Household Production and Development

by Stephen L. Parente, Richard Rogerson, and Randall Wright

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Introduction

Differences in standards of living across countries are large. For example, Summers and Heston (1991) indicate that income per worker is around 30 times higher in the richest countries than it is in the poorest countries.

Why are differences in living standards so big? One position is that some countries have relatively low income levels due to their relatively low stocks of capital; this is particularly true if we interpret capital generally to include human and other intangible capital (see Mankiw, Romer, and Weil [1992]). Of course, this raises the question, why do some countries have such low capital stocks in the first place? One suggestion is that these countries are burdened with policies that distort agents' incentives to accumulate capital, policies that will be referred to here as *barriers to capital accumulation.*

This paper analyzes the effects of such barriers quantitatively. Compared to previous studies that have analyzed the effects of such policies on relative levels of income in the neoclassical growth model,[1] the key difference in this study is that we explicitly incorporate nonmarket activity—that is, *household production*—into the analysis. We argue that distinguishing between economic activity in market and nonmarket sectors may go a long way toward understanding international differences in capital and income.

The essence of our argument is as follows: First, the nature of the development experiences that we describe leads us to explain differences in per-worker income levels across countries (rather than differences in growth rates). The question, therefore, is how much of the observed differences in income levels can be attributed to empirically realistic barriers to capital accumulation? It is well known that the standard neoclassical growth model accounts for very few of these differences. However, the effects of such policies can be significantly larger when home production is included in the model, at least for certain parameter values (in particular, values that imply that capital is less important in nonmarket than in market production, such that nonmarket- and market-produced goods are relatively close substitutes). For example, in a standard model without home

1 For example, Parente and Prescott (1994) and Chari, Kehoe, and McGrattan (1996).

production, the distortionary policy must be about 100 times larger in one country for it to have one-tenth the income of another country, while in one (admittedly extreme) version of our home-production model, the distortionary policy need be only about three times bigger.

In models with household production, agents are generally more willing to shift resources out of market activity in response to policy distortions. Intuitively, policies that affect capital accumulation may also influence the mix of economic activity in market and nonmarket sectors, and so policy distortions can have significant effects. In the standard model without home production, the policy distortion required to generate a given income difference is so large because the time agents spend working in the market does not depend on the size of the distortion (given functional forms consistent with balanced growth). Hence, in that model, cross-country differences in output per worker are entirely attributed to differences in capital per worker. In the home-production model, although these same policies may not affect total hours worked, they generally do affect how hours are allocated between the market and nonmarket sectors. As individuals change their allocation of time spent in market work and in home work, differences in output per person will be due to both differences in capital and in market hours per worker.

As Parente and Prescott (1994) and Chari, Kehoe, and McGrattan (1996) have noted, an augmented neoclassical growth model without household production—but with capital broadly defined to include tangible and intangible capital—can go quite far in accounting for differences in income with reasonably sized barriers, *if* one is willing to assume that total capital's share in the production function is large. Such models, however, imply a large amount of unmeasured capital and investment. Household production is a complementary extension of the neoclassical model, in that a sizable fraction of the observed differences in income across countries can be accounted for in a model without intangible capital. If we include both intangible capital and home production, the amount of intangible capital and, hence, the role assigned to unmeasured investment, will be smaller.

The model with intangible capital and the model with home production both entail unmeasured output in the economy. However, in the home-production model, this unmeasured output takes the form of consumption rather than investment. Furthermore, the model without home production predicts the same fraction of unmeasured output in rich and poor countries, while the home-production model predicts a greater fraction of unmeasured output in poor countries. Hence, the home-production model predicts that the true differences in output, and especially in consumption, are smaller than those reported in the National Income and Product Accounts because nonmarket production and consumption are relatively more important in poor countries. This helps us to understand how individuals can survive on the amount of consumption reported in the official data in the poorest countries—an issue raised, for example, by Lucas (1988). It also allows us to compute the welfare implications of policy differences and, thus, of output differences in a way that explicitly recognizes nonmarket activity and its importance in poorer countries.

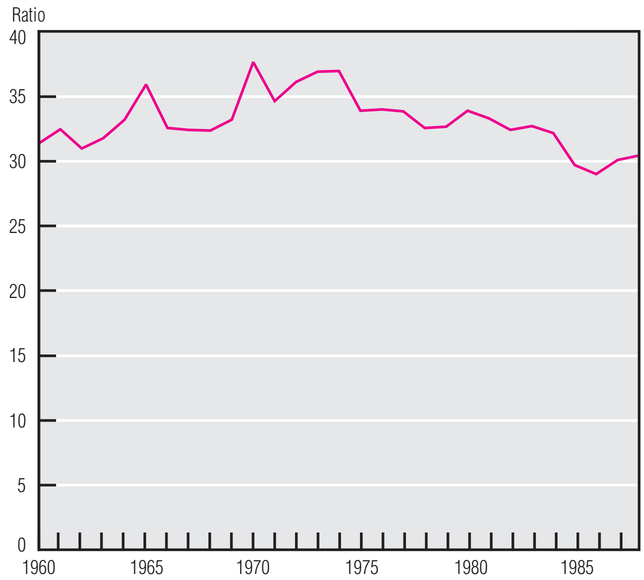
It may be worth mentioning at this point an analogy between the approach to development economics adopted here and modern business-cycle theory. In that literature, one attempts to identify and measure impulses (the underlying sources of fluctuations, such as technology shocks, changes in monetary policy, and so on) and then study the extent to which these impulses are amplified or propagated by different economic models. For example, one might ask, what fraction of observed business-cycle fluctuations can be accounted for with a given impulse and model? In this paper, we take as a maintained (if presumably counterfactual) hypothesis that countries differ only with respect to their barriers to capital accumulation. We establish reasonable magnitudes for these barriers, and then we ask, what fraction of the observed income differences can we account for? The point of this analysis is that the answer to the question changes once one recognizes that much economic activity takes place outside the formal market. Likewise, answers to several questions in business-cycle theory change once one incorporates home production into otherwise standard models.[2]

The rest of the paper is organized as follows: Section I reviews some basic development facts. Section II documents how the standard neoclassical growth model fails to account for these facts, given empirically plausible parameter values. We show how this model, augmented to include a second form of capital, can account for these facts, but also can predict a large amount of unmeasured capital and investment. Section III introduces home production into the

■ 2 See Greenwood and Hercowitz (1992), Behabib, Rogerson, and Wright (1992), and McGrattan, Rogerson, and Wright (1997), for example, for applications of home production in business-cycle theory.

FIGURE 1

Relative Income, Richest Countries to Poorest Countries



SOURCE: Summers and Heston (1991).

basic neoclassical model (without the second form of capital) and reports the quantitative impact of size differences in the barrier for several parameterizations of the model on observable variables and on welfare. Section IV integrates the model with two types of capital and with household production. Section V considers evidence supporting the view that home production is relatively important in less-developed economies.[3] Section VI contains some brief concluding remarks.

I. Key Development Facts

In this section we briefly present some key development facts (more detailed discussions can be found in Parente and Prescott [1993, 1994]) which dictate our choices of questions and modeling strategies. Some researchers have concluded that a theory of relative income levels, as opposed to a theory of growth-rate differentials, is appropriate for understanding the pattern of economic development. Since an exogenous growth model of relative income levels is the framework of this paper, we motivate our choice by describing the relevant data.

Let y_t measure gross domestic product (GDP) per worker in a country at date t divided by GDP per worker in the United States at date t, computed at world prices. For the 102 countries in Summers and Heston (1991) with at least one million in population for which the data is complete between 1960–88, figure 1 plots the ratio of the average y_t in the five richest countries to the average y_t in the five poorest countries. First, notice that the GDP disparity is big—the richest five countries are about 30 times richer than the poorest five. Second, observe that this disparity has not increased. The ratio remains essentially the same over the period. (The standard deviation of the income distribution increases some, from about 1.25 to 1.50, with some of the mass spreading from the center to the tails.) In addition, while the rich got richer, so did the poor: with rare exceptions, all countries grew, suggesting no absolute poverty trap. The average annual growth rate in the sample is 1.9 percent.

Although it cannot be seen in figure 1, individual countries have moved within the distribution, suggesting no relative poverty trap: there have been both miracles and disasters.

Let us take as a base $\tilde{y}$, set equal to 10 percent of per capita GDP in the United States in 1985. Figure 2 plots the year in which each country achieved this level against the number of years it took that country to double its per capita output (that is, to go from $\tilde{y}$ to $2\tilde{y}$). Countries that achieve an income level of $\tilde{y}$ relatively early will take a longer period of time to double their income, while countries that achieve an income level of $\tilde{y}$ later can double their income much more rapidly. (This does not depend crucially on the choice of the base, and a similar pattern emerges for other values of $\tilde{y}$.) Hence, while the frontier is growing at a given rate, if a country lags significantly behind, it is possible to make rapid advances toward the frontier. This suggests that some countries have a policy or a set of institutions, perhaps, that keeps their income relatively low, but they are capable of catching up somewhat if the policy is eliminated or ameliorated.

■ 3 The idea that household production may be important to understanding economic development is not new. Kuznets (1960), for example, noted that nonmarket activities are more important in relatively poor nations. Eisner (1994) attributes the difference between the true and reported outputs to home production. Previous attempts to model household production in the context of economic development include Hymer and Resnick (1969) and Locay (1992), but these are not quantitative, dynamic, general-equilibrium models. Easterly (1993) studies an endogenous growth model that can be interpreted as having a formal and informal sector, although it could just as well be interpreted as a one-sector model with two types of capital.

FIGURE 2

Years to Grow from $2,000 to $4,000 Per Capita Income versus Year Reached $2,000

a. Measured in 1990 U.S. dollars.
SOURCE: Parente and Prescott (forthcoming 2000).

These facts influence our choice of questions and models. In an endogenous growth model, differences in policies translate into differences in growth rates, but the data indicate that growth-rate differences are not permanent, as income levels across countries do not diverge over the postwar period. Even if we allow policies and (therefore) growth rates to change over time, an endogenous growth model cannot clearly explain the fact that countries that achieve a given base income later are able to double their income more quickly. Therefore, it is reasonable to adopt an exogenous growth model—that is, to assume that countries grow at the same average rate—and to ask what produces the observed differences in relative income levels.[4] In this model, countries that are behind the frontier because of a particular policy can indeed move up rapidly within the income distribution once the policy is removed. It is also desirable to consider policies for which we have some quantitative information. This will lead us to model barriers to capital accumulation in a particular way, as we discuss below.

II. Background

The starting point of our analysis is the standard one-sector growth model. Assume an infinitely lived representative agent with preferences given by

$$(1)\quad \sum_{t=0}^{\infty} \beta^t [\log c_t + \alpha \log(1-n^t)],$$

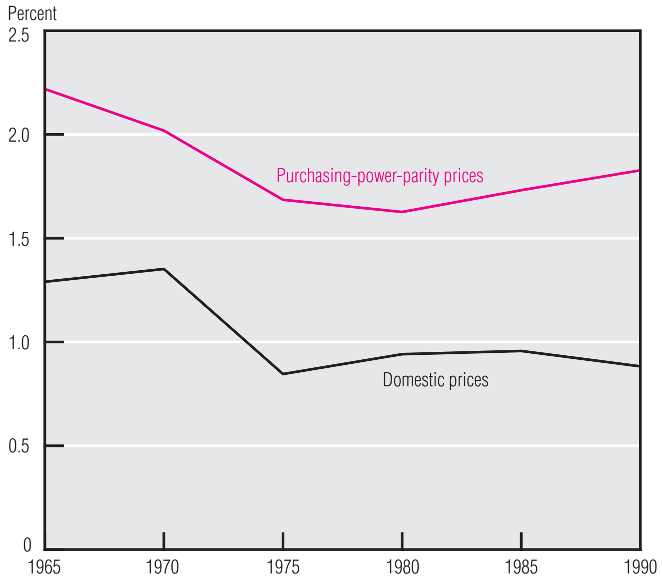
where c_t denotes consumption, n_t denotes time spent working at date t, and $\beta \in (0,1)$ denotes the discount factor. The representative agent is endowed with one unit of time in each period and k_0 units of capital at $t=0$. A constant-returns-to-scale production function uses capital and labor to produce output

$$(2)\quad y_t = A\, k_t^{\theta} [(1+\gamma)^t n^t]^{1-\theta},$$

4 Exogenous growth, incidentally, does not mean that a country can realize increases in output without undertaking any action. Parente and Prescott (1994) show that the equilibrium behavior of a model in which firms choose whether to adopt better technologies over time and in which the stock of knowledge that firms can adopt increases exogenously, is equivalent to the neoclassical growth model augmented with a second form of capital.

FIGURE 3

Relative Investment Shares, Rich vs. Poor Countries



SOURCES: Summers and Heston (1991), International Monetary Fund (1994)

where exogenous, labor-augmenting technological change occurs at rate γ per period. Output in each period is divided between consumption and investment,

$$(3)\quad c_t + x_t \le y_t.$$

Capital accumulation is represented by

$$(4)\quad k_{t+1} = (1-\delta)k_t + x_t,$$

where $\delta \in (0,1)$ is the depreciation rate.

One approach to studying the implications of the neoclassical growth model for development is to view each country as a closed economy, described by the same preferences and technology, and to look for policies that differ across countries and that may affect relative levels of output. Since the key economic decision in the model is the consumption–savings decision, it is natural to look for policies that distort incentives for agents to accumulate capital. There are many candidate factors, ranging from taxation and regulation to fear of confiscation. Two policies that have been studied in the literature are capital income taxation and policies affecting the relative price of capital goods, which we refer to as barriers to capital accumulation. From the perspective of modeling relative income, these two policies have similar effects. However, there are reasons to believe that barriers that distort the relative price of investment goods may be a more promising route.

If cross-country income differences are explained by differences in tax rates, then per capita income and taxes should be negatively correlated; however, the data do not show such a relationship (see Easterly and Rebelo [1993]). If one assumes that barriers to capital accumulation are the source of income differences, then there should be a negative correlation between per capita income and the price of investment relative to consumption goods. Jones (1994) documents differences in the price of equipment relative to consumption goods across countries and does indeed find a strong negative correlation between this variable and per capita output.

Since the two policies have different implications for prices, they have different implications for the investment–income ratio. Empirically, investment shares measured using domestic prices display no correlation with per capita output, whereas investment shares computed using purchasing-power-parity prices show a positive correlation with output per capita. Figure 3 plots the ratio of investment share in rich countries to the investment share in poor countries, computed with both domestic prices and with purchasing-power-parity prices. We argue that models with barriers that distort the relative price of capital are better able to match this observation.

We focus on policies that affect the price of investment relative to consumption goods, parameterized by changing capital accumulation (equation [4]) to

$$(5)\quad k_{t+1} = (1-\delta)k_t + \frac{x_t}{\pi},$$

where π is the size of the barrier. If $\pi = 1$, then one unit of consumption can be turned into one unit of capital, while in a country with $\pi > 1$, each unit of consumption invested yields only $(1/\pi < 1)$ units of capital. Thus, π is the relative price of investment goods. Jones' (1994)

TABLE 1

Differences in Relative Income, y^*/y^*_{US}

	θ=1/4	θ=1/3	θ=1/2	θ=2/3	θ=3/4
π = 2	0.79	0.71	0.50	0.25	0.13
π = 3	0.69	0.58	0.33	0.11	0.04
π = 4	0.63	0.50	0.25	0.06	0.02
π = 10	0.46	0.32	0.10	0.01	0.001

SOURCE: Authors' calculations.

evidence not only gives us reason to believe that differences in barriers may be the source of income differences, it also allows us to establish reasonable estimates of the magnitude of π. Jones reports a range of equipment relative to consumption goods prices between 1 and 4 across countries, with the United States normalized to 1.[5]

Pursuing the business-cycle analogy, we now have a more or less quantifiable impulse for the phenomenon in which we are interested, and we can now think about asking, how much of the observed income disparity can be accounted for by variations in π? Although we do not believe that policies distorting the prices of investment goods are the *only* factor accounting for cross-country income differences, it is still of interest to examine the effects that can be generated as a function of π, given a particular model.

Given π, the unique equilibrium in the model has the property that, starting from any $k_0>0$, we converge to a balanced growth path, along which output, consumption, investment, capital, and wages all grow at the same rate γ, while the rate of return to capital and hours worked are constant.[6] For the most part, we will focus on balanced growth paths, and in particular on the relative level of balanced-growth-path output across economies with different values of π (although we will also take into account transitions from one balanced growth path to another when we analyze welfare). With our functional forms, it is straightforward to characterize the balanced growth path as a function of π. First, the fraction of time devoted to work is independent of π. Second, given that π=1 in the United States, the relative capital stock and output in an economy with a barrier of size π will be

$$(6)\qquad \frac{k^*}{k^*_{US}}=\pi^{-1/(1-\Theta)} \text{ and } \frac{y^*}{y^*_{US}}=\pi^{-\Theta/(1-\Theta)}.$$

Does this yield a good theory of development? To answer this question, one must say something about parameter values. Table 1 reports the relative output differences generated by differences in barriers from $\pi=2$ to $\pi=10$ for various values of Θ. If k is interpreted as physical capital, we are led to consider a value of Θ between 1/4 and 1/3. For these parameter values, the model accounts for very little of the observed differences in per capita income; for example, with Θ = 1/3, U.S. output is only twice as high as output in an economy with π = 4, and only three times as high as an economy with π = 10. Recall that the data indicate that U.S. output per worker is 30 times higher than output per worker in the poorest countries. To generate output differences of 30 with Θ =1/3, we would need a barrier of π = 900. This model is off by orders of magnitude.

Table 1 provides results for higher values of Θ, which, as one can see, allow the model to account for much larger differences in relative income. For example, if Θ=2/3, we can generate output differences of 30 with a barrier of about π=5.5. To rationalize such higher values of Θ, several researchers (including Mankiw, Romer, and Weil [1992], Parente and Prescott [1994], and Chari, Kehoe, and McGrattan [1996])

■ 5 Restuccia and Urrutia (1996) find a range closer to 12. Like Jones (1994), they compute the ratio of the price level of investment to the price level of consumption goods, taken from the Penn World Tables; unlike Jones, they consider all investment goods, rather than a subcategory, and use both benchmarked and unbenchmarked countries. However, the big difference seems to be due to revisions of the price data in the Penn World Tables between PWT and PWT5.6. In another sense, the range of 4 may be too large. According to PWT5.6, the prices of consumption goods vary much more across countries than prices of investment goods (that is, it is not that computers are expensive in poor countries, but that haircuts are cheap). It appears that differences in the price of consumption goods account for about half of the variation in these relative prices, suggesting a barrier closer to 2.

■ 6 Note that, even though this economy has a distortionary policy, one can characterize a competitive equilibrium by solving an augmented social planner's problem, where the planner faces the law of motion for k_t that includes the barrier $k_t=(1-\delta)k_t+x_t/\pi_t$.

TABLE 2

Model with Unmeasured Capital

θ_k	θ_z	$\frac{x_z}{c+x_k}$	$\frac{x_k}{c+x_k}$	$\frac{k}{z}$
0.10	0.57	0.76	0.13	0.18
0.20	0.47	0.55	0.24	0.43
0.30	0.37	0.39	0.32	0.82
0.40	0.27	0.26	0.38	1.50
0.50	0.17	0.15	0.44	3.00
0.60	0.07	0.05	0.48	9.00

SOURCE: Authors' calculations.

have discussed expanding the notion of capital beyond physical capital to broader notions, including human and organizational capital. However, some issues must be faced if one goes this route. First, the values of π that we infer from empirical work are based on data for physical capital, and it is unclear to what extent barriers of this size apply to other types of investment. For example, in the case of human capital, a substantial component of accumulation takes place in the formal education sector, which is heavily subsidized in many countries, especially in poor countries. Second, since current national-income-accounting procedures do not recognize capital other than physical capital, and investments in intangible capital (with the exception of some education expenditures) are not measured, assuming high values of θ implies that a large amount of capital and investment will go unmeasured.

To illustrate this point explicitly, we modify the previous model to include an intangible capital good, z. Let investment in physical and in intangible capital be denoted by x_k and x_z, respectively, so that we have

$$(7) \quad c_t + x_{kt} + x_{zt} \le y_t = A k_t^{\theta_k} z_t^{\theta_z} [(1+\gamma)^t n_t]^{1-\theta_k-\theta_z}.$$

The empirical counterpart of y_t is no longer output as reported in the National Income and Product Accounts, due to the unmeasured investment; rather, output in the national product accounts corresponds to $(c_t + x_{kt})$ in the model. We assume the two capital stocks evolve according to:

$$(8) \quad k_{t+1} = (1-\delta_k) k_t + x_{kt}/\pi$$

and

$$(9) \quad z_{t+1} = (1-\delta_z) z_t + x_{zt}/\pi .$$

It is a straightforward generalization of the standard model to characterize the balanced growth path for this model as a function of π.

Table 2 presents summary statistics for several combinations of θ_k and θ_z that sum to 2/3, meaning that the π needed to generate the observed international income differences is 5.5.[7] The third column reports unmeasured investment as a fraction of measured output; the fourth column reports measured investment as a fraction of measured output; and the last column reports the ratio of the two capital stocks. If θ_k=0.40, for example, unmeasured investment is only 26 percent of measured output. However, such a value for θ_k implies that measured investment equals 38 percent of measured output—nearly twice as high as in the U.S. data. To match the measured investment–output ratio, θ_k cannot be greater than 0.20; for such values of θ_k, the implied value of unmeasured investment exceeds half of measured output, and the unmeasured capital stock is well over double the measured capital stock.[8]

This discussion is not meant to suggest that models with higher capital shares are necessarily inconsistent with the data; after all, it is tautological to say that we do not have measures of unmeasured investments.

We believe, however, it does suggest that it may be worthwhile to consider other approaches.

7 Other parameters are calibrated as follows: $\delta_k = \delta_z = 0.06$; γ is set to achieve 2 percent growth per year; β is set to achieve a real interest rate of 4.5 percent; the preference parameter α is set so that the fraction of time spent working is 1/3.

8 Chari, Kehoe, and McGrattan (1996) set θ_k=1/3, making their model inconsistent with the ratio of measured investment to measured output. Mankiw, Romer, and Weil (1992) likewise set θ_k=1/3, but their model is not inconsistent with this observation, since they calibrate other parameters to match the measured investment–output ratio; however, this implies a real rate of interest in excess of 10 percent. Parente and Prescott (1994) calibrate to a real rate of return of 4.5 percent and a measured investment-output ratio of 20 percent, implying that θ_k = 0.19 and that unmeasured investment is 41 percent of measured output. This is lower than reported in table 2 because Parente and Prescott's calibration implies a lower depreciation rate on intangible capital of 3.5 percent. Their ratio of unmeasured to measured capital, however, is still quite large.

The remainder of this paper outlines an alternative but complementary framework—the home-production model. This model helps to account for cross-country income differences, but at the same time has implications differing from the previous models. For example, while both approaches imply unmeasured output, the model with intangible capital and without home production emphasizes unmeasured investment, whereas the home-production model emphasizes unmeasured consumption. Although it is not apparent from table 2, an important point for future reference is that the model with intangible capital and without home production implies that unmeasured investment as a fraction of measured output is independent of π.[9] Thus, high- and low-distortion economies have the same ratios of unmeasured investment to measured output, and so the difference in measured output across countries accurately reflects the difference in total (measured plus unmeasured) output. This will not be true for the home-production model.

III. The Home-Production Model

Following Becker's (1965) line of thought, we now extend the standard model to allow for nonmarket, or household, production. Some researchers in macroeconomics have found this useful in accounting for high-frequency aspects of the data (for example, Benhabib, Rogerson, and Wright [1991] or Greenwood and Hercowitz [1991]). One reason is that home-production models provide additional margins of adjustment relative to models without home production. Thus, whereas in the standard model there are only two uses for output—consumption and investment—in a home-production model there are three—consumption, investment in market capital, and investment in nonmarket capital. Likewise, in the standard model there are only two uses for time—leisure and work—but in a home-production model there are three—leisure, market work, and nonmarket work. In particular, a reduction in return-to-market activity reduces time spent in market work in the standard model only to the extent that it increases leisure. In a home-production model, agents can adjust their market hours by altering the mix of market work and home activity, even if they do not change their leisure-time allocation.[10]

Generalizing the previous model, preferences are now given by

$$(10) \quad \sum_{t=0}^{\infty} \beta^t \left[\log c_t + \alpha \log(1-n_t)\right],$$

where c_t is an aggregate of market and nonmarket consumption,

$$(11) \quad c_t = \left[\mu c_{mt}^{\varepsilon} + (1-\mu) c_{nt}^{\varepsilon}\right]^{1/\varepsilon},$$

and n_t represents the sum of time spent working in the market and at home,

$$(12) \quad n_t = n_{mt} + n_{nt}.$$

The market-production function is unchanged,

$$(13) \quad y_t = A k_{mt}^{\theta} \left[(1+\gamma)^t n_{mt}\right]^{1-\theta}.$$

However, a home-production function is now given by

$$(14) \quad c_{nt} = A k_{nt}^{\phi} \left[(1+\gamma)^t n_{nt}\right]^{1-\phi}.$$

Exogenous technological change occurs at the same rate in the home and market sectors, implying that from any initial condition, the model converges to a balanced growth path along which y_t, c_{mt}, c_{nt}, k_{mt}, and k_{nt} all grow at the rate γ, while n_{mt} and n_{nt} remain constant.

■ **9** For unmeasured investment, note that along the balanced growth path, $x_z = \pi(\gamma + \delta_z)z$, where all variables have been transformed into stationary equivalents by dividing the date t by $(1+\gamma)^t$. For the transformed variables, it follows that

$$\frac{x_z}{c+x_k} = \frac{x_z}{y-x_z} = \frac{\pi(\gamma+\delta_z)z}{k^{\theta_k} z^{\theta_z} - \pi(\gamma+\delta_z)z}.$$

Using the first-order condition for profit maximization, we have

$$\pi(i+\delta_z) = \theta_z\, k^{\theta_k} z^{\theta_z - 1},$$

where i is the interest rate, and so it follows that $x_z/(c+x_k)$ is independent of π.

■ **10** It should be noted that models with home production cannot explain observations on market variables that could not be explained, *in principle*, by a model without home production (see Benhabib, Rogerson, and Wright [1991]). That is, one can always choose preferences in a model without home production that perfectly mimic the market outcomes of a given model with home production. However, the implied choice of preferences might generally be viewed as nonstandard. For instance, to be consistent with balanced growth and different amounts of market work for different barriers, the implied choice of preferences in a model without home production would be time dependent; therefore, even *if* we only want to look at data on market variables, an advantage of the home production framework is that it permits one to consider a richer class of specifications without sacrificing time-independent preferences or balanced growth. In fact, there are data on how time is allocated across activities, including home production, and these models provide a structure for interpreting this data.

TABLE 3

Values of π That Will Generate $y^*/y^*_{US} = 1/10$

	$\phi \approx 0$	$\phi = 0.05$	$\phi = 0.10$	$\phi = 0.20$	$\phi = 0.33$
$\varepsilon \approx 0$	100.0	100.0	100.0	100.0	100.0
$\varepsilon = 0.2$	59.3	65.1	71.2	83.7	100.0
$\varepsilon = 0.4$	27.6	34.1	42.2	63.1	100.0
$\varepsilon = 0.6$	10.3	13.9	19.4	38.9	100.0
$\varepsilon = 0.8$	3.3	4.4	6.5	16.4	100.0

SOURCE: Authors' calculations.

TABLE 4

Values of ϕ and ε That Will Generate $y^*/y^*_{US} = 1/10$

ϕ	ε	True output ratio Domestic prices	Welfare cost U.S. prices	Welfare cost Steady states	Welfare cost Dynamics
0.001	0.77	0.42	0.52	1.30	1.18
0.05	0.82	0.43	0.52	1.32	1.21
0.10	0.87	0.44	0.52	1.42	1.24
0.15	0.98	0.45	0.52	1.43	1.25

SOURCE: Authors' calculations.

An important distinction between the market and home sectors is that, by assumption, capital goods can be produced only in the market sector. That is, market output is still divided between consumption and investment in the two types of capital,

$$(15) \quad c_{mt} + x_{mt} + x_{nt} \leq y_t \,,$$

while all home-produced output is consumed. At this stage, we allow distortionary policies to differ for the two types of investment goods. Thus, the two capital stocks evolve according to

$$(16) \quad k_{mt+1} = (1-\delta_m)\, k_{mt} + x_{mt} / \pi_m$$

and

$$k_{nt+1} = (1-\delta_n)\, k_{nt} + x_{nt} / \pi_n .$$

We assume that capital is not mobile across sectors, though this assumption does not actually affect balanced-growth-path analysis.

The degree to which individuals respond to economic distortions typically depends on the other opportunities they face. Home production is an alternative to market production, and hence, it may be relevant to evaluating the way market activity responds to distortions. This intuition suggests that three parameters are especially relevant in determining the impact of the distortions on which we are focusing: 1) the elasticity of substitution between home and market consumption, ε; 2) the share of capital in the home sector, ϕ; and 3) the relative size of the barriers in the two sectors, π_m and π_n. For home production to produce a greater response of market output to a given investment barrier, the model requires that individuals be willing to substitute home consumption for market consumption; such willingness is obviously affected by ε. Additionally, even if individuals are willing to substitute between market- and home-produced goods, the distortions on investment must create an incentive to do so. For this to occur, either home activity must be less capital intensive than market activity, or the distortion to the price of capital used in the nonmarket sector must be smaller than the distortion to the price of capital used in the market sector.

We begin with the case in which the barriers on the two investments are the same, $\pi_m = \pi_n = \pi$. Table 3 displays the value of π that is required to decrease market output by a factor of 10 relative to the $\pi = 1$ case. Several combinations of values for the two key parameters, ϕ and ε, are considered, and in each case Θ is set to 1/3.[11]

As a benchmark, it can be shown formally that if $\phi = \varepsilon = 0$, the home-production economy yields predictions for market variables that are identical to those for the basic model. In other words, for these parameter settings, home

11 The other parameters are set as follows: $\delta_m = \delta_m = 0.06$, $\gamma = 0.02$, $\beta = 0.98$, and preference parameters are set to generate $n_m = 0.33$ and $n_n = 0.28$ when $\pi = 1$.

TABLE 5

Equilibrium Relative to Undistorted Economy, $\pi_m = \pi_n$

	ε=0.0001	ε=0.2	ε=0.4	ε=0.6	ε=0.8
y	0.50	0.47	0.41	0.32	0.12
k_m	0.13	0.12	0.10	0.08	0.03
c_m	0.50	0.47	0.41	0.30	0.09
c_n	0.90	0.97	1.09	1.31	1.74
x/y	1.00	1.00	1.00	1.00	1.00
y/n_m	0.50	0.50	0.50	0.50	0.50
k_m/n_m	0.13	0.13	0.13	0.13	0.13
r	4.00	4.00	4.00	4.00	4.00
n_m	1.00	0.94	0.83	0.62	0.22
n_n	1.00	1.08	1.21	1.46	1.94

SOURCE: Authors' calculations.

production does not matter. Hence, the cell corresponding to $\Theta = \varepsilon \approx 0$ indicates that in the standard model without home production, given $\Theta = 1/3$, we require $\pi = 100$ in order to generate an income differential of 10.

Not surprisingly, the results in table 3 accord well with the above intuition, in that a higher elasticity of substitution between the two consumption goods or a lower capital intensity in home production implies that a lower barrier is needed to achieve a given reduction in market output. However, the quantitative results are quite striking: if the home technology uses very little capital and the two consumption goods are close substitutes, we can reduce the required barrier from $\pi = 100$ in the standard model to $\pi = 3.3$ in our model.[12]

Table 4 presents similar information in a different way: we fix $\pi = 4$, and for various values of ϕ, we report the value of ε needed to yield $y^*/y^*_{US} = 1/10$ (other parameters are as in table 3). The results confirm our intuition that when capital's share in the home is bigger, individuals must be more willing to substitute between the two goods to generate the same results. We also report several other statistics, including the ratio of total output in the two economies, with total output computed two ways: market-produced output plus home-produced output weighted by its domestic shadow price; and market-produced output plus home-produced output weighted by its shadow price in the undistorted economy. Although the measured market output ratio is 1/10, the true output ratio by either measure is closer to 1/2, because home production plays a relatively more important role in the distorted economy.[13] Recall from table 1 that when $\pi = 4$ and $\Theta = 1/3$, the model without home production implies $y^*/y^*_{US} = 1/2$. Thus, while the home-production model generates much larger ratios of measured outputs, it generates similar ratios of true outputs.

Because the true output ratio is so different from the measured output ratio, it seems interesting to ask about welfare. Table 4 reports the welfare cost of the barrier in terms of additional consumption required for an individual who is indifferent to having or not having the distortion (for example, a number of 1.25 means that an agent needs 25 percent more of both market and home consumption to be as well off with the barrier as he would be without it). We compute these welfare measures first by simply comparing steady states—in which case, the result tells us how much we need to pay an agent to induce him to *not* move from a distorted economy to an undistorted economy already on its balanced growth path—and also by taking into account transition paths, in which case the result tells us how much we need to pay an agent to induce him to not remove the distortions where he lives. The table reports that agents must be paid 30 percent–40 percent of their consumption to not move, and 18 percent–25 percent to not remove the barrier. As a

■ 12 While it is not clear that one wants to use the same parameter values in a development context that one uses for studying U.S. business cycles, we mention here the values of the two key parameters found in some of the related literature. Estimates of ε from micro data in Rupert, Rogerson, and Wright (1995) and from macro data in McGrattan, Rogerson, and Wright (1997) both yield values close to $\varepsilon = 0.4$. Business-cycle models with home production have a range of values for ϕ; for example, in Benhabib, Rogerson, and Wright (1992), $\phi = 0.1$, while in Greenwood and Hercowitz (1991) and in McGrattan, Rogerson, and Wright (1997) ϕ is much bigger. The issue is what one wants to match: lower ϕ generates values for k_n/y consistent with measuring home capital in terms of consumer durables but not residential structures, while higher values are needed to match k_n/y if housing is to be included.

■ 13 The true output ratio is slightly bigger when it is computed using the price of home-produced output in the undistorted economy because home-produced goods are relatively more scarce and hence more expensive in the undistorted economy.

TABLE 6

Equilibrium Relative to Undistorted Economy, $\pi_m > \pi_n$

	ε=0.0001	ε=0.2	ε=0.4	ε=0.6	ε=0.8
y	0.50	0.48	0.45	0.40	0.30
k_m	0.13	0.12	0.11	0.10	0.07
c_m	0.50	0.46	0.41	0.31	0.12
c_n	0.80	0.83	0.88	0.98	1.17
x/y	1.00	1.08	1.13	1.27	1.72
y/n_m	0.50	0.50	0.50	0.50	0.50
k_m/n_m	0.13	0.13	0.13	0.13	0.13
r	4.00	4.00	4.00	4.00	4.00
n_m	1.00	0.95	0.90	0.62	0.59
n_n	1.00	1.04	1.11	1.46	1.47

SOURCE: Authors' calculations.

benchmark, in the model without home production, if $\pi = 4$, which yields $y^*/y^*_{US} = 1/2$, we need to pay agents 40 percent of their consumption to not remove the barrier.

Compared to the model without home production, the model with home production generates much larger differences in measured output, comparable differences in true output, and smaller welfare differences. What is behind these results? To answer this question, it is instructive to look at a larger set of statistics describing the equilibrium. For $\phi = 0.05$, $\pi = 4$, and various values of ε, table 5 reports the ratio of several variables in the distorted and the undistorted economies (with the other parameters set as above). The first column serves as a benchmark: with $\varepsilon \approx 0$, the model is very close to the model without home production, while the other columns illustrate what happens as individuals become more willing to substitute between home and market goods.

Several features are worth noting. First, as ε increases, market activity as measured by y, c_m, and n_m falls, while household activity as measured by c_n and n_n increases. Second, x/y is unaffected by the size of π. Hence, the investment-to-output ratio is not lower in poorer countries if it is measured using domestic prices, although it is lower if measured using U.S. prices (because the U.S. price of capital is 1, while the domestic price is π). This matches well with the data, which shows a relationship across countries between output and investment, measured using world prices but not domestic prices (recall figure 3). Third, although the rental rate of capital, r, is four times greater in the distorted economy, this is independent of ε; therefore, larger differences in y across countries do not imply larger differences in r, as is true in the model without home production. Fourth, while increases in ε reduce market output, they do not affect the average productivity of labor in the market: y/n_m is half as large in the distorted economy as it is in the undistorted economy, independent of ε. The key factor behind this result is that when k_m falls, so does n_m, so that k_m/n_m stays constant when ε increases. Also notice that as n_m decreases, n_n increases, so that total time working remains roughly constant.

The above results are for a relatively low value of capital's share in home production, $\phi = 0.05$. As ϕ increases, the overall effect of adding home production decreases, because barriers to capital accumulation divert resources from market to nonmarket activity to a greater extent when nonmarket activity is relatively less capital intensive.[14] Indeed, if the home and market technologies have the same capital share, $\phi = \Theta$, there is no difference between the models with and without home production in terms of the barrier required to generate a factor-10 difference in output (see table 3). However, this is true only if we assume the *same* barriers to market and nonmarket capital accumulation, $\pi_m = \pi_n$, which is not necessarily the most interesting case.

Table 6 reports the ratios of variables in one economy with $\pi_m = 4$ and $\pi_n = 1$, and another economy with $\pi_m = \pi_n = 1$, assuming equal capital shares in the home and in the market, $\phi = \Theta = 1/3$ (other parameters are set as above). The distortion affects only market capital accumulation. Even with Θ, output in the distorted

■ **14** Also, for larger values of Θ, the investment share measured using domestic prices may be increasing in ε, since the capital used in the home sector is produced in the market sector but does not produce measured output. This somewhat reduces the model's ability to match the fact discussed above, that there is a relationship between output and savings measured using world prices but not using domestic prices; however, the magnitude of this effect is relatively small for ϕ less than 0.10 and ε less than 0.60.

TABLE 7

Parameters in the Integrated Model That Generate $y^*/y^*_{US} = 1/10$

θ_z	θ_k	ε	True output ratio Domestic prices	True output ratio U.S. prices	Welfare cost Steady states	$\frac{x_z}{c+x_k}$
0	—	—	0.42	0.52	1.30	0
0.1	0.25	0.75	0.40	0.49	1.33	0.08
0.2	0.22	0.66	0.30	0.38	1.52	0.18
0.3	0.20	0.50	0.20	0.26	1.93	0.30
0.4	0.19	0.25	0.12	0.16	2.99	0.44

SOURCE: Authors' calculations.

economy falls with ε, although not by very much. Asymmetric barriers do not have a significant effect when $\phi = \theta$, even with large values of ε. Although agents want to increase nonmarket activity, when nonmarket activity is capital intensive, they cannot reduce the size of the market sector by much because we assume that household capital must be produced in the market. While asymmetric barriers imply a reallocation from market to home production, the effect will not be significant if household production is very capital intensive and nonmarket capital can be produced only in the market.

IV. An Integrated Model

We have discussed how two extended versions of the standard neoclassical growth model can account for cross-country income differences, based on reasonable differences in policies or institutions that act as barriers to capital accumulation: the model augmented to include intangible capital, and the model augmented to include household production. These approaches are not mutually exclusive, however, and in this section we briefly discuss the implications of including both intangible capital and household production in the same model. We will not present the equations explicitly, since it should be clear how one would combine the two; we simply report the results.

Table 7 presents information for an integrated structure similar to that of table 4 for the home-production model without intangible capital. Here, we vary intangible capital's share, θ_z, then choose θ_k to match the ratio of measured investment to measured output, and choose ε to generate $y^*/y^*_{US} = 1/10$ with $\pi = 4$. For each θ_z, the table reports θ_k, ε, and several other statistics. For the sake of illustration, we set ϕ near zero. As the importance of intangible capital increases (larger θ_z), less importance must be assigned to home production (lower ε) to generate $y^*/y^*_{US} = 1/10$. Conversely, the more importance one is willing to assign to household production, the less one must rely on intangible capital and, hence, the less unmeasured investment one has to accept. For example, suppose $\varepsilon = 1/2$, which is not far from estimates for the United States. In this case, $\theta_z = 0.3$ generates a ratio of measured outputs of $y^*/y^*_{US} = 1/10$ and implies that unmeasured investment is 30 percent of measured output. It also implies that the ratio of true output is between 0.20 and 0.26, depending on how home-produced output is priced. Finally, the barrier of $\pi = 4$ entails a large welfare cost: an agent would have to receive an additional 93 percent of his consumption to induce him not to move to an undistorted economy.

V. Evidence

We have demonstrated that, compared to the model without home production, the model with home production can generate much larger differences in measured output, comparable differences in true output, and smaller differences in welfare. The home-production model also has some implications that differ from standard models, namely, that hours of market work will be lower in poor economies. In this section, we discuss some evidence relating to these implications.

The prediction that individuals in poorer economies devote less time to market work is straightforward; however, it is not easy to test using conventional data sources, because these countries do not measure hours of market work in a systematic fashion. The International Labor Office publishes statistics on participation rates for a large number of countries, but this is clearly different from hours of market work. In fact, participation rates have very little meaning in the poorest countries, where more than 80 percent of the population may be engaged in agriculture, much of which is subsistence farming (and thus better characterized as home rather than market production). Therefore, one must be somewhat resourceful in evaluating this prediction of the model.

Mueller (1984) uses the *Rural Income Distribution Survey* in Botswana. These data cover agricultural workers and are constructed from time diaries in which interviewers asked respondents to account for their time during the previous day. Interviews took place five times during the year on various days of the week. The survey included roughly 4,600 individuals best described as subsistence farmers. The data present percentages of total time devoted to several activities, with 12 hours per day as the base. Time is allocated to each of the following activities: crop husbandry, animal husbandry, wage labor, trading/vending /processing, hunting/gathering, repairing/new building, fetching water, child care, housework, schooling, leisure, and a few miscellaneous categories. The findings are striking. For males, only about 10 percent of working time is accounted for by wage labor, and for females, the figure is closer to 2 percent. Kirkpatrick (1978) finds similar time allocations in a survey of the rural sector in Melanesia. In 84 hours per week of daylight, the average adult in five Melanesian villages spent 19.7 hours on all phases of agriculture. A good portion of the remaining waking hours were spent spinning, weaving, gathering and processing fuels and food, metalworking, dressing and tanning leather, manufacturing and repairing tools, and fence repairing, to name a few. Transportation, recreational, religious, financial, and insurance services are also provided in the household sector.

One measurement issue that must be addressed is that many poor countries make some attempt to impute in their GNP accounts amounts to cover own-use agriculture and, in some cases, house building. Blades (1975) discusses these issues in detail and finds that in some countries, the imputed value of subsistence activities is as high as 40 percent of base-level GNP, although the average for the African countries in his sample is 10 percent–15 percent. However, it is important to note that virtually no attempt is made to impute values for any services that may be produced in the nonmarket sector, and it seems likely that this is a sizable omission. For instance, it seems more than likely that care for children and the elderly, or financial and social services, just to name two examples, are provided to a relatively greater extent outside the formal market in poorer countries.

The poorest countries in the world also have a great deal of economic activity which could be classified as illegal or informal, and while this type of activity may not fit perfectly into the explicit home-production model analyzed above, it is in the same spirit. MacGaffey et al. (1991) report an estimate of total output in Zaire which includes black-market goods and services as well as goods and services produced for self-consumption that is three times larger than output in the official national accounts. They estimate the size of the black-market economy alone for other African nations between two-thirds and one-third of reported output. Important sources of these estimates are household consumption surveys. These surveys show that households consume much more than they earn in wages and salaries. MacGaffey et al. summarize a 1986 survey for households in Kinshasa, Zaire, showing that households consumed more than twice as much as they reportedly earned in wages and salaries.

Young (1994) documents large increases in market participation rates for workers in his study of the economic miracles of East Asia: Taiwan, Singapore, South Korea, and Hong Kong (see also Pack [1988]). Over the period 1966–90, the participation rate increased from 0.38 to 0.49 in Hong Kong; 0.27 to 0.51 in Singapore; 0.27 to 0.36 South Korea; and 0.28 to 0.37 in Taiwan. Data for hours per worker are not reported, but Young claims that only in Hong Kong have hours per worker declined. Such increases are consistent with the home-production model. It should be noted, however, that even in a model in which hours are independent of distortions along the balanced growth path, hours will typically change along the transition from one balanced growth path to another, and so more time must elapse before these cases constitute definitive evidence.

One more piece of evidence is contained in Kuznets (1960) concerning a related but distinct implication of the analysis in the previous section. In models in which balanced-growth-path hours of market work are not affected by the policies under consideration, differences in income are proportional to differences in average productivity in the market sector. As we noted following table 5, however, the home-production model predicts that differences in the average productivity of market labor are much smaller than differences in income. Kuznets presents data for a sample of 33 countries and finds that differences in the average product of labor in manufacturing are smaller across rich and poor countries than are differences in incomes. In contrast, differences in the average product of labor in agriculture are greater than differences in income. One interpretation of this finding that is consistent with our model is that productivity in agriculture in poor countries is biased downward by systematic overmeasurement of labor input. This follows from the tendency for all rural workers to be counted as agricultural workers, without any attempt to measure hours devoted to agriculture. If, in fact, substantial amounts of time are devoted to nonmarket activities, the average product of labor will be understated. Mueller (1984), for example, reports that workers on commercial farms work more hours per day than workers on noncommercial farms. Livingstone (1981) reports that the *Survey of Rural Workers* in Kenya shows rural workers devote only about half as much time to agriculture per week than the standard workweek in industry.

In summary, while there are some serious measurement issues that deserve further study, and while we would obviously like to have more and better data, it seems that the information we do have supports explicitly incorporating household production into models of economic development.

VI. Conclusions

Many economists have suggested that an important difference between rich and poor countries is the fraction of economic activity in formal versus informal markets. Most recent work that tries to account for income differences across countries abstracts from this feature. In this paper, we have argued that explicitly incorporating this feature into an otherwise standard model may enhance the model's ability to account for the data. In our model, policies which decrease the incentive to accumulate capital also lead to a substitution of economic activity away from the market sector and into the household-production sector. Our analysis suggests that this channel may be quantitatively important.

An implication of our analysis is that poor countries are relatively not as poor as published measures of income would indicate. However, we are not arguing that poor countries are just like rich countries except that less economic activity is measured: even when home production plays a big role, we found that poorer countries are still substantially worse off in terms of welfare.

To the extent that the output of goods and services outside formal markets is poorly measured, it is difficult to find direct evidence to support our framework. However, the model has some predictions that are consistent with empirical findings. For example, Young (1994) reports that labor participation rates increased substantially in each of the four "Asian tigers" during their periods of high growth. Also, Kuznets (1960) reports that international productivity differences are greatest in agricultural and least in manufacturing, which is consistent with our approach, if one views measurement of labor input in manufacturing to be higher quality. Finally, direct evidence from time diaries in sub-Saharan Africa supports the finding that individuals spend a relatively small fraction of their time in formal market activities. While more empirical work needs to be done to corroborate these findings, we conclude that it may be important to explicitly model the nonmarket sector in the context of studying economic development.

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