## AFRICAN ECONOMIC DEVELOPMENT[†]

# The Return to Capital in Ghana

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Robert E. Lucas, Jr. (1990) famously asked, "Why doesn't capital flow from rich to poor countries?" If aggregate production functions representing approximately the same technology across countries exist, then the vastly higher output per worker in richer countries implies a much lower rate of return to capital in rich rather than in poor countries. The details of the calculation depend on specific assumptions. The magnitudes are sufficiently large, however, that the absence of massive capital flows to the poorest countries is puzzling.

Lucas argues that capital market imperfections are unlikely to account for most of the difference implied by his calculation. He, therefore, raises the possibility that there are huge differences in human capital across countries, and therefore that returns to physical capital are not so different across countries. Accordingly, there is no mystery about the lack of physical capital flows. In contrast, Abhijit V. Banerjee and Esther C. Duflo (2005) review a good deal of evidence, mostly from India, showing widely varying and often very high real interest rates. In addition, they summarize a relatively smaller set of studies estimating rates of return to capital, again showing that real rates of return often exceed 100 percent. We provide some evidence about rates of return to capital in Ghana's informal sector, among entrepreneurs who might have particularly limited access to financial markets.

### I. The Returns to Investment in a New Technology

We begin with the simplest approach to calculating the return to capital: calculate the internal rate of return to investment in a sample of enterprises. Data challenges arise, particularly for smaller enterprises in developing countries where personal and enterprise accounts are typically intermingled (for good reason, because in the context of imperfect financial markets, the "separation" of production and consumption does not occur and simple profit maximization no longer necessarily maximizes the utility of the entrepreneur). To get a reasonable estimate of enterprise-specific flows of revenue and costs requires detailed information on the associated transactions (Angus S. Deaton, 1997, pp. 29–32).

Markus P. Goldstein and Udry (1999) collected intensive data on inputs and outputs at the plot level for 1,659 plots cultivated by 435 farmers in four village clusters over a two-year period in southern Ghana. Over the survey period, resident enumerators interviewed each farmer at approximately six-week intervals. This relatively high frequency was designed to increase the accuracy of recall concerning plot-specific farming activities, particularly regarding the use of household labor and the continual harvests of some staple crops.

We examine the return to investment on these plot-level farming enterprises in southern Ghana. Long integrated into world trade, this region first produced palm oil and later cocoa for export. Since the mid-twentieth century, the primary farming system has been based on an intercropped mixture of maize and cassava,

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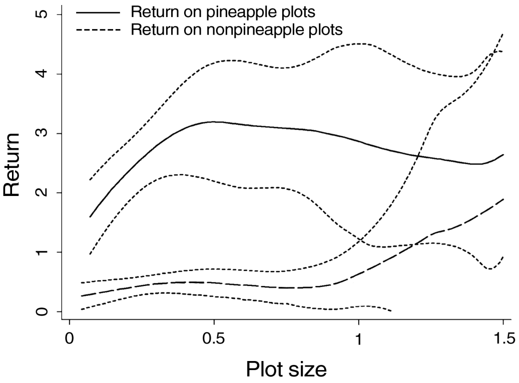

Figure 1. Rates of Return by Plot Size with 2 s.e. Pointwise Confidence Interval

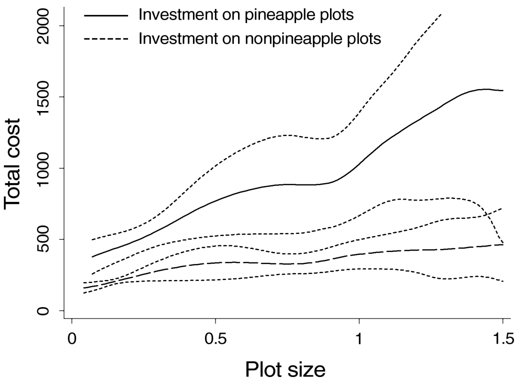

Figure 2. Investment by Plot Size with 2 s.e. Pointwise Confidence Interval

food crops produced for nearby urban markets. A structural adjustment program in the 1980s increased the relative price of tradeables, and beginning in the 1990s farmers in the area began to produce pineapple for export as fresh fruit to Europe (Timothy G. Conley and Udry, 2005).

We calculate for each plot the internal rate of return to investment on that plot. Output (sold or not) is valued at village-survey round specific prices. Inputs are also valued at market prices; in particular, household labor is valued at village-survey round-gender specific wage rates. We simply report the real internal rate of return for the investments on each plot, treating all inputs and outputs as costlessly tradeable.

In Figure 1, we report these returns by plot size, along with pointwise 95-percent confidence intervals.[1] The distribution of internal rates of return is reported separately for the new and apparently highly profitable technology of pineapple cultivation and for other plots (primarily planted with an intercropped mixture of maize and cassava). In Figure 2, we present similar calculations of the magnitude of the investments made in these enterprises, again by plot size. The first point that is evident from the figures is that the return to investment in pineapple cultivation is extremely high. On median-sized plots of one-third hectare, mean returns are over 250 percent per annum.

Second, rates of return are high even on plots cultivated with the traditional, well-established technology. Even on small plots at the tenth percentile of the size distribution, the mean real rate of return is 30 percent; the return rises to almost 50 percent for plots of a third of a hectare.

Finally, it can be seen in Figure 2 that the cost of cultivating pineapple is far higher than the cost of traditional crops. Approximately 500,000 Ghanaian cedis are required to cultivate a typical quarter-hectare pineapple plot (this was about US$250). There is a minimum plot size below which exporters will not send their refrigerated trucks to collect pineapple for transport. The total cost of cultivating even this small plot (0.135 ha) with pineapple is larger than the cost of all but the largest 3 percent of other plots. This finding lends some credence to the ubiquitous claim by farmers that lack of capital is the primary barrier to the adoption of pineapple.

It should be clear that these figures are *not* marginal rates of return to capital. These are average rates of return, albeit for very finely defined, small (by global standards) investments. These returns are not adjusted for risk. Most importantly, it is not possible to distinguish the returns to entrepreneurship from those to capital. We have valued at market wages the time spent by the cultivator actually working on his or her farm, but we have no way of accounting for the effort that has been put into making decisions on the farm. This is a standard—and fundamental—difficulty with accounting approaches to estimating the return to capital. One component of the enormous measured returns to investment in pineapple may be precisely the unobserved return to innovation and experimentation.

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[1] These are local weighted regressions with a quartic kernel and a bandwidth of 0.5. Estimates of pointwise standard errors are obtained from 100 bootstrap replications.

## II. Durable Goods and the Return to Capital

If these direct measures of the return to investment provide an upper bound to the real marginal product of capital, we can use data on the relative prices of durable goods with different expected lives to provide a lower bound estimate of the return to capital. *Ceteris paribus,* as the rate of return to capital in a local economy rises, the equilibrium price of the more durable good falls relative to that of the less durable good.[2]

We collected information on the prices and expected lives of groups of parts from a number of used auto parts dealers in the capital of Ghana. Each group is defined as a number of units of a very specific part, used in a specific model of car, sold by a single dealer, varying (we hope) only by expected life. For each group, we have at least two observations. For example, we have data on two used fan blade motors for a Daewoo Tico sold by a single parts dealer. One can be expected to last for 1.5 years in constant use (in a hypothetical taxi running a particular route), while the other can be expected to last only one year. A research assistant accompanied by an experienced auto mechanic hired for this project collected data on both the prices and life expectancies of all of the parts. We have usable data on 56 pairs of parts.

We presume that price data were collected without error. We abstract from any problem of asymmetric information concerning part quality, but we do permit such information to be imperfect. In particular, we assume that there is proportional measurement error in the expected life of any part. Let $p_{ik}$ be the price of part $i$ in group $k$, and let $T_{ik}$ be the reported expected life of that part. The actual expected life of the part is $\tilde{T}_{ik} = T_{ik}\varepsilon_{ik}$ where $\varepsilon_{ik}$ is a (lognormally distributed) proportional reporting error.

We begin by assuming, counterfactually, that there exists a common opportunity cost of capital to all agents in a given local economy. The expected present value of the cost of using part $i$ from now to infinity is

$$PV_{ik} = \sum_{n=0}^{\infty} \frac{p_{ik}}{(1+r)^{n\tilde{T}_{ik}}}. \tag{1}$$

In equilibrium, the expected present value of the cost of each part in group $k$ should be equal. For simplicity, presume that there are two parts ($i$ and $j$) in each group. Therefore, we have

$$\frac{p_{ik}}{1-\left(\frac{1}{1+r}\right)^{\tilde{T}_{ik}}} = \frac{p_{jk}}{1-\left(\frac{1}{1+r}\right)^{\tilde{T}_{jk}}}. \tag{2}$$

Given $(p_{ik}, p_{jk}, \tilde{T}_{ik}, \tilde{T}_{jk})$, it is possible to calculate the discount rate $r$ ($>0$) that warrants the observed relative prices and durabilities of the two goods. Suppose for the moment that there is no measurement error in the expected life of each durable. We can then calculate for each part pair $k$ the $r_k$ that satisfies (2).

The method proposed here provides a lower-bound estimate of the return to capital because we abstract from any costs associated with breakdowns of the durable good as it approaches the end of its useful life, and from search costs and the labor cost of installation. The latter pair of costs are likely to be relatively small in the context of this market (labor charges by mechanics are small and most purchasers do self-installation during the constant process of tinkering with their taxis to keep them running). The cost of breakdowns, however, looms large in conversations with drivers.

The median of these $r_k$ is 32 percent; the mean is 66 percent. These might serve as appropriate estimates of this lower bound to the real opportunity cost of capital in this local economy. These are arbitrary calculations, however. Why should the discount rate, $r$, vary across pairs of durable goods? These are equilibrium prices in a single, narrowly defined market. Instead, we can define the maximum likelihood estimate of the real opportunity cost of capital.

Without loss of generality, choose indices such that $p_{ik} > p_{jk}$ ($i$ is the durable in "better" condition). For any observation ($p_{ik}$, $p_{jk}$, $T_{ik}$, $T_{jk}$), there is a unique function $\varepsilon^{*}_{ik}(\varepsilon_{jk})$, such that (2) is satisfied:

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[2] Jerry A. Hausman (1979) uses the same core idea in a very different context and with an alternative statistical methodology to estimate individual discount rates.

$$\varepsilon^{*}_{ik} = \frac{-1}{T_{ik}\ln(1+r)} \times (\ln(PV_{jk} - p_{ik}) - \ln(PV_{jk})). \tag{3}$$

The domain of (3) are those $\varepsilon_{jk}$, such that $PV_{jk} - p_{ik} > 0$ (if the cost of a single purchase of $i$ is as great as the present value of purchasing an infinite stream of $j$, there is no measurement error $\varepsilon_{ik}$ that can satisfy (2)). Thus,

$$\varepsilon_{jk} < \frac{\ln p - ln(p_{ik} - p_{jk})}{T_{jk}\ln(1+r)} \equiv \varepsilon^{c}_{jk}. \tag{4}$$

Our data are ($T_{ik}$, $T_{jk}$, $p_{ik}$, $p_{jk}$) for $k = 1, \ldots, N$. We model ($\varepsilon_{ik}$, $\varepsilon_{jk}$) as independently drawn realizations of the lognormally distributed proportional measurement error $\varepsilon$. Then for each observation $k$, (3) and (4) describe the set $\{(\varepsilon_{ik}, \varepsilon_{jk}) | \varepsilon_{ik} = \varepsilon^{*}_{ik}(\varepsilon_{jk}), 0 < \varepsilon_{jk} < \varepsilon^{c}_{jk}\}$. Let $\lambda_k$ denote an unobserved random effect that selects one pair from this set, in particular, $\varepsilon_{jk} = \lambda_k \varepsilon^{c}_{jk}$, for $\lambda_k \in (0, 1)$ (James J. Heckman and Burton H. Singer, 1984). We let $\lambda$ take on a discrete set of values $\Lambda = \{\lambda^1, \ldots \lambda^l, \ldots \lambda^m\}$ with associated probabilities $p^l$. Thus, $\varepsilon^{l}_{jk} \equiv \lambda^l \varepsilon^{c}_{jk}$ *and* $\varepsilon^{l}_{ik} \equiv \varepsilon^{*}_{ik}(\varepsilon^{l}_{jk})$ and the contribution of pair $k$ to the likelihood is

$$\sum_{l=1}^{m} p^l h(\varepsilon^{l}_{ik}, \varepsilon^{l}_{jk}; \sigma) \tag{5}$$

where $h$ is the bivariate log normal density with means 1, variance $\sigma$, and covariance 0. Our point estimate for $r$ is 0.60, with a standard error of 0.02.[3]

## III. Durable Goods and the Return to Capital without Financial Markets

If the individuals purchasing the durables considered in Section II all faced a common real interest rate in a smoothly operating credit market, then that section provides a method for estimating that rate. Of course, in that case one could simply gather data on the interest rate to know the return to capital in that economy. What does the relative price of durables with different durability tell us about the returns to capital when financial markets are not so perfect?

Consider the opposite extreme case, in which financial markets are entirely absent and profit-maximizing entrepreneurs move resources through time only via production, or through holding durable assets. A simple two-period model suffices to clarify the relationship between prices and the return to capital in this case. Individual $i$ has an endowment ($k^{u}_{ie}$) of used capital, which is tradeable at price $p^{u}_{0}$ within the local economy. She can purchase a costlessly storable, internationally tradeable good (for which the price is normalized to unity), or purchase new capital $k^{n}_{i0}$ at price $p^{n}_{0}$ to use in production of that good. New and used capital is identical, except that after production $k^{u}_{i0}$ depreciates into valueless waste, while $k^{n}_{i0}$ depreciates into $k^{u}_{i1}$. We presume that new capital is also internationally tradeable and choose units to normalize its price to unity as well. In period 0, $i$'s endowment is $y_{i0} = p^{u}_{0}k^{u}_{ie}$; $i$'s income in period 1, then, is

$$y_{i1} = f(k^{n}_{i0} + k^{u}_{i0}) + p^{u}_{1}k^{n}_{i0} + (y_{i0} - k^{n}_{i0} - p^{u}_{0}k^{u}_{i0}). \tag{6}$$

The first term is the value of output of the good, the second is the value of the new capital purchased in period 0, which has now become used, and the third is the value of the good purchased in period 0 and stored until period 1. In period 1, new and used capital is again used to produce the tradeable good, which is then consumed:

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[3] The variance of $\varepsilon$ is estimated as 0.05 (standard error 0.01). $\Lambda \equiv \{1/4, 1/2, 3/4\}$, and we estimate $p_1 = 0.07$ (0.04) and $p_2 = 0.52$ (0.07). The likelihood function is not globally concave, but this is the local interior optimum with the highest likelihood.

$$c_i = f(k^n_{i1} + k^u_{i1}) + p^u_2 k^n_{i1} + (y_{i1} - k^n_{i1} - p^u_1 k^u_{i1}). \tag{7}$$

The individual chooses new and used capital each period to maximize consumption, $c_i$, subject to (6) and (7), the budget constraints $y_{it} - k^n_{it} - p^u_t k^u_{it} \geq 0$, and the nonnegativity constraints $k^u_{it}, k^n_{it} \geq 0$ for $t = 0, 1$.

There is no production after period 1, so $p^u_2 = 0$. If $p^u_1 < 1$, then $k^n_{i1} = 0$ (because used capital has no value after period 1). Let $k^*_1$ be defined by $f'(k^*_1) = p^u_1$. Then, if $y_{i1} \geq p^u_1 k^*_1$, $k^u_{i1} = k^*_1$. Otherwise, $k^u_{i1} = y_{i1}/p^u_1$. For all $i$, $dk^u_{i1}/dp^u_1 < 0$. Given the purchases of $k^n_{i0}$ by all the agents in period 0 (which becomes the inelastic supply of used capital in period 1), there is a unique equilibrium $p^u_1$ that sets demand equal to supply for used capital.

In period 0, given prices $p^u_0$ and $p^u_1$, there are three different behaviors, depending upon the agent's endowment. A range of "middle wealth" agents use both used and new capital, setting their capital stock $k^*$, such that $f'(k^*) + p^u_1 = f'(k^*)/p^u_0$, or

$$f'(k^*) = \frac{p^u_1 p^u_0}{(1 - p^u_0)}. \tag{8}$$

The lower bound of this range is the individual $i$ with endowment $k^u_{ie} = k^*$; this agent keeps all of her endowment in used capital. Agents with higher endowments maintain a constant productive capital stock by purchasing more expensive new capital in period 0. The upper bound of the endowment range of those who hold both new and used capital in period zero is the agent with an endowment $k^u_{ie} = k^*/p^u_0$.

Agents with endowments larger than $k^*/p^u_0$ purchase only new capital, and for these agents

$$f'(k^n_{i0}) < \frac{p^u_1 p^u_0}{1 - p^u_0}. \tag{9}$$

(There is a further lower bound to the marginal product of capital, provided by the storability of the good.) In contrast, agents with endowments $k^u_{ie}$ lower than $k^*$ purchase only used capital, and for these agents

$$f'(k^u_{i0}) > \frac{p^u_1 p^u_0}{1 - p^u_0}. \tag{10}$$

From (8) through (10), it is straightforward to derive the demand for new and used capital by each agent. It can be shown (albeit not in the context of this short note), that for strictly concave $f$, there is a unique equilibrium pair $(p^u_0, p^u_1)$ that equalizes supply and demand for used goods in each period for any given distribution of endowments $k^u_{ie}$, subject to minimal regularity conditions.

In an economy with missing financial markets in which both new and used goods are purchased, the price of the less durable good, relative to the more durable good, reveals information about the returns to capital. Consider marginal purchasers—those indifferent between purchasing more and less durable capital goods. Equation (8) shows that the marginal product of capital for these agents increases as the price of the used (less durable) good rises toward 1 (the price of the more durable good). The returns to capital for those agents who purchase only the least durable goods, of course, is always even larger.

## IV. Conclusion

We have provided evidence that the rate of return to capital in Ghana's informal sector is quite high. For farmers, we find real returns in the range of 250 to 300 percent in the new technology of pineapple cultivation, and 30 to 50 percent in well-established food crop cultivation. We then turn to an examination of the relative prices of durable goods of varying durability, noting that the price of less durable goods rises relative to that of more durable goods as the opportunity cost of capital becomes higher. From this exercise, we can estimate the lower bound of the marginal return to capital as revealed in an equilibrium price, not subject to the standard biases associated with production function estimates. Our estimate of the real return to capital in Ghana's informal sector using this method is 60 percent.

These high observed returns to investment in Ghana, therefore, bring us full circle. Why doesn't capital flow from rich to poor countries? We suggest that financial market imperfections that hinder flows of capital into the informal sector are likely an important component of the explanation.

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