Relative Prices and Relative Prosperity

Chang-Tai Hsieh
Princeton University

Peter J. Klenow
Federal Reserve Bank of Minneapolis

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Abstract

The positive correlation between the real (PPP) investment rate and the level of PPP income across countries is one of the most robust findings of the empirical growth literature. We show that this relationship is almost entirely driven by differences in the price of investment relative to GDP, rather than by differences in nominal investment rates. When measured in nominal terms (i.e., at national prices rather than at PPP prices), investment rates are little correlated with income. We find that the high relative price of investment in poor countries is solely due to lower prices of consumption goods in poor countries. Investment prices are no higher in poor countries than in rich countries. These facts suggest that the low real investment rates in poor countries are not due to low nominal savings rates or to high tax or tariff rates on investment. Poor countries instead appear to be plagued by low efficiency in producing investment goods and in producing exportables to trade for machinery and equipment.

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1. Introduction

One of the strongest relationships established in the empirical growth literature is the positive correlation between the investment rate in physical capital and the growth rate of income per capita across countries. Levine and Renelt (1992) single out the investment rate as the lone robust correlate with growth in income per person. Sala-i-Martin (1997) finds that the investment rate is significantly correlated with growth in 99.97% of the 32,509 cross-country regressions he ran with investment alongside other covariates. The correlation holds even when conditioning on initial income, so the investment rate is also robustly correlated with the *level* of income at the end of the sample. That is, richer countries (not just faster-growing countries) have higher investment rates in physical capital. Figure 1 illustrates the relationship in 1996 across 115 countries. Based on this evidence, empirical work accounting for country income differences has assigned an important role to differences in physical capital intensity. See, for example, Mankiw, Romer and Weil (1992), Chari, Kehoe and McGrattan (1996), Klenow and Rodríguez-Clare (1997), and Hall and Jones (1999).

Many theories have been proposed to explain the differences in investment rates across countries. Some operate indirectly through savings rates (combined with limited international capital mobility). Prime examples are theories in which poor countries have low savings rates because of subsistence consumption needs. Some versions, such as the classic Nelson (1956) and Solow (1956) papers, describe low-savings poverty traps.[1] More recent papers in which subsistence consumption suppresses savings include Gersovitz (1983), Matsuyama (1992), and Ben-David (1998). Poor countries have also been hypothesized to have low savings rates because of high dependency ratios (e.g., Higgins and Williamson, 1997), high discount rates (Carroll et al., 1994), and high tax rates on capital income (Easterly and Rebelo, 1993). Other

[1] Lewis (1954, p. 155): "The central problem in the theory of development is to understand the process by which a community which was previously saving and investing 4 or 5% of its national income or less, converts itself into an economy where voluntary saving is running at about 12 to 15% of national income or more." Rostow (1960) saw savings as the necessary trigger for takeoff into development. Bhagwati (1966) advocated taxes to boost national saving, and Chenery and Strout (1966) advocated foreign aid. See Easterly (2001, chapter 2) for a recent critique of this "financing gap" view of underdevelopment.

theories of investment rate differences focus on forces that directly affect investment. Examples include investment taxes or subsidies (Jones, 1994, and Chari et al., 1996, and McGrattan and Schmitz, 1999) and barriers to importing equipment (Jones, 1994, Lee, 1995, and Eaton and Kortum, 2001).

We present a series of facts to shed light on the underlying causes of differences in PPP investment rates across rich and poor countries. The facts involve the price of investment versus the price of consumption, and the rate of investment at PPP prices versus at national prices. When evaluated at national prices, richer countries have only modestly higher investment rates than poorer countries do. Figure 2 illustrates this relationship for 115 countries in 1996. Whereas the correlation between the PPP investment rate and PPP income is 0.54, the correlation between the nominal investment and PPP income is only 0.09.[2] This evidence undermines explanations involving discount rates, subsistence consumption, low-savings traps, and the taxation of capital income. We find that investment goods are 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.

The facts instead point to differences in the productivity of the investment goods sector (and other tradable sectors) across countries. Poor countries appear to have low investment rates in PPP terms primarily because their investment sectors have particularly low productivity compared to their consumption sectors. This interpretation is entirely consistent with investment goods being internationally tradable (even perfectly so), but does require that not all consumption be costlessly tradable. To the extent that investment goods are more easily traded

[2] The drop in correlation is very similar if we weight countries by their log population. The drop is even greater if we exclude the four countries with very high PPP investment rates (Turkmenistan, Thailand, Korea and Singapore). Finally, the results are even stronger if we weight countries by their PWT data quality grade. We treated A=4 (19 countries, all in the OECD), B=3 (14 countries), C=2 (76 countries), and D=1 (the six countries Belarus, Mongolia, Tajikistan, Turkmenistan, Uzbekistan, and Yemen).

than consumption goods and services, this is a corollary to the Balassa-Samuelson hypothesis that poor countries have low productivity in tradables relative to nontradables.

Our results imply that the covariation of physical capital investment rates and income arises from a deeper productivity puzzle. The challenge is not just to explain low productivity in poor countries, but to explain their low productivity in investment goods production relative to consumption goods production (and, more generally, their low productivity in tradables relative to nontradables).

The rest of this paper proceeds as follows. In section 2 we present a model in which a country's investment rate and level of income 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, respectively. In section 3 we compare the predictions of the model to Penn World Table benchmark data on investment prices, investment rates in nominal and PPP terms, and PPP income levels. In section 4 we summarize and offer some ideas for future research to explain these productivity patterns.

2. A Model with Endogenous Investment Rates and Income Levels

We consider a simple model with two sectors and two tax rates: a nontradable consumption sector, a tradable investment sector, a tax rate on importing and producing investment goods, and a tax rate on capital income. We use the capital income tax rate as a stand-in for many potential determinants of a country's nominal saving rate. Aside from its separate consumption and investment sectors, it is a conventional neoclassical growth model. After laying out the model, we will show how the two tax rates and productivity levels affect a country's price of investment, price of consumption, PPP investment rate, and PPP income per worker. Our aim is to identify telltale markings these forces should leave in the data.

In the model each of L_j workers in country j inelastically supply one unit of labor each period. Each worker chooses current consumption to maximize

$$\sum_{t=0}^{\infty} \beta^t \frac{C_{j,t}^{1-1/\sigma}}{1-1/\sigma}$$

subject to constraints

$$K_{j,t+1} = (1-\delta) K_{j,t} + I_{j,t}$$

$$I_{j,t} = \left\{ w_{j,t} + \left[R_{j,t} - \tau_{K_j} (R_{j,t} - \delta P_{I_{j,t}}) \right] K_{j,t} + T_{j,t} - P_{C_{j,t}} C_{j,t} \right\} / P_{I_{j,t}}$$

(1) $$R_{j,t} = \frac{r_{j,t} + \delta - \delta \tau_{K_j}}{1 - \tau_{K_j}} P_{I_{j,t}}.$$

Here C is real consumption, β is the discount factor, σ is the intertemporal elasticity of substitution, K is the real stock of physical capital, I is the flow of real investment, δ is the depreciation rate on physical capital, w is the wage, R is the rental price of capital, τ_K is the tax rate on capital income, P_I is the price of investment goods, T are transfers from the government, P_C is the price of consumption goods, and r is the real interest rate net of depreciation and taxes. The CRRA utility function and geometric depreciation are standard assumptions. The transfers are rebated tax collections (the model has no government purchases or production) which each worker takes as given. The investment expression says disposable income not spent on current consumption is devoted to purchasing investment goods.

We assume that consumption goods cannot be traded internationally, whereas investment goods are fully tradable internationally. Empirically, some consumption is in fact tradable (e.g., clothing and cars) and some investment nontradable (e.g., some construction services). In the empirical section that follows we contrast the most nontradable forms of consumption with the most tradable component of investment. Specifically, we compare services consumption with investment in machinery and equipment. For expositional simplicity we model here the polar case of purely nontradable consumption and fully tradable investment.

We assume that the PPP price of investment is a world price that each country takes as beyond its control. (As we discuss later, most equipment is produced by OECD countries, which collectively receive three-quarters of the weight in determining PPP prices.) The price of investment goods in country j is pinned down by the world price plus the country-specific tax and tariff rate τ_{Ij} that applies to producing and importing investment goods. Suppressing time subscripts here (and where possible below):

$$P_{I_j} = (1 + \tau_{I_j}) P_I^{\text{PPP}}. \tag{2}$$

Within each country j, firms rent capital and hire labor in competitive spot markets. Firms sell their output in competitive markets in order to maximize static profits. For firms producing consumption and investment goods, respectively, current profits are

$$P_{C_j} C_j - w_j L_{C_j} - R_j K_{C_j} \tag{3}$$

and

$$P_{I_j} I_j - \tau_{I_j} P_I^{\text{PPP}} I_j - w_j L_{I_j} - R_j K_{I_j} . \tag{4}$$

The corresponding production technologies are

$$C_j = A_{C_j} K_{C_j}^{\alpha} L_{C_j}^{1-\alpha} \tag{5}$$

and

$$I_j = A_{I_j} K_{I_j}^{\alpha} L_{I_j}^{1-\alpha}. \tag{6}$$

A_C and A_I are exogenous productivity indices in the consumption and investment sectors, respectively. $\alpha \in (0, 1)$ is the elasticity of output with respect to physical capital and $(1-\alpha)$ is that with respect to labor. We assume these elasticities are the same across countries and across

sectors within countries. Gollin (2002) finds that payments to physical capital range from 25% to 40% of GDP across countries, but that the variation is not correlated with the level of country income. In U.S. data for which sectoral factor shares are available, we find that factor shares are very similar across investment and consumption sectors.[3]

Using first order conditions from (3) through (6), one can show that

(7) $$R_j = \alpha P_I^{\text{PPP}} A_{I_j} \left(K_j / L_j\right)^{\alpha-1}$$

and

(8) $$\frac{P_{C_j}}{P_{I_j}} = \frac{A_{I_j}}{A_{C_j}(1+\tau_{I_j})}.$$

Equation (7) equates the rental price of capital 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 economywide ratio K_j/L_j. Expression (8) says the local 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.

The discount rate (β), intertemporal elasticity (σ), and depreciation rate (δ) are the same in all countries. The sectoral TFP's grow at the constant rate g_A across sectors and across countries. Parameter values that *do* vary across countries are the tax rate on capital income (τ_{K_j}), the tax rate on producing and importing investment goods (τ_{I_j}), TFP in the investment goods sector (A_{I_j}), and TFP in the consumption goods sector (A_{C_j}). TFP's ascend parallel paths, but can differ across countries and sectors at a point in time.

[3] For each sector we defined Labor's Share = Compensation / (Value Added – Indirect Business Taxes – Proprietor's Income). Using U.S. Bureau of Economic Analysis data available at www.bea.gov, we calculated the average labor share over 1987-2000 to be 78% in the consumption sector and 79% in the investment sector. In this calculation we excluded housing from consumption because only capital inputs are incorporated in the service flow from housing.

Variation in these four parameters generates cross-country variation in steady state levels of the price of investment, the nominal investment rate, and the price of consumption relative to investment. Differing parameter values also yield different levels of PPP income per worker at a point in time along steady state paths. In steady state, no international goods arbitrage opportunities exist by (2) plus the assumption that consumption is nontradable. Because capital income is taxed based on where the capital is located, in steady state no incentive for international capital flows exists either. After-tax, after-depreciation real interest rates are the same in all countries and equal to

$$r_j = r = (1+g)^{1/\sigma}/\beta - 1 \,. \tag{9}$$

Here $(1 + g) = (1 + g_A)^{1/(1-\alpha)}$. Expression (9) follows from the consumption Euler equation and the steady state assumption. As no capital flows internationally, nominal saving and investment rates are equal within countries.

Before expressing steady state values, it is useful to define the following:

$$\text{Nominal GDP} = Y_j = P_{C_j} C_j + P_{I_j} I_j$$

$$\text{PPP GDP} = Y_j^{\text{PPP}} = P_C^{\text{PPP}} C_j + P_I^{\text{PPP}} I_j$$

$$\text{Nominal Investment Rate} = i_j = \frac{P_{I_j} I_j}{Y_j}$$

$$\text{PPP Investment Rate} = i_j^{\text{PPP}} = \frac{P_I^{\text{PPP}} I_j}{Y_j^{\text{PPP}}} \,.$$

It is straightforward to that show the steady state *nominal* investment rate in country j is

$$(10) \qquad i_j = \frac{(1+\tau_{I_j})(g+\delta)\alpha\beta(1-\tau_{K_j})}{(1+\tau_{I_j})[(1+g)^{1/\sigma}-\beta(1-\delta(1-\tau_{K_j}))]+\tau_{I_j}(g+\delta)\alpha\beta(1-\tau_{K_j})}.$$

Note that a country's nominal investment rate does not depend on its absolute or relative levels of sectoral TFP. TFP levels do not affect the nominal investment rate because the quantities and prices of investment and consumption respond in precisely offsetting ways. Our functional forms are, of course, critical to this result. But we stress that the critical assumptions are standard in the growth and business cycle literatures, and for good reasons. The constant intertemporal elasticity of substitution is needed for the existence of steady state investment rates and real interest rates. Geometric depreciation has been deemed a good approximation to actual depreciation. And Cobb-Douglas production technologies are consistent with the stability of factor shares over time and across countries.

Given that each parameter appearing in (10) has a value between zero and one, the nominal investment rate is strictly decreasing in both tax rates. To see why intuitively, combine (1), (2), (7), and (9) to obtain

$$(11) \qquad \frac{r+\delta-\delta\tau_{K_j}}{1-\tau_{K_j}}(1+\tau_{I_j}) = \alpha A_{I_j}\left(K_j/L_j\right)^{\alpha-1}.$$

A higher capital income tax rate raises the left hand side (and the steady state rental price of capital), so the right hand side (and the steady state 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 real capital-labor ratio and therefore a lower real investment rate. The tax rate on capital income does not affect relative prices by (8), so the investment rate is lower in nominal terms as well as in real terms.

The negative effect of the investment tax on the 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 real investment rate. The negative effect on the nominal investment rate is less transparent. A higher investment tax rate raises the relative price of investment goods in (8), a force for a higher nominal investment rate. But the adverse effect on the real quantity of investment is larger, leaving the nominal investment rate lower. As shown in (11), the real capital-labor ratio must fall proportionately more than the tax-induced increase in the price of investment because $\alpha < 1$. As the real capital-labor ratio is proportional to the real investment rate along the steady state path, this means the real investment rate must fall more than the price of investment rises, yielding a lower nominal investment rate.[4]

The investment rate in real (PPP) terms is

$$i_j^{\text{PPP}} = \frac{A_{I_j}/A_{C_j}}{\frac{[(1+g)^{1/\sigma}-\beta(1-\delta(1-\tau_{K_j}))](1+\tau_{I_j})}{(g+\delta)\alpha\beta(1-\tau_{K_j})} + A_{I_j}/A_{C_j} - 1} . \tag{12}$$

For this expression we normalized P_C^{PPP}=1 and P_I^{PPP}=1. This normalization has no effect on any of the comparative statics. For instance, the PPP investment rate is invariant to equiproportionate changes in sectoral TFP's. Low TFP in the investment sector *relative* to TFP in the consumption sector, however, does depress a country's PPP investment rate. It makes investment expensive just like high taxes on capital income and investment do. Because PPP prices of investment and consumption do not vary across countries, there is no offsetting relative price effect as operates on the nominal investment rate. For the same reason, a higher investment tax rate lowers the PPP investment rate more than it lowers the nominal 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 the nominal and PPP investment rates.

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

[4] For plausible parameter values we find this negative net effect to be small. We illustrate this below.

$$(13) \qquad Y_j^{\text{PPP}}/L_j \;=\; \left[\frac{i_j^{\text{PPP}}}{(g+\delta)}\right]^{\frac{\alpha}{1-\alpha}} \left[\frac{A_{I_j}A_{C_j}}{A_{I_j}(1-i_j^{\text{PPP}}) \;+\; A_{C_j}i_j^{\text{PPP}}}\right]^{\frac{1}{1-\alpha}}.$$

Equivalently,

$$(14) \qquad Y_j^{\text{PPP}}/L_j \;=\; \left[\frac{K_j^{\text{PPP}}}{Y_j^{\text{PPP}}}\right]^{\frac{\alpha}{1-\alpha}} \left[\text{TFP}_j\right]^{\frac{1}{1-\alpha}}.$$

Here aggregate TFP is in PPP terms. Expression (14) 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. From (12) we know that a higher tax rate on investment goods lowers the PPP investment rate and therefore PPP capital intensity. Unless A_C and A_I are equal (more generally, unless $P_C^{\text{PPP}}A_C$ and $P_I^{\text{PPP}}A_I$ are equal), 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 re-express economywide TFP as

$$(15) \qquad \text{TFP}_j \;=\; A_{C_j}\left(\frac{L_j - L_{I_j}}{L_j}\right) \;+\; A_{I_j}\frac{L_{I_j}}{L_j}.$$

From this expression it is clear that reallocating labor away from investment goods production lowers aggregate TFP if $A_C < A_I$, and raises aggregate TFP if $A_C > A_I$. The fixed PPP prices are crucial here. In local currency, the marginal product of labor is always equated across sectors. In PPP terms this need not be so.

One can similarly show that sectoral TFP's affect both aggregate TFP and capital intensity. Consider a drop in A_I, holding A_C fixed. This lowers aggregate TFP *and* lowers 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 affect on capital accumulation.[5] 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 particularly low A_I. Their low sectoral TFP's contribute to their low aggregate TFP, and their low A_I/A_c ratios contribute to their low physical capital intensity in PPP terms.

Table 1 summarizes the model's qualitative predictions. Figure 3 illustrates quantitative predictions over a range of parameter values. (For this exercise we set capital's share α = 1/3, the depreciation rate δ = 0.07, the annual growth of income per worker g = 0.02, the intertemporal elasticity σ = 1, and the discount factor β = 0.97.) Table 1 shows that no two exogenous variables have the same qualitative effect on all of the endogenous variables. Figure 3 demonstrates that the forcing variables have first order effects on the observables. With data on the endogenous variables we can therefore infer variation in the underlying causal variables. In the next section we do just that.

3. Cross-Country Facts About Investment Rates and Income Levels

In the Penn World Table (PWT), "benchmark countries" are those for which the project collected data on the prices of individual goods and services in a given year. The PWT uses this price data to convert expenditures in national currency into common PPP units. For non-benchmark country-years, the project collected no micro data on prices. Thus for most years and countries, 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 was collected. Benchmark data currently exists 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 non-OECD countries.[6]

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[5] Schmitz (2001) emphasizes this effect in a model with inefficient government production of investment goods.
[6] We obtained the benchmark data from the PWT website http://pwt.econ.upenn.edu. See Summers and Heston (1991) for a fuller description of PPP methodology.

We examine simple univariate regressions of observables on country log PPP income per worker, rather than broader set of regressors as in the cross country growth regression literature. Our first variable of interest is the PPP fixed investment rate. Fixed investment 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. Table 2 provides results of regressing PPP fixed investment rates on PPP income per worker. In each of the three cross-sections (1980, 1985, and 1996), an additional log point of income is associated with about a five percentage point higher PPP investment rate. Across the 115 benchmark countries in 1996, the mean fixed investment rate is 17.4% 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.

Table 2 also presents results for machinery and equipment investment. Machinery and equipment investments are arguably the most tradable components of fixed investment (in contrast to construction). Also, De Long and Summers (1991) presented evidence that the investment rate in machinery and equipment was most strongly related to economic growth and development. Using the PPP investment rate in machinery and equipment, the coefficients on country income remain highly significant. Although the coefficients are less than half as big, so is the mean investment rate in machinery and equipment at 7.9%.

We next examine the *nominal* investment rate, defined as the ratio of investment to GDP when both are measured in terms of national prices. As Table 3 documents for all three years, coefficients on PPP income per worker fall by two-thirds or more when the fixed investment rates are in nominal terms rather than in PPP terms. Savings rates follow much the same pattern: very positively related to income in PPP terms, much less so in nominal terms. Parente and Prescott (2000, p. 39) also noted this low correlation between nominal saving rates

and income across countries; Eaton and Kortum (2001) and Restuccia and Urrutia (2001) did the same for nominal investment rates and income across countries.

The results in Table 3 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. Table 3 shows that the investment rate is rendered insignificant when it is expressed in nominal terms for the broadest set of countries (the 1996 sample), and for all years for the most tradable portion of investment (machinery and equipment). Note that no conditioning variables are included in the regressions. The distinction between nominal and PPP investment rates is, of course, the price of investment relative to output in national currency versus in PPP terms. This relative price is evidently crucial to the connection between investment rates and income levels. We now investigate price differences across the benchmark countries.

Many studies have taken note of 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 et al. (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 not only relative to the price of output in poor countries, but also relative to the price of investment prevailing in rich countries. This pattern is thought to stem from high tariff rates on investment goods imports and/or high tax rates on domestic production of investment goods. As the model in the previous section suggests, this hypothesis can be tested by directly comparing prices of investment goods in rich and poor countries after appropriate conversion into a common currency.

Table 4 presents regressions of investment goods prices on PPP GDP per worker. We obtained these prices by converting the PWT benchmark prices in national currency units into U.S. dollars. We did this in two different ways: using official exchange rates from the PWT (whose source is the IMF) and using black market exchange rates from the World Currency Yearbook. Although the official exchange rate may accurately reflect the market exchange rate

in many country-years, black market premia were well-documented to exist in many poorer countries in 1980 and 1985.[7] 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 capital flows). Second, countries may allow preferential access to the official exchange rate for imports of equipment and machinery (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 prices are converted at the official exchange rate. This should bias our results toward finding higher prices in poorer countries. Official exchange rates are the most favorable to the conventional view that investment goods are expensive in poor countries.

As documented in Table 4, neither the price of fixed investment nor the price of machinery and equipment are significantly negatively related to the level of PPP income per worker. This is true when prices are converted at official exchange rates as well as when they are converted at black market exchange rates. In several cases investment goods actually appear *more* expensive in richer countries. Figure 4 illustrates the case of the 1996 price of machinery and equipment. As the Figure reveals, the price of machinery and equipment does vary across countries, especially outside the richest countries. But machinery and equipment prices look no higher overall than in rich countries.[8]

PWT prices are supposed to be inclusive of all taxes, tariffs, and transportation costs. The results in Table 4 are therefore a blow to the "investment barriers" explanation for the low PPP investment rates in poor countries. This explanation required a significant *negative* relationship between the investment price and income across countries. The lack of any significant relationship at official exchange rates suggests such barriers are not large. Another contributor might be lower distribution costs in poorer countries. Using input-output data,

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[7] Black market premia were much smaller in 1996. We report only results with official exchanges rates for 1996 because the results with black market exchange rates are so similar for that year.
[8] The results are not sensitive to omitting outliers such as Macedonia (MKD), Syria (SYR), and Gabon (GAB).

Burstein, Neves and Rebelo (2000) estimate that distribution costs accounted for 16% of the price of fixed investment in the U.S. in 1992. The positive relationships between income and investment prices at black market exchange rates could also reflect that some imports of equipment and machinery occur at official exchange rates rather than the black market exchanges in poorer countries.

If the high relative price of investment in poor countries does not stem from a high absolute price of investment, it must reflect a low absolute price of consumption. Figure 5 shows the pattern of consumption prices across countries in 1996. Table 5 provides estimated elasticities with respect to country income. A doubling of country income per worker is associated with between 22% and 45% higher consumption prices, depending on the year and the exchange rates used. This Table confirms that the force behind richer countries having higher PPP investment rates is not low investment prices in rich countries, but rather high consumption prices in rich countries.

Table 5 also provides elasticities separately for "nontradable" and "tradable" consumption. We define nontradable consumption as Heston et al. (1995) do: nontradables are services (housing, medical care, purchased transportation, communications, recreation, education, and personal services), and tradables are goods (food, beverages, tobacco, clothing, footwear, fuel, house furnishings, vehicles, and personal care items). The elasticities for nontradable consumption prices with respect to PPP income per worker in Table 5 are between 38% and 70%. Those for tradable consumption prices are markedly lower, ranging from 14% to 37%.[9]

The higher price elasticities for nontradables than for tradables fit the predictions of the Balassa-Samuelson hypothesis: nontradables are *relatively* cheap in poor countries. But why would tradable consumer goods be significantly cheaper in *absolute* terms in poor countries?

[9] Our measure of nontradable consumption only includes *private* services. We obtained very similar nontradable elasticities (half a percentage point larger) when we added government services.

Just as for machinery and equipment, this could reflect local distribution costs. Higher land prices and labor costs may feed into higher distribution costs in rich countries. Implicit in this explanation is that TFP in retail and wholesale trade is not commensurately higher along with wages and land prices in richer countries. Burstein et al. (2000) estimate that distribution costs represent about 40% of the average retail price of consumer goods in the U.S., and about 60% in Argentina. Interestingly, this range is precisely what would be needed to explain Table 5 if the elasticity for tradables was a weighted average of that for nontradables and a zero elasticity for truly tradable consumption goods. That is, the tradable price elasticities are 40-60% of the nontradable price elasticities in Table 5.

So far in this section we have compared only the qualitative implications of the model to the data. We now ask what parameter values would enable the model to quantitatively mimic the data. That is, we calculate the tax rate on capital income τ_{K_j}, the tax rate investment goods τ_{I_j}, the level of TFP in the investment sector A_{I_j}, and the level of TFP in the consumption sector A_{C_j} in each country j that would allow the model to exactly fit the price of investment goods, the price of consumption relative to investment, the nominal investment rate, and PPP income per worker. We do this for 64 benchmark countries in 1985 and 112 benchmark countries in 1996, maintaining a healthy skepticism because of measurement error in the data and specification error in the model.

For this exercise 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 $\beta = 0.97$. Conditional on these parameter values, there are four equations in four unknowns, so the model is just-identified. The model is recursive, so we proceed sequentially: First, we use data on investment prices in dollars to calculate the tax rate on investment goods from (5), normalizing the PPP price of investment to one. Second, we use data on the price of consumption relative to investment to infer TFP in investment goods production relative to that in the production of consumer goods from (10). Third, we use data on the nominal investment rate to solve for the tax rate on capital income from (12). Fourth and finally, we use data on

PPP income per worker and the PPP investment rate to calculate the level of TFP in the investment sector from (13) together with (14).

Table 6 presents the results of this exercise. The first two rows show that the implied tax rates on investment and capital income are not significantly lower in richer countries. According to the model, differences in these tax rates do not help explain why countries are rich vs. poor. The next two rows say richer countries tend to have higher productivity in producing both investment and consumption goods – hardly surprising. More striking is that richer countries appear particularly proficient at making investment goods. Countries with 1% higher income tend to have 0.4% higher TFP in the investment sector *relative* to the consumption sector. In the model this triggers a 0.4% lower price of investment goods relative to consumption goods. Because investment is tradable, its price is pinned down in the world market (conditional on the investment tariff). Rich countries' productivity advantage in investment therefore shows up as a 0.4% higher price of consumption in rich countries. This, of course, is just what we estimated in Table 5. Viewed through the lens of the model, poor countries have low PPP investment rates because they have especially low productivity in their investment sectors.

To recap, poor countries do not exhibit particularly low nominal investment rates. Nor do they exhibit high investment goods prices. Instead they exhibit low consumption prices. When their consumption is valued at the higher prices prevailing in rich countries (as is done in PPP calculations), the investment rates in poor countries are lower than in rich countries.[10] 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 nominal investment rates in poor countries. Nor do they appear to heavily tax the returns to capital. If they did we would expect to see low nominal investment rates in poor countries. Finally, poor

[10] PPP prices (relative to the PPP price of U.S. output – the numeraire) are quantity-weighted averages of price in all benchmark countries. In practice, these quantities are dominated by OECD countries. For example, 71% of PPP consumption and 85% of PPP investment took place in OECD countries in 1985 (when OECD countries represented 26 of the 64 benchmark countries).

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 good prices in poor countries.

Couldn't poor countries just import investment goods?

In our model poor countries cannot export consumer goods, their comparative advantage in production. Our model therefore ignores a way poor countries might circumvent their low efficiency in producing investment goods, namely exporting *tradable* consumer goods (e.g., food or clothing) and importing machinery and equipment.[11] This would substitute a larger tradable consumption goods sector for an inefficient machinery and equipment sector. Empirically, most developing countries do import a significant fraction of the equipment they purchase. Eaton and Kortum (2001) report that the median share of equipment imports relative to domestic investment in equipment was 70% across 14 non-OECD countries in 1985.

It would not be difficult to extend our model to accommodate a tradable consumption sector. Our results would survive so long as poor countries have low productivity in producing *tradable* consumer goods tantamount to their low productivity in producing investment goods. Of course, they must have some comparative advantage in consumer tradables to explain why they are net importers of investment goods. But the extent of this advantage could be arbitrarily small. Note that our finding in Table 5 that poor countries have high prices of consumer tradables relative to nontradables is consistent with their having low productivity in consumer tradables relative to nontradables.

Could our findings reflect measurement error in the PWT data?

The U.N. Food and Agricultural Organization (FAO) provides an independent source of data on food prices in many countries, which we can compare to the food prices in the PWT data. In 1994 (the year with FAO data for the most countries), the prices of all 190 crops rise

[11] Also, many migrants from poorer to richer countries work in nontradable consumption sectors and send remittances to their country of origin – effectively exporting nontradables to richer countries.

with country income. For 48 of the 49 crops with data for at least 50 countries, the elasticity is statistically significant. Pooling all 190 crops (and allowing for crop dummies), we estimate an elasticity with respect to country income per worker of .37 (standard error .01). This does not merely reflect agricultural price supports in OECD countries; the elasticity is .32 (.01) across non-OECD countries. The elasticities would, of course, 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.

One could argue that crops are relatively homogeneous, whereas other goods and services can differ substantially in quality across countries. This raises the issue: How closely do the Summers-Heston data come to pricing *comparable quality* items in different benchmark countries? This is the stated goal of the project, so there is some hope that comparable quality items are priced even when the average quality of items sold rises with income. The project compares the prices of particular car models across countries (e.g., Ford Escort 1100's, BMW 1602's, Chevy Camaro's, etc. in 1975). It compares houses of the same size, vintage (year built), and facilities (electricity, water, bath, central heating).

The PWT's goal notwithstanding, the project may price higher quality items in richer countries. Properly adjusted for quality differences, the price of investment goods might actually decline with country income and the price of consumption might not rise with country income. Trade barriers to importing equipment could be higher in poor countries than the PWT prices suggest. Eaton and Kortum (2001) take this view. If they are right, then Summers-Heston data understate differences in PPP income per worker across countries. 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.[12]

[12] According to Table 5, an unmeasured quality elasticity of at least .25 would be needed to keep quality-adjusted consumption prices from rising with PPP income. Hummels and Klenow (2002) estimated an elasticity of export quality with respect to PPP income of about .25 across 110 countries in 1995. If representative of a country's expenditures, then *all* quality variation would need to go unmeasured in the PWT data to explain our findings.

Moreover, might unmeasured quality differences be larger for consumption (e.g., education and health care) than for investment? If so, then measurement error would contribute to the high measured price of consumption and high measured PPP investment rates in rich countries. (Adding in the unmeasured PPP consumption in rich countries lowers their PPP investment rates.) The correlation between PPP investment rates and PPP income would be partially a figment of measurement error rather than reality. This would undercut a Balassa-Samuelson interpretation of the data, but also tax and tariff explanations of the investment-income correlation. 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.

4. 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 higher investment rate in PPP terms, but not in nominal terms. This pinpoints the low price of investment relative to consumption in rich countries as the force behind their high PPP investment rates. We find no lower investment prices but notably higher consumption prices in rich economies.

Subject to caveats about possible measurement error in the PWT data, we conclude that low PPP investment rates in poor countries are not due to low savings rates or high tax rates on capital or investment. We instead trace the low investment rates in poor countries to their low TFP in producing investment goods relative to consumption. Consumption is cheap in poor countries, making investment expensive and lowering PPP investment rates.

To the extent consumption is less tradable than investment, our findings are consistent with the Balassa-Samuelson hypothesis. This holds that productivity in nontradables (e.g., haircuts, taxicabs, retail trade) rises less with country income than does productivity in

tradables. The Balassa-Samuelson hypothesis begs the question of *why* this should be so. We offer some conjectures:

First and foremost, tradables might have greater capacity for productivity variation than services because the latter tend to be labor-intensive and hard to mechanize. This is often given for why tradables productivity appears to rise faster over time than services productivity does.[13] The same logic could be applied across space as across time.

Second, corruption and regulation may disproportionately affect larger firms, and firms may be larger in the tradable sector. If poor countries are plagued by corruption and regulation, this may be hindering their tradables sectors the most. Third, by increasing the scale of the market, tradability may raise the return to innovations. This could lead to faster innovation for tradables. A faster pace of innovation might mean a greater effect on *sectoral* productivity of a country's abundance of human capital or openness (presuming these are complementary to technology adoption). Fourth, tradability may increase the extent of competition in open relative to closed economies. Whereas all countries are closed when it comes to nontradables, only poor countries may be closed when it comes to tradables. Across open versus closed economies, tradable sectors may therefore differ more in their degree of competition. This could in turn affect productivity, as in the model of Melitz (2002). For evidence that greater competition can boost the level of productivity, see the references in Melitz (2002) and the recent work of Schmitz (2002).

[13] See Kongsamut, Rebelo and Xie (1997) for evidence that service prices have risen relative to goods prices in the U.S. in the last half-century.

Figure 1: PPP Investment Rates in 1996

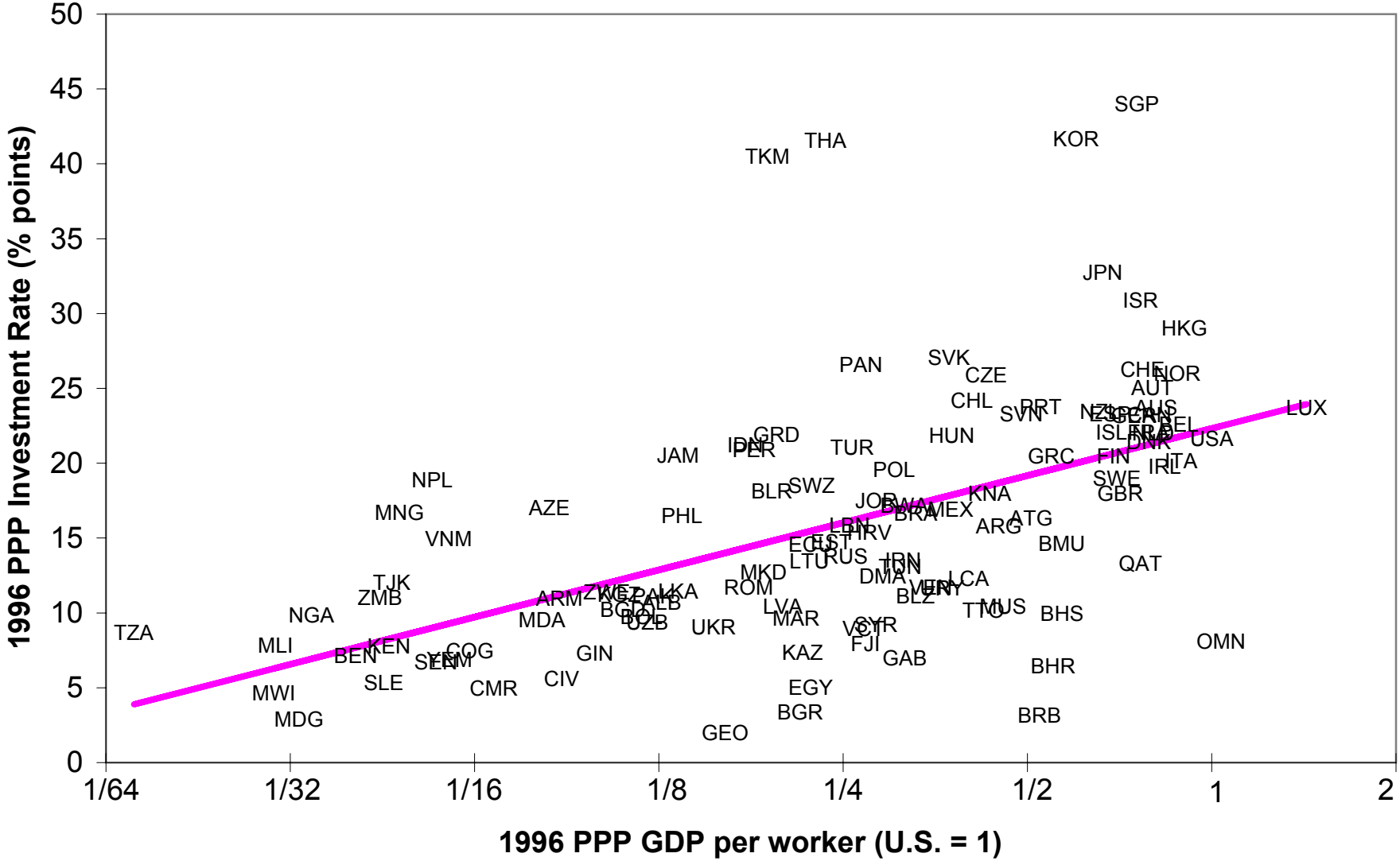

Figure 2: Nominal Investment Rates in 1996

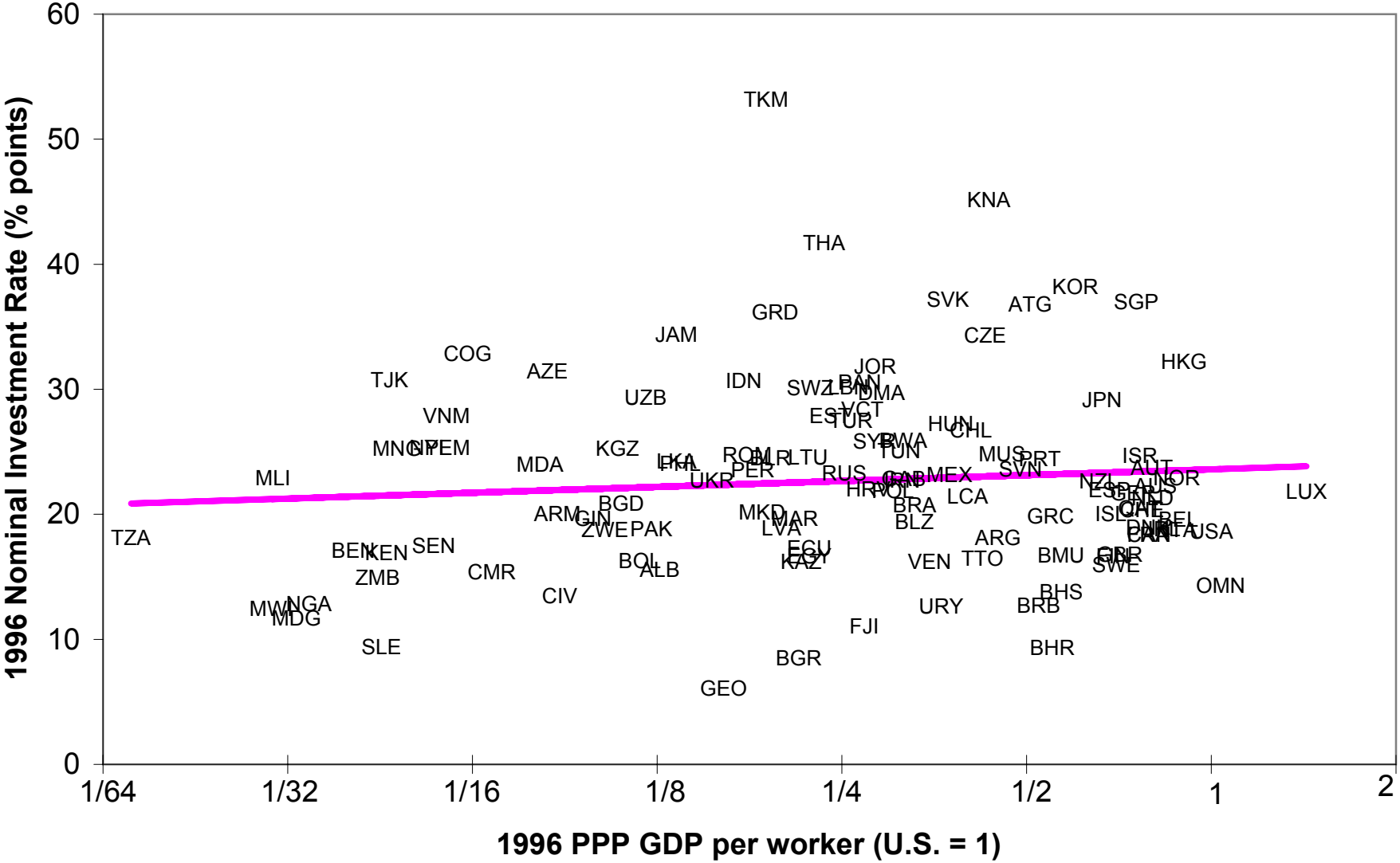

Figure 3

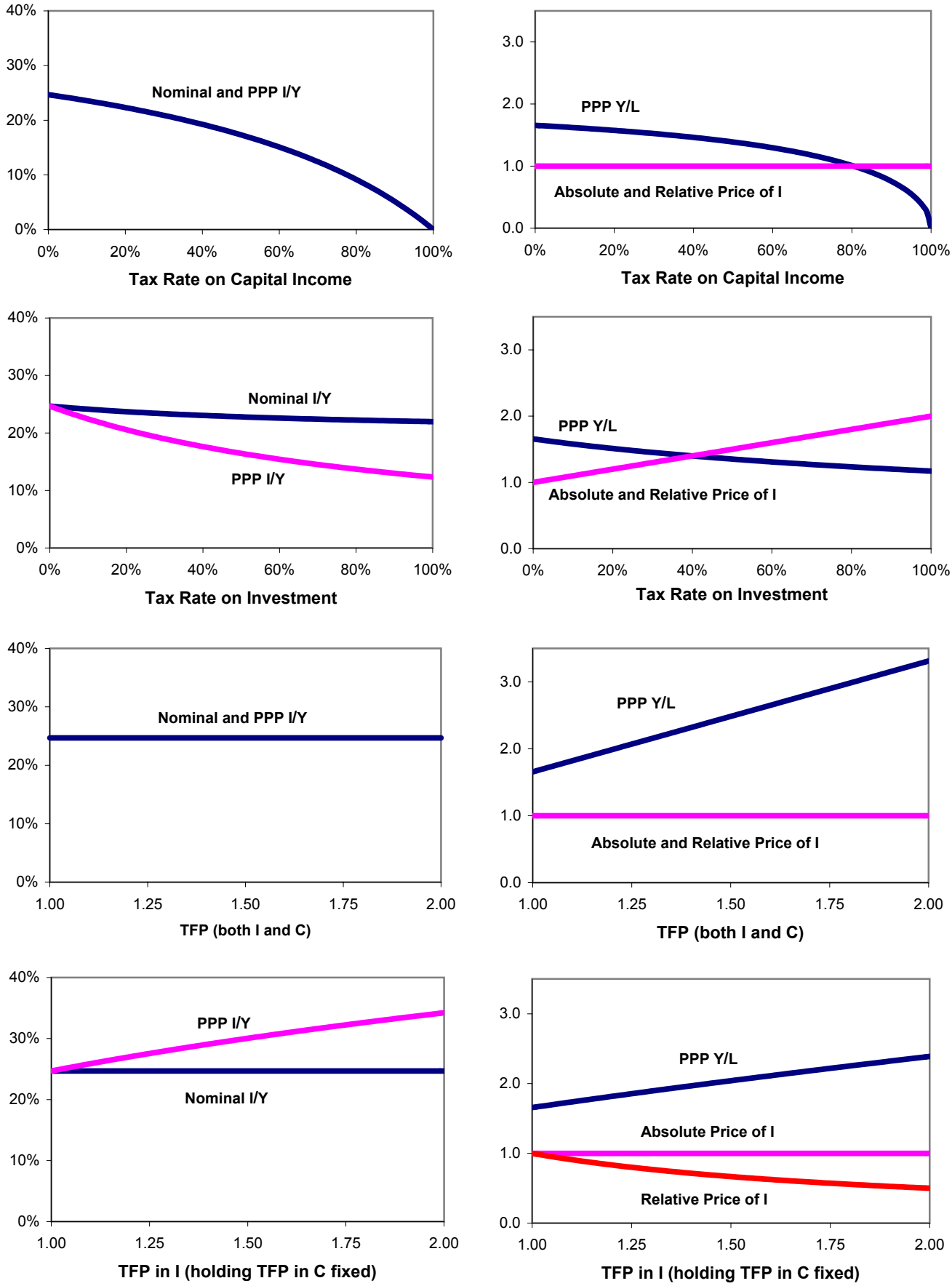
40%
30%
20%
10%
0%
Nominal and PPP I/Y
0%
20%
40%
60%
80%
100%
Tax Rate on Capital Income
3.0
2.0
1.0
0.0
PPP Y/L
Absolute and Relative Price of I
0%
20%
40%
60%
80%
100%
Tax Rate on Capital Income
40%
30%
20%
10%
0%
Nominal I/Y
PPP I/Y
0%
20%
40%
60%
80%
100%
Tax Rate on Investment
3.0
2.0
1.0
0.0
PPP Y/L
Absolute and Relative Price of I
0%
20%
40%
60%
80%
100%
Tax Rate on Investment
40%
30%
20%
10%
0%
Nominal and PPP I/Y
1.00
1.25
1.50
1.75
2.00
TFP (both I and C)
3.0
2.0
1.0
0.0
PPP Y/L
Absolute and Relative Price of I
1.00
1.25
1.50
1.75
2.00
TFP (both I and C)
40%
30%
20%
10%
0%
PPP I/Y
Nominal I/Y
1.00
1.25
1.50
1.75
2.00
TFP in I (holding TFP in C fixed)
3.0
2.0
1.0
0.0
PPP Y/L
Absolute Price of I
Relative Price of I
1.00
1.25
1.50
1.75
2.00
TFP in I (holding TFP in C fixed)

Figure 4: 1996 Price of Machinery and Equipment

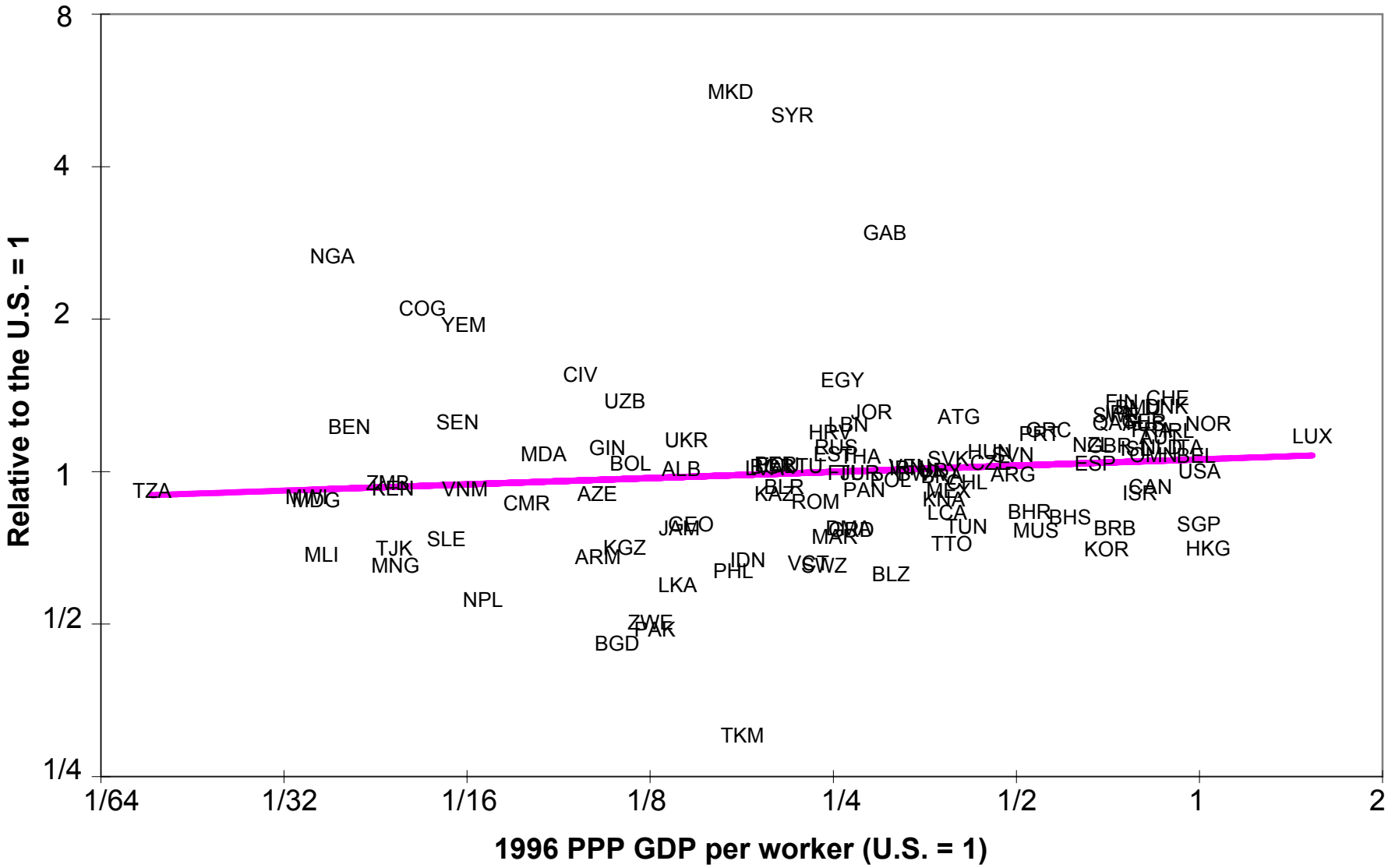

Figure 5: 1996 Price of Consumption

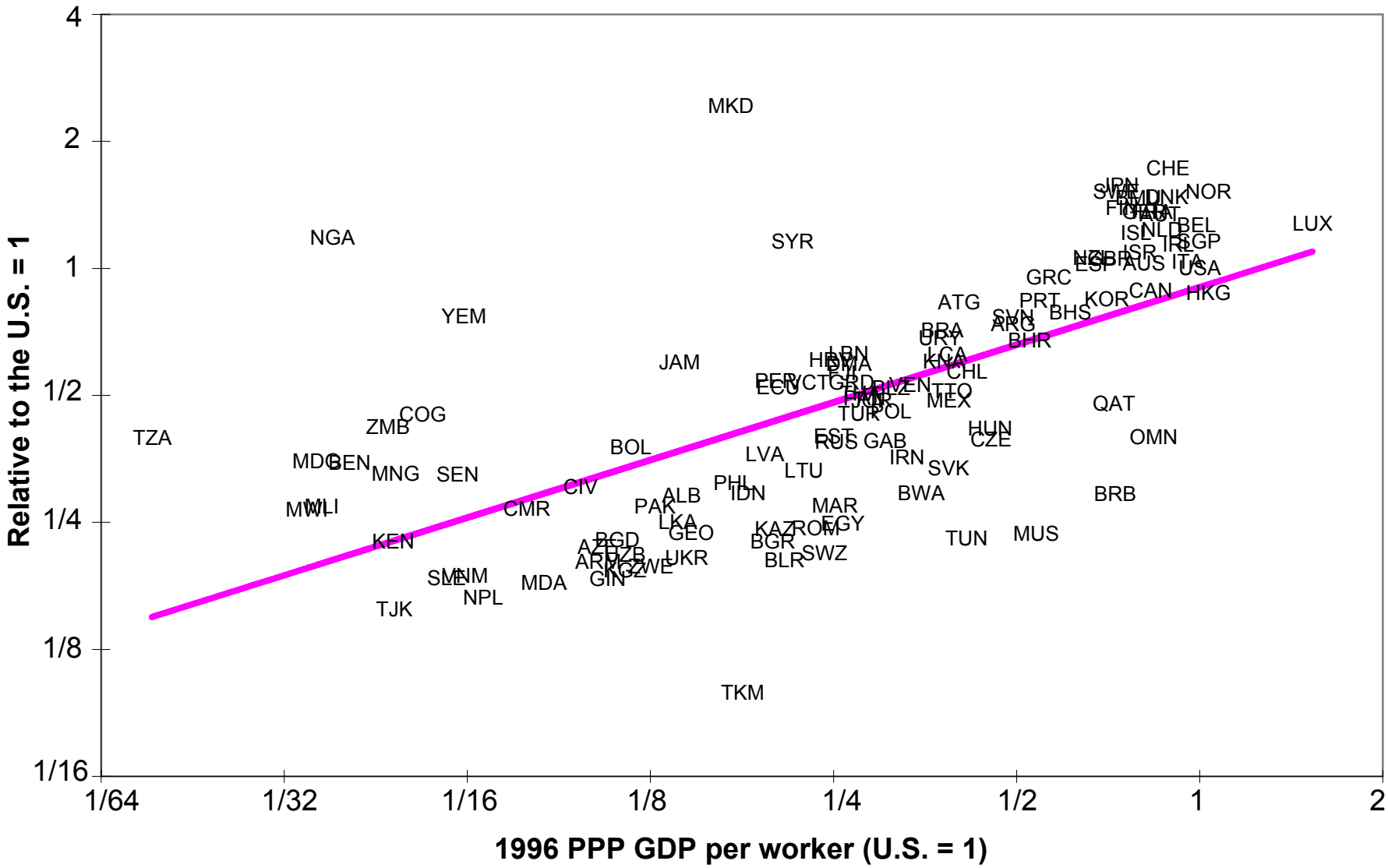

Figure 6: 1996 Price of Nontradable Consumption

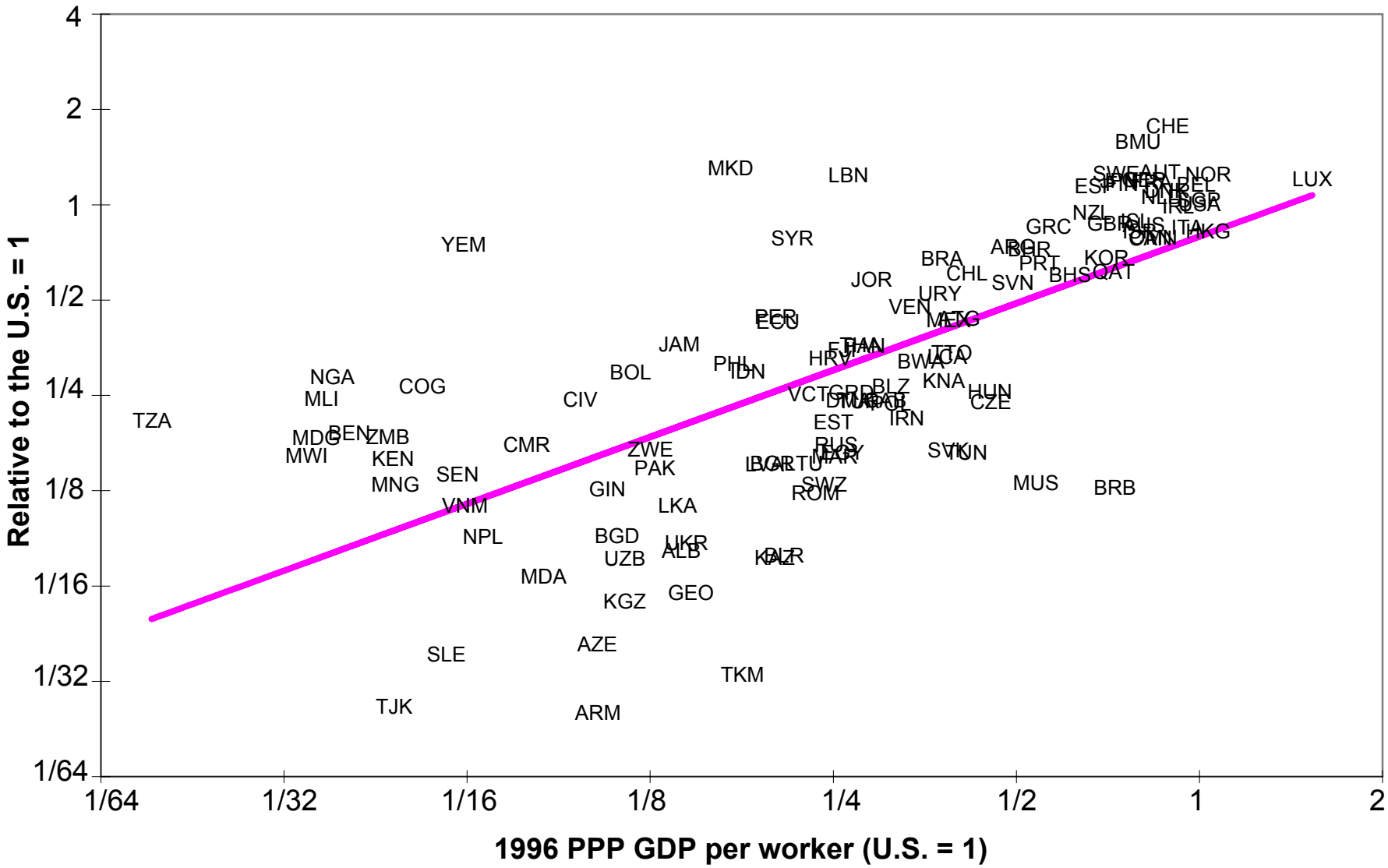

Table 1

Comparative Steady States in the Model

Endogenous → Exogenous ↓	i	i^{PPP}	P_I	P_I/P_C	Y/L
τ_K	−	−			−
τ_I	−	−	+	+	−
A_I and A_C					+
A_I (A_C fixed)		+		−	+

Note: Blank entries denote independence between the variables.

i = the *nominal* investment rate. i^{PPP} = the *PPP* investment rate.

P_I = the price of investment goods. P_C = the price of consumption.

Y/L = PPP GDP per worker. τ_K = the tax rate on capital income.

τ_I = the tax rate on producing and importing investment goods.

A_I = investment sector productivity. A_C = consumption sector productivity.

Table 2

PPP Investment Rates

Independent Variable = log PPP GDP per worker

Dependent Variable ↓	1980	1985	1996
Fixed Investment	**4.64** (0.75)	**5.74** (0.46)	**4.70** (0.74)
	$R^2 = .32$	$R^2 = .60$	$R^2 = .26$
Machinery and Equipment	**1.23** (0.35)	**1.89** (0.20)	**2.67** (0.43)
	$R^2 = .14$	$R^2 = .50$	$R^2 = .25$
# of benchmark countries	61	64	115

Notes: Entries are regression coefficients. Robust standard errors are in parentheses. Bold coefficients are significant at the 5% level. Fixed Investment includes equipment and structures, and excludes inventory investment. Machinery and Equipment includes both electrical machinery and nonelectrical machinery.

Table 3

Nominal Investment Rates

Independent Variable = log PPP GDP per worker

Dependent Variable ↓	1980	1985	1996
Fixed Investment	**1.51** (0.71)	**1.59** (0.54)	0.77 (0.73)
	$R^2 = .06$	$R^2 = .10$	$R^2 = .01$
Machinery and Equipment	0.26 (0.28)	0.45 (0.25)	-0.29 (0.60)
	$R^2 = .01$	$R^2 = .03$	$R^2 = .00$
# of benchmark countries	61	64	115

Notes: Entries are regression coefficients. Robust standard errors are in parentheses. Bold coefficients are significant at the 5% level. Fixed Investment includes equipment and structures, and excludes inventory investment. Machinery and Equipment includes both electrical machinery and nonelectrical machinery.

Table 4

The Price of Investment Goods

Independent Variable = log PPP GDP per worker

Dependent Variable ↓	At *Official* Exchange Rates			At *Black Market* Exchange Rates	
	1980	**1985**	**1996**	**1980**	**1985**
Fixed Investment	.024 (.049)	-.038 (.048)	**.191** (.048)	**.190** (.053)	.096 (.050)
	$R^2 = .00$	$R^2 = .01$	$R^2 = .12$	$R^2 = .14$	$R^2 = .03$
Machinery and Equipment	.014 (.041)	-.058 (.035)	.041 (.037)	**.180** (.058)	.076 (.048)
	$R^2 = .00$	$R^2 = .03$	$R^2 = .01$	$R^2 = .14$	$R^2 = .02$
# of benchmark countries	61	64	115	61	64

Note: Prices are in dollars (converted from national currencies at official or black market exchange rates.)

Table 5

The Price of Consumption

Dependent Variable ↓	At *Official* Exchange Rates			At *Black Market* Exchange Rates	
	1980	**1985**	**1996**	**1980**	**1985**
All Consumption	**.221** (.053)	**.286** (.049)	**.454** (.050)	**.380** (.049)	**.415** (.038)
	$R^2 = .25$	$R^2 = .41$	$R^2 = .43$	$R^2 = .43$	$R^2 = .52$
Nontradable Consumption	**.377** (.064)	**.415** (.050)	**.701** (.069)	**.542** (.062)	**.540** (.050)
	$R^2 = .38$	$R^2 = .51$	$R^2 = .48$	$R^2 = .49$	$R^2 = .53$
Tradable Consumption	**.141** (.047)	**.223** (.049)	**.365** (.046)	**.307** (.045)	**.357** (.034)
	$R^2 = .15$	$R^2 = .33$	$R^2 = .36$	$R^2 = .37$	$R^2 = .41$
# of benchmark countries	61	64	115	61	64

Notes: The independent variable is always log PPP GDP per worker. Nontradables are services, tradables are goods.

Table 6

Implied Tax Rates and Productivity Levels

(Elasticities with respect to PPP Y/L)

	1985	**1996**
τ_I	.046 (.054)	**.122** (.056)
τ_K	-.078 (.059)	-.059 (.082)
A_I	**.895** (.040)	**.939** (.035)
A_C	**.475** (.023)	**.485** (.020)
A_I/A_C	**.420** (.057)	**.453** (.050)
# of countries	64	112

τ_I = tax rate on investment goods.

τ_K = the tax rate on capital income.

A_I = productivity in the investment sector.

A_C = productivity in the consumption sector.

References

Balassa, Bela (1964), "The Purchasing-Power Parity Doctrine: A Reappraisal," **Journal of Political Economy** 72, 584-596.

Ben-David Dan (1998), "Convergence Clubs and Subsistence Economies," **Journal of Development Economics** 55, 155-171.

Bhagwati, Jagdish (1966), **The Economics of Underdeveloped Countries**, McGraw-Hill, New York.

Burstein, Ariel T., Joao C. Neves and Sergio Rebelo (2000), "Distribution Costs and Real Exchange Rate Dynamics During Exchange-Rate-Based-Stabilizations," NBER Working Paper 7862 (August).

Carroll, Christopher D., Byung-Kun Rhee, and Chang-Yong Rhee (1994), "Are There Cultural Effects on Savings? Some Cross-Sectional Evidence," **Quarterly Journal of Economics** 109 (August), 685-699.

Chari, V.V., Patrick J. Kehoe, and Ellen R. McGrattan (1996), "The Poverty of Nations: A Quantitative Exploration," NBER Working Paper 5414 (January).

Chenery, Hollis B. and Alan M. Strout (1966), "Foreign Assistance and Economic Development," **American Economic Review** 56 (September), 679-733.

De Long, J. Bradford and Lawrence H. Summers, (1991) "Equipment Investment and Economic Growth," **Quarterly Journal of Economics** 106 (2), 445-502.

Easterly, William and Sergio Rebelo (1993), "Fiscal Policy and Economic Growth: An Empirical Investigation," **Journal of Monetary Economics** 32 (3), 417-458.

Easterly, William (2001), **The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics**, MIT Press, Cambridge, MA.

Eaton, Jonathan and Samuel Kortum (2001), "Trade in Capital Goods," **European Economic Review** 45, 1195-1235.

Gersovitz, Mark (1983), "Savings and Nutrition at Low Incomes," **Journal of Political Economy** 91 (5) October, 841-855.

Gollin, Douglas (2002), "Getting Income Shares Right," **Journal of Political Economy** 110 (2), 458-474.

Hall, Robert E. and Charles I. Jones (1999), "Why Do Some Countries Produce So Much More Output per Worker than Others?" **Quarterly Journal of Economics** 114 (1), 83-116.

Heston, Alan, Robert Summers, Bettina Aten, and Daniel A. Nuxoll (1995), "New Kinds of Comparisons of the Prices of Tradables and Nontradables," CICUP Paper 95-3, University of Pennsylvania.

Heston, Alan, Robert Summers and Bettina Aten (2001), Penn World Table Version 6.0, Center for International Comparisons at the University of Pennsylvania (CICUP), December.

Higgins, Matthew and Jeffrey G. Williamson (1997), "Age Structure Dynamics in Asia and Dependence on Foreign Capital," **Population and Development Review** 23 (2) June, 261-293.

Hummels, David and Peter J. Klenow (2002), "The Variety and Quality of a Nation's Trade," NBER Working Paper 8712 (January).

Jones, Charles I. (1994), "Economic Growth and the Relative Price of Capital," **Journal of Monetary Economics** 34 (3), 359-382.

Jovanovic, Boyan and Rafael Rob (1999), "Solow vs. Solow," manuscript, New York University.

Klenow, Peter J. and Andrés Rodríguez-Clare (1997), "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?" **1997 NBER Macroeconomics Annual**, B. Bernanke and J. Rotemberg ed.s, MIT Press, Cambridge, Massachusetts, 73-103.

Kongsamut, Piyabha, Sergio Rebelo, and Danyang Xie (1997), "Beyond Balanced Growth," NBER Working Paper 6159 (September).

Lee, Jong-Wha (1995), "Capital Goods Imports and Long-Run Growth," **Journal of Development Economics** 48 (1), 91-110.

Levine, Ross and David Renelt (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions," **American Economic Review** 82 (4), 942-963.

Lewis, W. Arthur (1954), "Economic Development with Unlimited Supplies of Labor," **Manchester School of Economic and Social Studies** 22, 139-191.

Matsuyama, Kiminori (1992), "Agricultural Productivity, Comparative Advantage, and Economic Growth," **Journal of Economic Theory** 58 (December), 317-334.

McGrattan, Ellen R. and James A. Schmitz, Jr. (1999), "Explaining Cross-Country Income Differences," chapter 10 in the **Handbook of Macroeconomics**, Volume 1a, John B. Taylor and Michael Woodford, eds., North-Holland, New York, 669-737.

Melitz, Marc J. (2002), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," manuscript, Harvard University.

Nelson, Richard R. (1956), "A Theory of the Low-Level Equilibrium Trap in Underdeveloped Economies," **American Economic Review** 46 (1) December, 894-908.

Parente, Stephen L. and Edward C. Prescott (2000), **Barriers to Riches**, MIT Press, Cambridge, Massachusetts.

Restuccia, Diego and Carlos Urrutia (2001), "Relative Prices and Investment Rates," **Journal of Monetary Economics** 47 (1), 93-121.

Rostow, W.W. (1960), **Stages of Economic Growth: A Non-Communist Manifesto**, Cambridge University Press.

Sala-i-Martin, Xavier (1997), "I Just Ran Four Million Regressions," NBER Working Paper 6252 (November).

Samuelson, Paul A. (1964), "Theoretical Notes on Trade Problems," **The Review of Economics and Statistics** 46, 145-154.

Schmitz, Jr. James A. (2001), "Government Production of Investment Goods and Aggregate Labor Productivity," **Journal of Monetary Economics** 47 (1), 163-187.

Schmitz, Jr. James A. (2002), "Threats to Industry Survival and Labor Productivity: World Iron-Ore Markets in the 1980's," forthcoming in the **American Economic Review**.

Solow, Robert M. (1956), "A Contribution to the Theory of Economic Growth," **Quarterly Journal of Economics** 70(1) February, 65-94.

Summers, Robert and Alan Heston (1991), "The Penn World Table (Mark 5): An Expanded Set of International Comparisons," **Quarterly Journal of Economics** 106 (2), 327-368.

World Currency Yearbook (various years), Currency Data and Intelligence Inc.