontradable services. Using equation (26), we can estimate this key relative productivity directly from the price of consumption services. From the elasticity of the price of consumer services (converted at market exchange rates) to income presented in Table 3 (second row), we infer that a log point decline in income is associated with a 0.54 to 0.72 log point decline in the ratio of TFP in tradables to TFP in nontradables.

An alternative approach is to use the fact that the retail price of traded consumption goods is a function of the price of nontraded distribution and retail services. From (28), the ratio

[21] Our measure of nontradable consumption includes only private services. We obtained very similar price elasticities when we added government services to private services.

TABLE 4—THE SHARE OF TRADABLE CONSUMPTION AND INVESTMENT
(*Independent variable = log PPP GDP per worker*)

Dependent variable	1980	1985	1996
Share of goods in consumption (at domestic prices)	**−7.27** (0.99) $R^2 = 0.55$	**−9.49** (0.79) $R^2 = 0.66$	**−13.64** (0.69) $R^2 = 0.75$
Share of producer durables in investment (at domestic prices)	−2.10 (1.29) $R^2 = 0.07$	−0.70 (1.10) $R^2 = 0.00$	**−4.16** (2.01) $R^2 = 0.05$
Number of benchmark countries	61	64	114

Notes: The dependent variable is in percentage points. Each entry is a coefficient from a single regression. Robust standard errors are in parentheses. Bold coefficients are significant at the 5 percent level.

of TFP in tradables to nontradables is given by $(1/\theta_C)\log \tilde{P}^j_{CT}$, where θ_C is the share of distribution costs in the retail price of consumer goods. Ariel T. Burstein, João C. Neves, and Rebelo (2003) estimate this distribution share to average more than 40 percent in the G7 countries and over 60 percent in Argentina. Burstein, Martin Eichenbaum, and Rebelo (2002) assess distribution costs to be around 50 percent of consumer goods prices in South Korea and Mexico. If we take 50 percent as our central estimate of θ_C, the elasticities of the retail price of consumption goods (converted at market exchange rates) with income in Table 3 (third row) suggest that the ratio of TFP in tradables to nontradables declines by 0.62 to 0.74 percentage points for a log point fall in income. Thus, when we use an independent source of data to impute the ratio of TFP in tradables to nontradables, we obtain estimates that are virtually identical to those obtained directly from the price of consumption services.

Turning to the price of investment goods, what might explain the fact that these prices look no higher in poor countries? From (29), the four factors varying across countries that affect the price of investment are: (a) the ratio of TFP in tradables to nontradable services; (b) the ratio of TFP in tradables to investment structures; (c) the investment distortion; and (d) the nominal share of producer durables in aggregate investment. We assess each factor in turn.

First, as with the price of aggregate consumption, low TFP in tradables to nontradables in poor countries, by lowering the price of retail and distribution services, would lower the retail price of producer durables and, by extension, the price of aggregate investment. The importance of this effect on the retail price of producer durables depends on the share of distribution and retail services in the investment goods sector (equation (29)). Burstein, Neves, and Rebelo (2004) estimate that distribution costs accounted for an average of 17 percent of the price of machinery and equipment, with 7 percent as the low value (Spain) and 29 percent as the high value (Mexico). If we apply Burstein et al.'s central estimate of nontraded share in producer durables ($\theta_I = 16.7$ percent) to our estimates of the elasticity of the ratio of TFP in tradables to nontradable services with income, say 0.6, this would suggest that the lower price of services in poor countries would lower the retail price of producer durables by 10 percent (0.6×0.167) for every log point decline in income. Note that in the data, the 1996 price of producer durables falls by 11.3 percent for every log point fall in income (Table 2), which suggests that low TFP in tradables to nontradables in poor countries can explain most of the co-variation of the price of producer durables with income.

With this estimate in hand, we can use the retail price of producer durables to estimate the importance of investment barriers in poor countries. Specifically, we rearrange equations (28) and (29) to get the following expression (up to a constant) for the investment barrier:

$$\log(1 + \tau^j_I) = \log \tilde{P}^j_{IT} - \frac{\theta_I}{\theta_C} \log \tilde{P}^j_{CT}. \quad (34)$$

Using this equation, Table 5 (row 1) presents the estimated elasticity of the investment distortion to output per worker. The dependent vari-

TABLE 5—IMPUTED INVESTMENT DISTORTIONS
(*Dependent variable = log price of machinery and equipment* $-(\theta_I/\theta_C)$*log price of consumption; independent variable = log PPP GDP per worker*)

	At *official* exchange rates			At *black market* exchange rates		
	1980	1985	1996	1980	1985	1996
Using the price of consumer goods	−0.033	**−0.133**	**−0.052**	0.077	−0.043	−0.011
	(0.044)	(0.031)	(0.023)	(0.055)	(0.044)	(0.024)
$\theta_I = 0.167$	$R^2 = 0.01$	$R^2 = 0.16$	$R^2 = 0.03$	$R^2 = 0.04$	$R^2 = 0.01$	$R^2 = 0.00$
$\theta_C = 0.5$						
Using the price of consumer services	−0.049	**−0.127**	**−0.059**	0.089	−0.016	−0.007
	(0.041)	(0.032)	(0.027)	(0.056)	(0.043)	(0.024)
$\theta_I = 0.167$	$R^2 = 0.03$	$R^2 = 0.14$	$R^2 = 0.03$	$R^2 = 0.05$	$R^2 = 0.00$	$R^2 = 0.00$
$\theta_C = 1$						
Number of benchmark countries	61	64	114	61	64	114

able, based on equation (34), is the log price of producer durables minus θ_I/θ_C times the log price of traded consumption goods. We use Burstein et al. central estimates of the nontraded share in the two sectors, namely $\theta_I = 16.7$ percent and $\theta_C = 50$ percent. As can be seen, the elasticity of investment distortions to country income is basically zero in four out of six cases. In particular, when black market exchange rates are used to convert local currency prices to dollars, the estimates suggest that investment distortions are no higher in poor countries than in rich countries. The two cases that yield statistically significant point estimates are when official exchange rates are used to convert local currency prices to dollars. As previously mentioned, the use of official exchange rates to convert to a dollar price is likely to overstate the price of capital in a country with a large black market premium.

An alternative would be simply to use the price of consumer services as an estimate of the price of distribution services in the investment sector. The advantage of this procedure is that we would use an independent set of data (the price of consumption services rather than the price of consumer goods) to back out the imputed investment distortion. These estimates are shown in row 2 in Table 5. Here, the dependent variable is the log price of producer durables minus θ_I times the log price of consumption services (we maintain our assumption of $\theta_I = 16.7$ percent). As shown, the estimated elasticity of investment distortions to income is still basically zero in four out of the six cases, and statistically significant only when official exchange rates are used to convert local currency prices to dollars. These two pieces of evidence thus suggest that investment distortions are generally no higher in poor countries than in rich countries.

The two remaining forces that also potentially affect the price of capital are the share of producer durables in aggregate investment and the productivity in tradables relative to structures. From (27), we can infer the ratio of TFP in tradables to structures from the price of structures (shown in Table 2). As can be seen, the price of structures appears to be generally lower in poor countries, particularly when market exchange rates are used to convert domestic currency prices to US dollars. This negative correlation between income and relative TFP in tradables to structures would have the effect of *lowering* the price of aggregate investment in poor countries. Finally, as with the share of goods in aggregate consumption, the share of tradable investment goods in aggregate consumption appears to be negatively correlated with income (Table 4), although the point estimate is much smaller and statistically significant in only one year (1996).

In summary, low productivity in tradables (either in producing investment goods or in producing consumption goods for export) relative to nontradables appears to be the main force behind the low price of consumption in poor countries. The effect of low relative TFP on consumption prices is counteracted by the higher share of tradables in consumption in poor countries, but this effect is clearly smaller than the effect of low TFP in tradables relative to nontradables. Meanwhile, the two main forces behind the modestly lower price of aggregate

investment in poor countries are the lower price of distribution services and the lower price of structures. There appears to be no evidence, however, that investment distortions are higher in poor countries than in rich countries. In the next subsection, we quantify the contribution of these different factors in explaining the low real investment rates in poor countries.

A. *Development Accounting*

We now ask what tax rates and productivity levels would enable the model to match the data. For each country, we calculate the tax rate on capital income, τ_K, the tax rate investment goods, τ_I, and the level of TFP in each sector (A_T for tradable consumption or investment, A_S for services, and A_N for structures) so that the model matches exactly the country's price of tradable investment goods, price of structures, price of consumer services, investment rate at domestic prices, and PPP income per worker. We do this for the benchmark countries in each of the benchmark years (1980, 1985, and 1996).

As we did for Figure 3, we set capital's share, $\alpha = 1/3$, the depreciation rate, $\delta = 0.07$, the annual growth of income per worker, $g = 0.02$, the intertemporal elasticity, $\sigma = 1$, and the discount factor, $\beta = 0.97$. We use data on investment prices and tradable consumption prices to calculate the tax rate on investment goods as implied by (34). We set the world price equal to the US price of investment under the assumption that the US tax rate on investment goods is approximately zero. Using the price of consumer services, we infer TFP in the tradable sector relative to the service sector from (26). Similarly, we use the price of structures to estimate TFP in the tradable sector relative to construction from (27). We back out the tax rate on capital income from (30) and (31), using the domestic price investment rate and the inferred tax rate on investment goods in the process. Finally, we solve for the level of TFP in the tradable sector that, combined with the relative TFPs, will match the data on PPP income per worker.

The implications of this exercise for tax rates and productivity levels in 1996 are as follows. The median investment tax rate is 23 percent, and the interquartile range (twenty-fifth to seventy-fifth percentiles) is 5 percent to 40 percent. The United States, recall, was assumed to have an investment tax rate of zero. The median tax rate on capital income is 33 percent, with an interquartile range of -1 percent (a slight subsidy) to 53 percent. Median TFP in tradables production is 20 percent of the US level, with middle quarters 10 percent to 61 percent. Median TFP in structures is 32 percent of the US level, with an interquartile range of 19 percent to 58 percent. Median TFP in services is inferred to be 73 percent of the US level, with an interquartile range of 56 percent to 88 percent. Note that service TFP does not differ as much as investment TFP does. As we describe next, this suggests that differences in *relative* TFP explain some of the differences in PPP investment rates, capital intensity, and income.

Table 6 decomposes the elasticity of PPP investment rates with respect to PPP incomes. The top row presents the actual elasticity, and the rows beneath the sources of this elasticity. We vary the underlying determinants of country PPP investment rates one by one. We set all the variables to their US levels, save for the variable in the row. We have no row for γ_I^j, the share of tradable investment in total investment, because it has no effect on the PPP investment rate at the PPP prices considered.[22] According to the second row of Table 6, variation in γ_C^j, the share of tradables in total consumption, pushes PPP investment rates *down* in richer countries. But this force is an order of magnitude smaller than the overall elasticity to be explained. The third row of Table 6 shows that richer countries tend to have higher PPP investment rates in part because of their lower tax rates on capital income. But capital income tax rates explain around a quarter or less of the overall elasticity. The next row indicates that the implied barriers to buying investment goods play an even smaller role. As reported in the penultimate row, the dominant contribution comes from variation in relative sector TFPs. Excluding residual co-variance terms, higher TFP in tradables and structures in richer countries explains two-thirds or more of the overall PPP investment rate elasticity.[23]

Table 7 presents elasticities of productivity

[22] Empirically, the share of producer durables in investment appears to be little correlated with income (Table 4).

[23] We used official exchange rates in Table 6. TFP plays an even bigger role with black market exchange rates.

TABLE 6—DECOMPOSING PPP INVESTMENT RATES
(*Independent variable = PPP GDP per worker*)

Dependent variable	1980	1985	1996
Actual PPP investment rate	**0.298**	**0.520**	**0.311**
	(0.051)	(0.054)	(0.043)
PPP investment rate with only . . .			
. . . γ_C varying	**−0.033**	**−0.038**	**−0.050**
	(0.004)	(0.003)	(0.003)
. . . $(1 - \tau_K)$ varying	**0.079**	**0.097**	0.048
	(0.033)	(0.032)	(0.032)
. . . $(1 + \tau_I)$ varying	0.025	**0.079**	0.019
	(0.013)	(0.016)	(0.011)
. . . A_T/A_S and A_T/A_N varying	**0.252**	**0.283**	**0.276**
	(0.033)	(0.030)	(0.035)
residual	−0.025	0.099	0.018
Number of benchmark countries	61	64	114

Notes: All variables are in logs. Each entry is a coefficient from a single regression. Standard errors are in parentheses. Bold coefficients are significant at the 5 percent level. Investment refers to fixed investment. See equations (31) and (32) for how each variable listed affects the PPP investment rate. We set variables to their US values except for in the term listed. In constructing this table, we used prices converted into dollars at *official* exchange rates.

with respect to PPP output per worker in 1980, 1985, and 1996. The first three rows show that richer countries have higher productivity in producing tradables (whether investment goods or consumer goods), structures, and services—hardly surprising. More striking is that richer countries appear particularly proficient at making goods and structures compared to services. The elasticities of TFP for making goods and structures are more than double the elasticities for services TFP. In our model, these TFP patterns trigger a lower price of investment relative to consumption in richer economies services being more important to final consumption than to final investment goods. Because investment is tradable, its price before distribution is pinned down in the world market (conditional on the tariff). Rich countries' productivity advantage in investment and, more generally, in producing tradables shows up as a higher price of consumption services in rich countries. This is what we estimated in Table 3. Viewed through the lens of the model, poor countries have low PPP investment rates mostly because they have especially low productivity in their tradable sectors.

TABLE 7—PRODUCTIVITY LEVELS AND INCOME DIFFERENCES
(*Entries are elasticities with respect to PPP Y/L*)

	1980	1985	1996
A_T	**0.739**	**0.714**	**0.962**
	(0.049)	(0.047)	(0.047)
A_N	**0.723**	**0.743**	**0.622**
	(0.039)	(0.040)	(0.048)
A_S	**0.363**	**0.299**	**0.303**
	(0.030)	(0.025)	(0.029)
TFP as a result of A variation	**0.700**	**0.606**	**0.624**
	(0.031)	(0.031)	(0.034)
K/Y as a result of A variation	**0.126**	**0.141**	**0.138**
	(0.016)	(0.015)	(0.017)
Number of countries	61	64	114

Notes: All variables are in logs. Each entry is a coefficient from a single regression. Standard errors are in parentheses. Bold coefficients are significant at the 5 percent level. For the last two rows we calculated TFP and K/Y using country TFP in each sector but setting all other variables (spending shares on durables, tax rates) to US levels. In constructing this table, we used prices converted into dollars at *official* exchange rates.

The remaining two rows of Table 7 present development accounting. We use (33) to calculate the level of aggregate TFP implied by sectoral TFP, and we use (32) to find the PPP investment rates implied by sectoral TFP. We set all variables other than TFP (i.e., tax rates and spending shares) to their US levels to isolate the effects of TFP differences. We regress the predicted contributions to PPP incomes on *actual* PPP incomes (all variables in logs), and present the results in the last two rows of Table 7. Sectoral TFP appears to explain 60 percent or more of observed differences in income through

its impact on aggregate TFP. More to the heart of our investigation, *relative* sectoral TFP appears to explain another 13 percent of observed income differences through its impact on physical capital intensity. Consistent with our Table 6 results suggesting relative TFP explains most of the PPP investment rate elasticity, relative TFP appears to explain the bulk of the contribution of capital-output ratios to incomes.[24, 25]

To recap, poor countries do not exhibit particularly low investment rates at domestic prices. Nor do they exhibit high investment goods prices. Instead, they exhibit low consumption prices. When consumption is valued at PPP prices, the investment rates in poor countries are lower than in rich countries. Poor countries do not appear to suffer from low-savings traps brought on by high discount rates or subsistence consumption needs. If they did, we would expect to see much lower domestic-price investment rates in poor countries. Nor do they appear to heavily tax the returns to capital. If they did, we would, again, expect to see low domestic price investment rates in poor countries. Finally, poor countries do not appear to impose high taxes and tariffs on producing and importing investment goods. If they did, we would expect to see high investment goods prices in poor countries, as PWT prices are supposed to include all taxes, tariffs, and transportation costs. Poor countries do not appear to lack investment effort, but rather efficiency in producing tradable goods in exchange for investment goods.

III. Measurement Error

We have assumed that the ICP price data are well measured. In this section, we briefly consider how our inferences would change if the data were mismeasured in particular ways. First, we note that classical measurement error across countries would generate the opposite patterns as those in the data. Countries with overstated prices would tend to have understated incomes. Because consumption is about three times investment, countries with overstated prices of consumption *relative* to investment, in particular, would tend to have understated incomes. And countries with overstated PPP investment rates would tend to have understated PPP incomes. Some form of nonclassical measurement error would seem necessary to explain our findings.

The Food and Agricultural Organization of the United Nations (FAO) provides an independent source of data on food prices in many countries, which we can compare to the food prices in the PWT benchmark data.[26] In 1994, the year with FAO data for the most countries, the prices of all 190 crops rise with country income. For 48 of the 49 crops with data for at least 50 countries, the elasticity is statistically significant (the exception being wheat). Pooling all 190 crops and allowing for crop dummies, we estimate an elasticity with respect to country income per worker of 0.37 (standard error 0.01). This does not merely reflect agricultural price supports in Organisation for Economic Co-operation and Development (OECD) countries; the elasticity is 0.32 (0.01) across countries outside the OECD. The elasticities would be even higher using black market exchange rates. FAO data on food prices clearly support the conclusion we reach from the PWT data: food prices are decidedly higher in richer countries.[27]

One could argue that crops are relatively homogeneous, whereas other goods and ser-

[24] Using (15), the contributions of aggregate TFP and the capital-output ratio to PPP income differences are 85 percent and 15 percent in 1980, 75 percent and 25 percent in 1985, and 84 percent and 16 percent in 1996. Our analysis omits human capital, so these figures are in line with Klenow and Rodríguez-Clare (1997) and Hall and Jones (1999), who estimate that TFP and human capital together explain 75 to 85 percent of income differences, with physical capital responsible for the remaining 15 to 25 percent.

[25] The TFP and capital contributions in Table 7 do not sum to 100 percent because we set tax rates and spending shares to US levels. The higher share of services in rich country consumption, in particular, yields bigger TFP differences.

[26] The data can be downloaded from http://apps.fao.org/page/collections?subset=agriculture. The FAO data provide prices in local currency. We convert to dollar prices using IMF official exchange rates.

[27] Food may be more expensive in rich countries because our price data are *retail* prices. As discussed in Section III, the income elasticity of food prices is about half the income elasticity of services, which is consistent with the fact that the share of nontraded services in food at the retail level is roughly 50 percent. At the *wholesale* level, food prices should presumably be no higher in rich countries.

vices can differ substantially in quality across countries. This raises the issue: how closely does the ICP come to pricing *comparable quality* items in different benchmark countries? This is the stated goal of the ICP, so there is some hope that comparable quality items are priced even if the average quality of items sold is higher in richer countries.

The ICP's goal notwithstanding, it may inadvertently price higher-quality items in richer countries. Properly adjusted for quality differences, the price of investment goods might fall (and the price of consumption no longer rise) with country income. Trade barriers to importing equipment could be higher in poor countries than ICP prices suggest. Eaton and Kortum (2001) take this view. If they are right, then ICP data understate differences in PPP income per worker across countries. According to Table 3, an unmeasured quality elasticity of 0.25 or more would be needed to keep quality-adjusted consumption prices from rising with PPP income. With an elasticity of unmeasured quality of 0.25 with respect to measured PPP income, true purchasing power would vary by a factor of 40 rather than 32 across the richest and poorest economies.

Might unmeasured quality differences be larger for consumption (e.g., education and health care) than for investment? If so, then measurement error would contribute both to the high measured price of consumption and to the high measured PPP investment rates in rich countries. Adding in unmeasured consumption in rich countries would lower their PPP investment rates. The correlation between PPP investment rates and PPP incomes would partially reflect measurement error rather than reality. This would undercut our interpretation of the data, but would also undercut tax and tariff explanations. It would mean differences in PPP income are larger and differences in PPP capital intensity smaller than the PWT data suggest. If true, we have even more variation in income and TFP to explain and understand.

IV. Conclusion

The higher investment rate in rich countries than in poor countries is arguably the most consistent finding in the empirical growth and development literature. We find that richer countries have a significantly higher investment rate in PPP terms, but not in domestic price terms. This pinpoints the low price of investment relative to consumption in rich countries as the main force behind their high PPP investment rates. We find no lower investment prices but notably higher consumption prices in rich economies.

Many of these facts are individually well known. The contribution of this paper is to consider all these facts and to channel them into an explanation of why poor countries have low real investment rates. These facts suggest that low PPP investment rates in poor countries are not due to low savings rates or high tax rates on capital or investment. Instead, the facts point to low TFP in producing investment goods and tradable goods relative to nontraded consumption services. Consumption is cheap in poor countries, making investment expensive, and lowering PPP investment rates.

We offer two main caveats to our results. First, investment distortions could be more important than they appear from investment price data if they are masked by differences in local distribution costs. We estimate a modest effect of incorporating such distribution costs, but more direct evidence on distortions would be helpful. Second, our evidence and interpretations hinge on the quality of the ICP price data. It is likely that such data do not adequately control for differences in the quality of investment (e.g., equipment) and consumption (e.g., education and health) across countries.

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