Equation Chapter 1 Section 1

Can Wealth Inequality Limit Growth and Increase Instability?

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A two-sector three-factor model with credit rationing shows how inequality can reduce productivity and growth while amplifying cyclical instability.

Modern macroeconomic theory is incoherent and often unconvincing. Standard "Keynesian" macro deals with the gross economic behavior of a political entity, typically a nation. Models are simple and stylized, with a focus on "the" interest rate. Growth theory, based on the Solow model, does not even contain an interest rate. Trade theory deals with exchanges between macroeconomic entities, which arise from differences in factor endowments. Yet Keynesian macro omits any consideration of factor endowments. Neither Keynesian macro, growth theory nor trade theory address the distribution of wealth, despite overwhelming evidence from around the world that high inequality hinders growth.

I propose to build a new approach on the Classical three-factor "corn" model. I start with an area of land with a population of laborers who produce corn every period. If corn is saved, the economy grows. I put two such modules together into a two-sector "economy" –with a "rich" sector having a high ratio of land to labor, and a "poor" sector with a low ratio. Wealth in each sector consists of corn stocks plus capitalized land value. Consumption depends on both current income and wealth. Every period, the rich sector advances corn to the poor sector, and receives it back with interest. Advances may be limited by credit-rationing; rich sector lending depends on poor sector collateral, not the marginal productivity of investment. The use of land as wealth and as collateral in turn permits the development of "bubbles" during growth.

I. Classical Background

A. The Original Corn Model and the Wage Fund

David Ricardo's "corn model," published in 1818, was the earliest complete abstract economic model. (David Ricardo 1996).

The corn model consisted of a simple agricultural cycle with a single good, "corn," (ie. wheat) that served as both capital and consumption good. A central feature of the corn model was the so-called "wage fund," which traced back to Adam Smith and the Physiocrats before him. At the beginning of a cycle, the "proprietor" held a stock of corn, the "wage-fund." This served to feed the workers until the new corn could be harvested. (If the proprietor did not own his own land, the fund also served to advance the rent.) At harvest time, the proprietor received back his original stock, plus a percentage profit. If the proprietor did not consume his entire profit, but used it to expand his wage fund, hiring more workers, each harvest would exceed the prior—creating economic growth.

"Corn" or "subsistence" as the Classical economists also called it, of course does not represent all capital, but only liquid capital, finished goods ready for consumption, like MRE's—the "meals ready to eat" with which the Army equips soldiers in the field.

(Ricardo addressed fixed capital separately in Chp 1, Section 4, allowing that fixed capital interfered with his labor theory of value.)

The corn model explained not only growth, but shares of output to the three factors, land, labor and capital. Ricardo first clearly identified rent as the payment for productivity of land above that of marginal land. However, neither he nor the other classical economists worked out a marginal explanation for wages or profits. They found the wage rate by dividing the wage-fund by the number of workers. The rate of profit was just the residual after replenishing the wage fund. The wage fund eventually proved highly controversial; in the hands of Malthus and his allies, it seemed to prove that wages were strictly limited by available capital—and likely to fall as population grew.

During the marginalist revolution of the late 1800's, John Bates Clark replaced the wage-fund theory of wages and profit with the marginal product theory. (John Bates Clark 1891). This change had the advantage of treating all three factors symmetrically; in fact Clark's treatment continues as the standard approach in modern microeconomics. However, Clark's new paradigm also blurred the distinction between the three factors, leading to the practice, then and now, of merging land with capital.

Even worse, Clark's paradigm obliterated the key Classical insight, embodied in the wage fund, that liquid capital serves as the bridge from Then to Now. Break that bridge and we perish. In effect, Clark's paradigm flattens a three-dimensional model into two dimensions, squeezing out time. If time doesn't matter, then neither does the distinction between land—an infinitely durable, socially-created asset—and capital, a depreciating, privately-created asset.

B. Why a New Growth Model?

Why create a new growth model, or rather, why revive a very old one? Why not simply modify the elegant Solow growth model, which is still alive and well after almost 50 years? (Robert M. Solow 1956). Thomas Piketty has recently addressed wealth distribution and credit rationing in a modified Solow model (Thomas Piketty 1997). However, these and other growth models I have looked at share the conventional Neoclassical omission of land. Solow even once wrote, "…if God had meant there to be more than two factors of production, He would have made it easier for us to draw three-dimensional diagrams." (Robert M. Solow 1955)

This is not the place to elaborate the distinctions between land and capital, but see Gaffney's "Land as a Distinctive Factor of Production" (Mason Gaffney 1994). For my purposes here, land differs from capital in that: it is limited in supply, it lasts forever, and because its value is the discounted present value of future rents, expected growth makes its value appreciate. Because both discount rates and expectations can sometimes change dramatically, land values can change dramatically. Land often serves as collateral for loans. Land booms can generate large extensions of credit. Drops in land values during downturns can cause credit freezes, or, as occurred in the 1930's even credit collapse.

C. A Modern Two-Sector Corn Model with Lending

First, I will develop a simple simulation model with uniform land and population of simple "farmers." Unlike the classical corn model, all factors earn their marginal products. However like the classical model, liquid capital retains its crucial function as a bridge over time. I will run this model for two separate “sectors” of an economy, one with plentiful land and small population, and the other with limited land and large population. With no “technical progress,” both rich and poor sectors accumulate capital, the rich one more than the poor one, but at a slowing rate, up to a final equilibrium. Wages rise and interest rates fall in both sectors, but rich sector wages always exceed poor sector wages, while rich sector interest rates are always lower than poor sector rates.

Second, I combine the two, by allowing the “rich” farmers to loan corn to the “poor” farmers as the economy grows, advancing it at the beginning of each period, and recovering it at the end. I model two possibilities: a) The rich sector lends without restriction, equalizing interest rates between the two sectors. b) Rich sector lending is restricted, as in the real world, by transaction costs, moral hazard and adverse selection. The most striking result is that to the extent it can borrow cheap capital from the rich sector, the poor sector accumulates less capital itself. With unrestricted lending, as growth occurs, the poor sector even decumulates capital. Such behavior of course makes be poor sector highly vulnerable to sudden floods and withdrawals of capital—rather like the waves of “hot capital” rushing in and out of third world countries.

Third, I introduce “technical progress” by increasing “total factor productivity” at a low exponential rate, with small sine wave fluctuations. The fluctuations produce more dramatic swings in output and capital accumulation in the poor than in the rich sector.

Finally, I introduce lagged growth expectations. That is, the sectors project growth rates from the last several periods, leading to excessive consumption at the end of a “technical” boom. As a result, output, capital accumulation, and discount rates become even more spiky in the poor sector. This result arises primarily from the assumption that consumption depends partly on wealth, including land values.

II. The Simple Model

Imagine a uniform area of land, T, occupied by a uniform population of N individuals. Assume these individuals are simple “farmers”—they are simultaneously workers, landlords and capitalists. They generate a labor supply, L, such that L/N < D, the maximum possible hours of work in a day or other period of production. They receive a wage, w. As in the Classical models, they produce an annual output of a single consumption good, “corn.” Assume with the classical models that production takes a year, and that wages must be laid out in advance.

A. Production Function

Assume a well-behaved production function, depending on land, T, and labor, L:

$$Q = \varphi(T, L); \varphi_1 > 0; \varphi_2 > 0; \varphi_{12} > 0; \varphi_{11} < 0; \varphi_{22} < 0 \qquad (1.1)$$

For the simulation model, I use a simple, tractable function as follows:

$$Q = q_0 L(1 - q_1 \frac{L}{T}) \qquad (1.2)$$

where q_0 and q_1 are constants.

This function is linear homogeneous (although that is not necessary) and more plausible than a Cobb-Douglas function.

The marginal product of labor is:

$$\varphi_2 = q_0(1 - 2q_0 \frac{L}{T}) \tag{1.3}$$

Thus if the ratio of labor to land gets too high, the marginal product of labor can actually become negative—one can imagine surplus workers trampling the crops! (Cobb-Douglas would allow us to stack workers on a postage stamp while still maintaining output).

B. Labor Supply Function

How do the *N* farmers supply labor? It is conventional to express labor supply as a function of wage and total income, with total income including both labor income and exogenous non-labor income. There is an assumed underlying utility function in food and leisure. I will assume for simplicity that labor supply can be written as just a function of wage, *w*, exogenous income, *R*, and *D*, "day" the maximum time available in a period. I use *R* for that exogenous income, since in the model it is rent. So the labor supply equation for one individual can be written:

$$\frac{L}{D} = \gamma(w, R) < 1; \gamma_1 > 0; \gamma_2 < 0 \tag{1.4}$$

For a population of *N*, the supply is just *N* times the individual supply. The labor supply for a given period necessarily curves upwards towards the physiological limit, *D*. Assume it does not "bend backwards" as long as *R* remains constant. However, assume that the higher the non-wage income—ie profits or rents—the higher the labor supply curve. In other words, the higher non-wage income, the less labor will be supplied at a given wage. Below a certain wage, no labor will be supplied at all. Figure 1 shows labor supply as a function of wage and rent.

This upward-curving shape implies that the lower the labor supply, the greater the effect of a change in the wage. By the same logic, the lower the labor supply, the greater the effect of a change in rent. In other words, on the flat portion of the curve a small change in wage or rent has a large effect on labor supply, but little effect on the steep part; elasticity falls along a supply curve from left to right. This difference in elasticity implies that the more the "economy" operates in the flat portion of the labor supply curve, the more it will be more disrupted by fluctuations.

I use a simple, tractable labor supply function for the simulation model. For one individual:

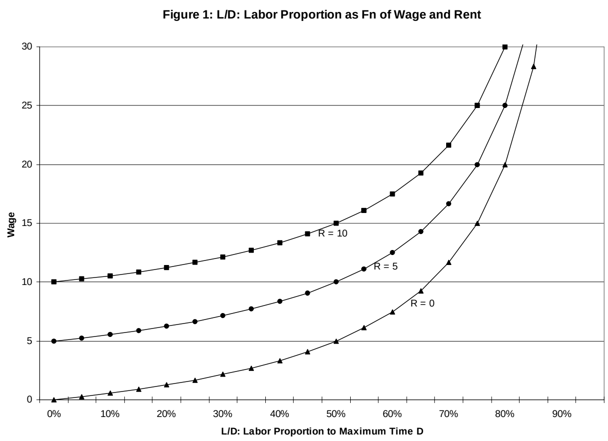
$$\frac{L}{D} = \frac{wD - R}{(w + w_0)D - R} < 1 \tag{1.5}$$

--where D is the maximum time, *w* is the wage, w_0 is a constant, and R is rent. Obviously, if $R >= wD$, labor supply is zero. *NL/D* is the labor supply for a population of *N* laborer/farmers.

Wage w can also be expressed as the inverse function of L/D as follows:

$$w = \frac{w_0 L/D}{(1-L/D)} + RD \tag{1.6}$$

As it should, w “explodes” as L/D approaches one.



C. Discount Rate

In a multi-period model, there must be a discount rate, or multiple discount rates to compare future to present values.

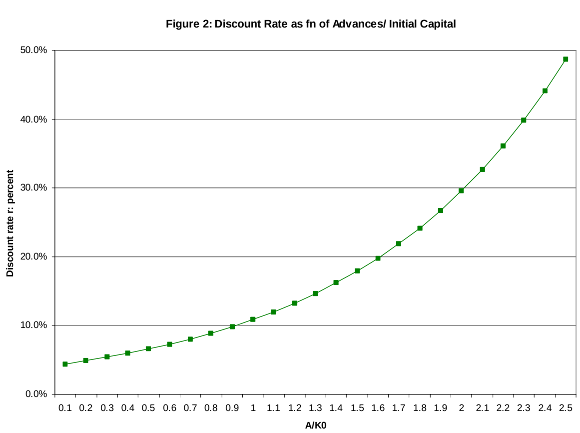
If discount rate, r, is not given, where does it come from? And how does it relate to the corn inventory at the beginning of each period?

In the classical models, profit is a residual after capital is advanced to pay rent and wages. Profit rate is profit divided by initial stock of capital, assumed to be 100% advanced. Profit rate in turn determines interest or discount rate. There is no concept of supply and demand for capital.

In modern microeconomics, interest or discount rate for the supply of capital depends on consumers’ preferences between present and future consumption, with future consumption being discounted relative to present. In macroeconomics, discount rate depends on preferences between money and bonds. Neither formulation lends itself to conveying the wage fund concept—that a given stock of consumption goods must carry consumers over a certain period before it can be replenished.

I use a different formulation:

$$r = \eta(\frac{A}{K_0}); \eta' > 0; \eta'' > 0 \tag{1.7}$$



where r = discount rate, K_0 is initial corn (ie liquid capital) and A stands for Advances. Discount rate is thus an increasing function of the ratio of advances to initial capital. In the classical model advances equal the wage bill. Thus A =

wL. (When we introduce credit, *A* will include loans.)

This is an unfamiliar approach. Usually we write a production function that depends on land, labor and capital (or just labor and capital). Then we set the marginal product of capital equal to the discount rate, which is given, to determine the amount of capital to be supplied. We assume that a high enough rate will call forth whatever quantity of capital may be desired. Here we do the opposite: we start with a given supply of real liquid capital, and say that the price of that capital depends on how fast we use it up in a given period—with catastrophe ensuing if we run out before the end of the period. However alien this interpretation of the discount rate seems to us, it is consistent with the classical model, –and would of course seem perfectly natural in famine-plagued parts of the world.

A literal interpretation of the classical model suggests a discount rate function that behaves like the labor supply function, rising steeply toward an absolute limit so as to foreclose the possibility that Advances exhaust initial liquid capital K_0. In practice a functional form of

$$r = r_0 e^{\frac{A}{K_0}} \tag{1.8}$$

works better in the simulation model—even though it allows $A/K_0 > 1$. This form can be rationalized by assuming that in an emergency some corn can be harvested early, or emergency stocks dug out of storage. (In the case of labor supply, there is no way to add even a second to a 24 hour day.)

Figure 2 shows this function, with r_0=.04—which is a reasonable number for the annual "natural" rate of interest.

Again, in this particular model, these are internal advances from the farmers to themselves, not an advance from one group to another, so the only implicit risk is that of running out of corn before the next harvest.

D. Consumption Function

In a multi-period model, as an accounting identity, ending capital stock each period equals beginning stock, plus production minus consumption. To model consumption, we need a consumption function. I have chosen a simple Keynesian-style function, in which consumption depends on wealth, *W* and current production, *Q*.

$$C = c_0 W + c_1 Q \tag{1.9}$$

c_0 and c_1 are constants. In the model, consistent with recent consumption function estimates (Sydney Ludvigson, Charles Steindel 1999), I will assume that the wealth coefficient c_0 = .04 and the output coefficient c_1 = .75.

Current production, *Q*, equals current income. No problem here.

But what is wealth? Wealth in each period must be initial capital K_0 plus the value of the other asset, land, *T*. In an infinite static model, with fixed *r*, land value $V = R/r$, rent divided by the discount rate. Assume that is the case here, as a reasonable approximation. That is, land value equals current rent divided by current discount rate. So:

$$W = K_0 + \frac{R}{r} \tag{1.10}$$

In a multi-period model, we can add in "adaptive expectations" and have wealth depend on some sort of running average of capital and rents during prior periods. Of course such short-sighted approximation can create instability.

E. Solving the Model for One Period

We can completely solve the model for one period. We just maximize rent.

$$Max: R = \varphi(T, L) - wL(1 + r) \tag{1.11}$$

And we get the familiar result:

$$\varphi_2 = w(1 + r) \tag{1.12}$$

The marginal product of labor equals the wage times (1+*r*).

Now, drawing on labor supply equation (1.4), and discount equation (1.7) we can solve for *w*, *r*, *L*, *R*, and *Q*. If we add the wealth equation (1.10), we can find consumption *C*, and from that, ending corn inventory:

$$K_1 = K_0 + Q - C \tag{1.13}$$

F. Solving the Model for Multiple Periods

We can now construct a multi-period simulation model, just by making ending capital of one period the beginning capital of the next.

Substituting for *C* in (1.13), there will be growth as long as:

$$K_1 - K_0 = (1 - c_1)Q - c_0 W > 0 \tag{1.14}$$

By assumption the wealth coefficient c_0 is very small, .04 in the model, while (1- c_1) is large by comparison, .25 in the model. So the model economy will grow while wealth W is small, and decline if it is too large. There is an equilibrium position, where capital = K*, at which there is no growth. Without the effect of wealth on consumption, with $c_1 < 1$, growth would continue forever.

G. Comparison to a static infinite model.

Of course the whole point of a dynamic model is that discount and growth rates are determined endogenously every period. However a static infinite model, with discount and growth rates given, yields similar equations. That makes it more plausible to assume short-sighted one-period maximization in a dynamic model.

In an infinite static model, we must either assume that each future period is identical or that there is a uniform growth rate, $g < r$. (If $g >= r$, the model will blow up.) Land value is the discounted present value of future output minus labor costs:

$$V = -wL + \frac{\varphi(T, L) - wL}{1 + r} + \frac{\varphi(T, L)(1 + g) - wL}{(1 + r)^2} + ... \tag{1.15}$$

Provided $g<r$, this expression converges to:

$$V = \frac{\varphi(T,L)(1+g)}{r-g} - \frac{wL(1+r)}{r} \tag{1.16}$$

Provided $g<r$, the general solution to the maximization problem is:

$$\varphi_2 = w(1+r)(1-\frac{g}{r}) \tag{1.17}$$

Absent growth, $g = 0$, infinite present value maximization yields the same equation, (1.12) as the one-period model.

$$\varphi_2 = w(1+r)$$

Notice that with $g > 0$, the marginal product of labor is lower than with $g = 0$, so that more labor is hired and production is greater.

H. A Multi-Period Two-Sector Model: Endogenous Growth Only, No Lending

Given the above equations, and plausible assumptions about parameters and starting values, we can turn the computer loose, generating each period from ending values of the prior period. I used GAMS, General Algebraic Modeling System. A truncated version, adequate for small models, can be downloaded free from the GAMS website, www.gams.com.

Imagine a two-sector economy, or alternatively, a rich and a poor nation side by side. The first “rich” sector, has land 900, and population 25. The second “poor” sector has land 100 and population 225. So 10% of the population has 90% of the land. Run the model over 100 periods. Assume all growth is endogenous, resulting from the gradual accumulation of corn stocks. Assume an arbitrary low starting point in both sectors.

Assume the two sectors are completely independent.

As shown in Figure 3, in both rich and poor sectors, output rises rapidly at first, then flattens off. Total output is much greater in the poor sector; with 90% of the population but only 10% of the land, the poor sector accounts for about 80% of output. However output per capita is greater in the rich sector (about 5 units per capita versus 2 units per capita). As shown in Figure 4, capital continues to accumulate, but at a decreasing rate,

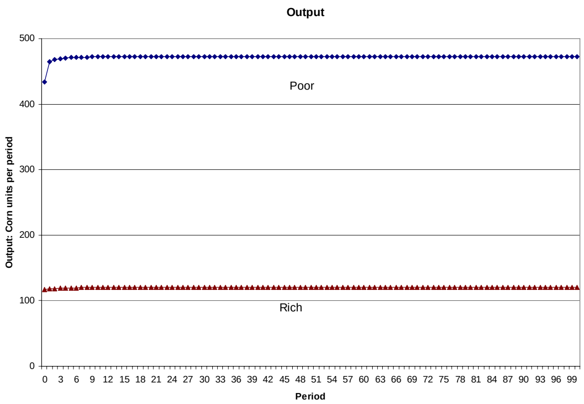


Figure 3

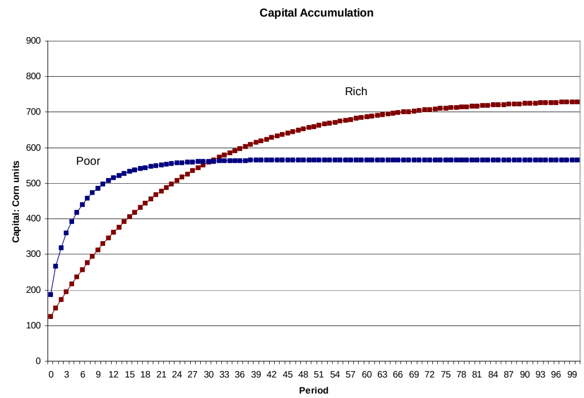


Figure 4

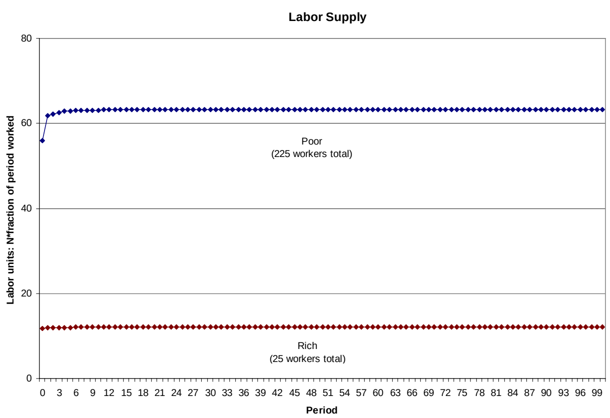


Figure 5

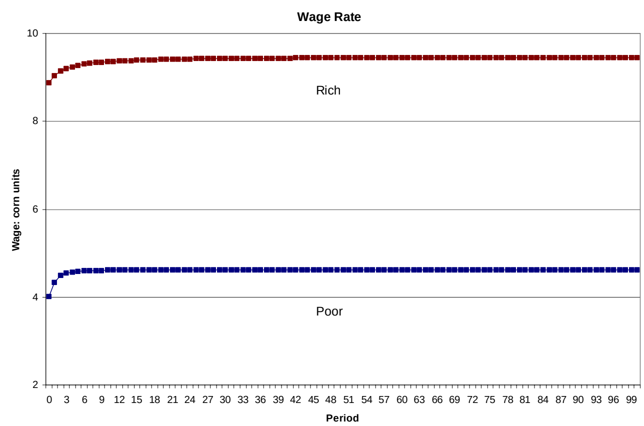


Figure 6

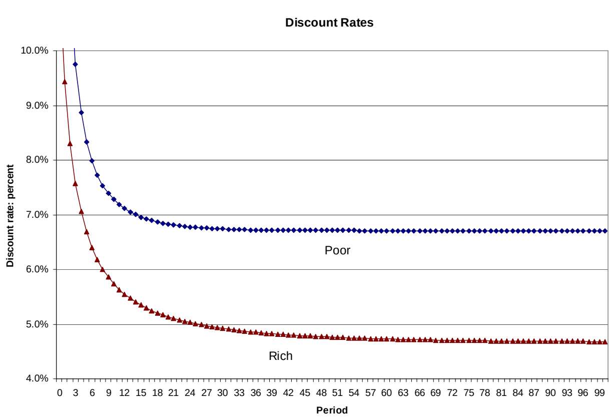


Figure 7

tapering off faster in the poor sector. Figure 5, shows labor supply. Total labor supply is much greater for the poor sector than for the rich. However, individually the rich work much harder, (about 50% of the time, as opposed to 30% for the poor). This isn’t surprising, since, as shown in Figure 6, wages of the rich sector are more than double those of the poor sector—due to the higher marginal product of labor.

Figure 7 shows discount rates for the rich and poor sectors. Discount rates fall in both sectors as capital accumulates.

However, the rate in the rich sector is everywhere lower than that in the poor sector—even near the beginning of the run, where the poor sector has accumulated more capital than the rich sector.

H. A Multi-Period Two-Sector Model: Endogenous Growth Only, With Lending

Now assume the rich sector can lend capital (corn) to the poor sector. There are two cases: In the first case, assume there are no transactions costs to impede lending so that discount rates of the rich and poor sector are identical. That is, referring back to equation (1.7):

$$r^P = \eta(\frac{w^P L^P + Z}{K_0^P}) = r^R = \eta(\frac{w^R L^R - Z}{K_0^R}) \tag{1.18}$$

where Z is the quantity of corn loaned by the rich sector to the poor sector at the beginning of each period, and returned with interest at the end of the period. (Superscripts P and R refer to Poor and Rich.). Figure 8 shows how the interest rates have converged to a rate between the separate rates in Figure 7.

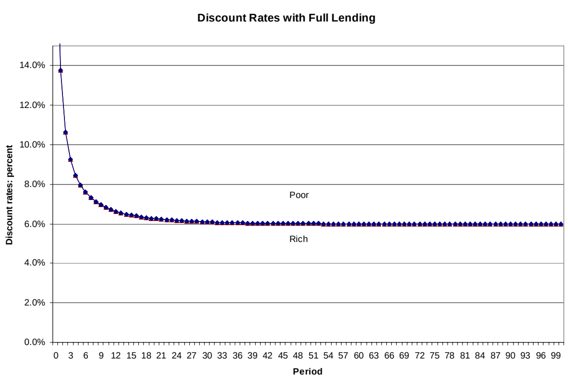


Figure 8

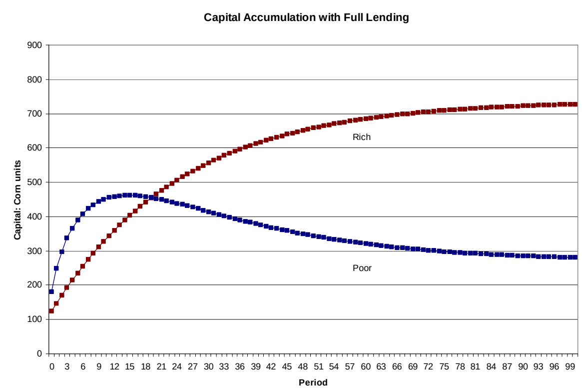


Figure 9

Figure 9 however, shows a remarkable contrast with Figure 4 above. In the poor sector, capital accumulation rises at first more rapidly than in the rich sector. But instead of leveling off at a high point, as it does in Figure 4, capital accumulation actually falls again, before eventually leveling off. The inhabitants of both sectors are in fact better off due to lending, as they should be. Output and consumption are both up—though not enough to show up clearly on a graph. A reasonable interpretation of the decline in poor sector capital accumulation shown in Figure 9 is that with relatively cheap capital now available from the rich sector, the poor sector no longer needs so much accumulation.

In the second case, assume that lending is impeded, as it is in the real world, by transactions costs, moral hazard and adverse selection. Basically, the larger a loan in proportion to the borrower's collateral, the greater the risk of default. Also, the higher the interest rate, the more likely the borrower is a bad credit risk, without better options elsewhere. Such barriers to lending are modeled in great detail by Stiglitz and Greenwald (Joseph E. Stiglitz, Bruce Greenwald 2003). So lending does not go as far as it would without such barriers. To keep things simple, I have modeled only the increase in possible loss proportional to borrower's collateral. Assume a loss function:

$$\chi(\frac{Z}{W^P}); \chi \le 1, Z = 0 \Rightarrow \chi = 1, \chi' < 0 \qquad (1.19)$$

Equation (1.11) for the rich sector now becomes:

$$Max: R^R = \varphi(T^R, L^R) - w^R L^R (1+r^R) + Z(1+r^P)\chi(\frac{Z}{W^P}) - Z(1+r^R) \qquad (1.20)$$

Maximizing with respect to Z yields:

$$0 = (1+r^P)\chi - (1+r^R) + Z(1+r^P)\chi' \qquad (1.21)$$

I used a very simple function for the simulation, where *pz* is a constant:

$$\chi(\frac{Z}{W^P}) = (1 + pz\frac{Z}{W^P})^{-1} \qquad (1.22)$$

So if loan amount Z>0, a gap emerges between the discount rates in the rich and poor sectors. Figures 10 and 11 show the consequences for discount rates and capital accumulation. The gap between discount rates is smaller than in Figure 7. Capital accumulation falls slightly in the poor sector, but not as much as in Figure 9, with no barriers to lending.

Figure 10

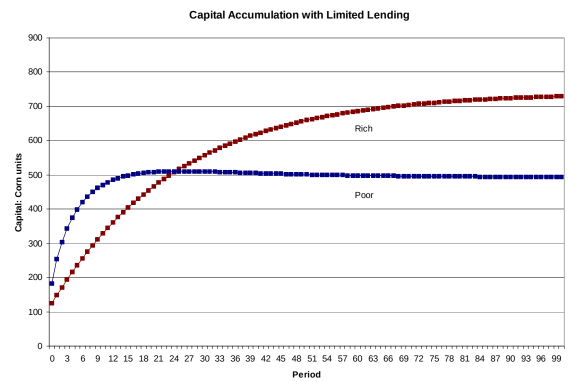


Figure 11

I. A Multi-Period Two-Sector Dynamic Model: Variable Exogenous Growth

Now we can introduce exogenous growth and fluctuations, in the form of changes to "total factor productivity." Assume that TFP grows at an underlying rate of 1% a period; in addition there are superposed sine wave fluctuations about that rate. From equation (1.2), replace constant q_0 with $q_0 e^{(1t+10\sin(\pi t/4))/100}$, where *t* is the period. This formula produces an 8 period cycle, in essence a "real business cycle." How does such growth affect the two sectors, with full lending, and with limited lending?

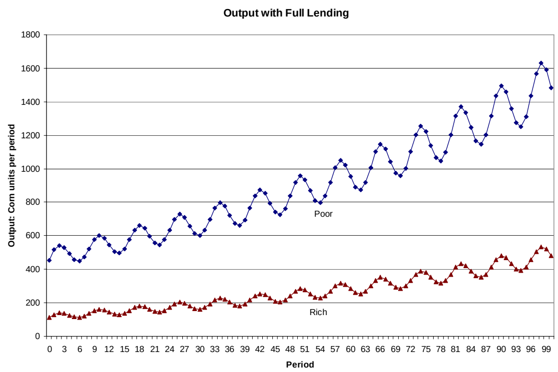


Figure 12

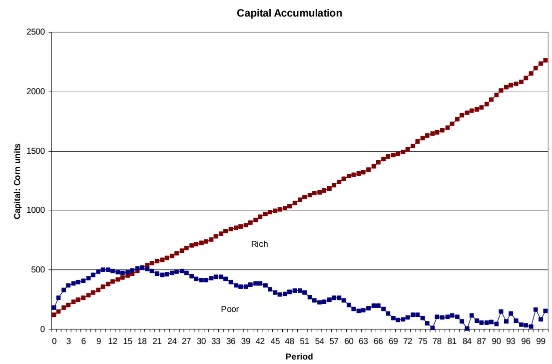


Figure 13

Figure 12 shows output with full lending. As before, the poor sector shows higher output; at the end of the run the poor sector, with 90% of the population and 10% of the land, produces about 75% of output. The poor sector also shows greater fluctuations absolutely, though not necessarily proportionally. Figure 13 shows capital accumulation. The rich sector accumulates capital with barely a ripple. After the beginning periods, the poor sector decumulates capital, with fluctuations that are both absolutely and proportionately greater than those of the rich sector.

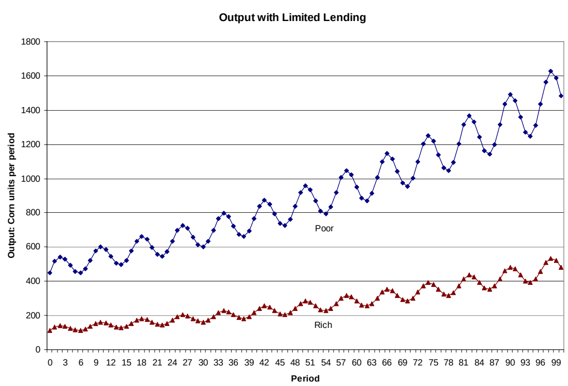


Figure 14

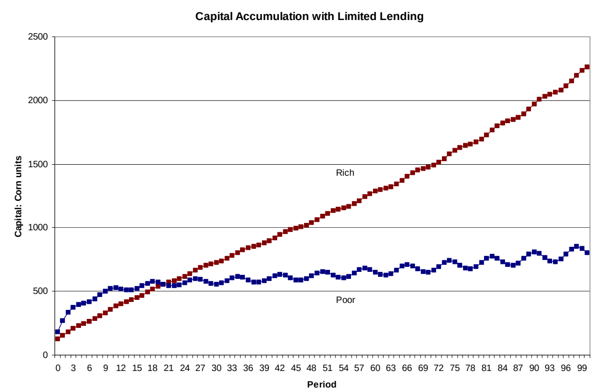


Figure 15

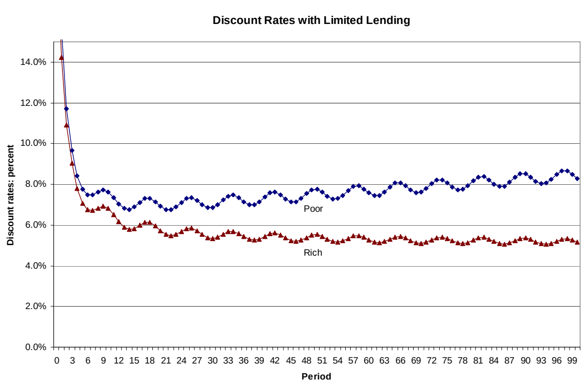


Figure 16

Figure 14 shows output with limited lending. Output looks quite similar to output with full lending. However capital accumulation, in Figure 15, differs substantially from that in Figure 13. It does not fall off, but ripples at higher amplitude than capital accumulation in the rich sector. Finally, Figure 16 shows discount rates in the rich and poor sectors. These were not shown for full lending, where they completely coincided. For limited lending the rates actually diverge over time, with the poor rate increasing.

J. A Multi-Period Two-Sector Dynamic Model: With Lagged Expectations

Now suppose that the farmers of the two sectors incorporate expectations of growth into their estimations of wealth. Instead of discounting expected profits at their current discount rate r, they discount them at r-g, where g depends on their expected rate of profit growth. Consequently they will consume more in a boom, and less in a downturn. In short, the real business cycles set off bubbles and busts.

I modeled lagged expectations quite simply: expected growth is a running average of growth during the last five periods. Applying this pattern to an eight period cycle means that the sectors act as if growth is still continuing strongly after a downturn has begun, and fail at first to respond to the next upturn. It makes discount rate fluctuations look more like sawteeth.

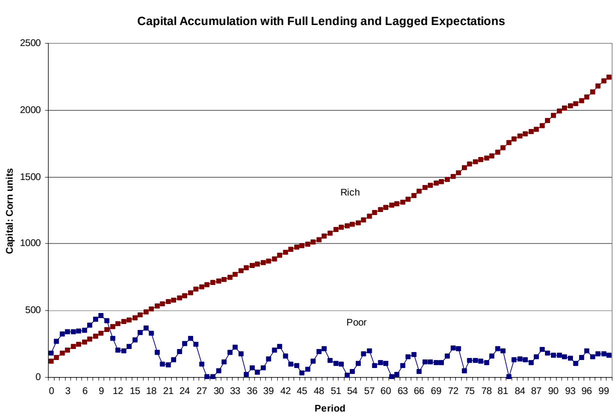


Figure 17

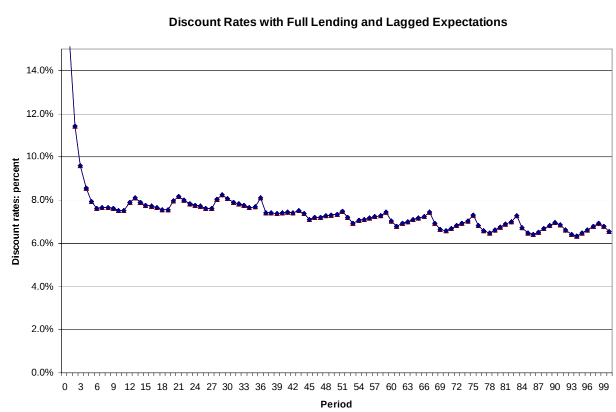


Figure 18

Figure 17 shows the effect of lagged expectations on capital accumulation with full lending. Compared to Figure 13, capital accumulation with full lending but no lagged expecations, capital accumulation—and decumulation—is even lower and spikier. Figure 18 shows the sawtooth path of combined discount rates. Output with full lending and lagged expectations does not look very different from that without lagged expectations, shown in Figure 12.

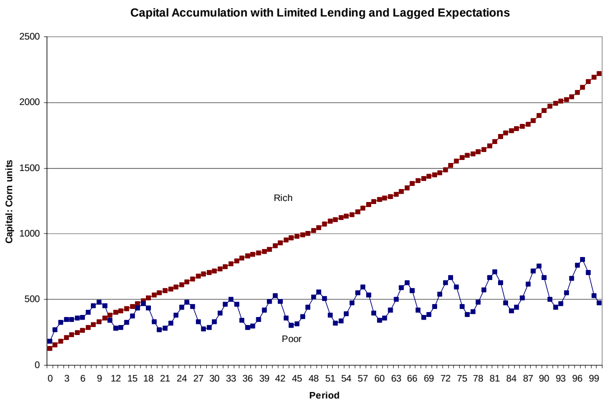


Figure 19

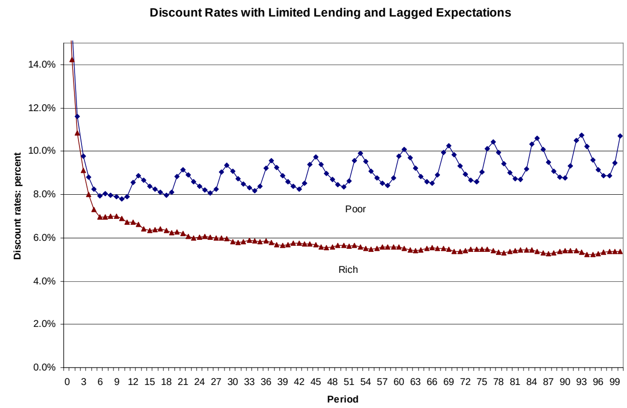


Figure 20

Figure 19 shows the effect of lagged expectations on capital accumulation with limited lending. Compared to Figure 17, the sawtooth pattern in the poor sector is more dramatic, but capital accumulation does not fall off as it does with full lending. Figure 20 shows the discount rates for the two sectors. Here the spikiness occurs almost entirely in the poor sector. However, the spikiness is an intrinsic feature of the poor sector. Figure 21 shows discount rates with lagged expectations and no lending. Both the rich and the poor sectors are even more spiky than in Figure 20. Lending actually damps spikiness.

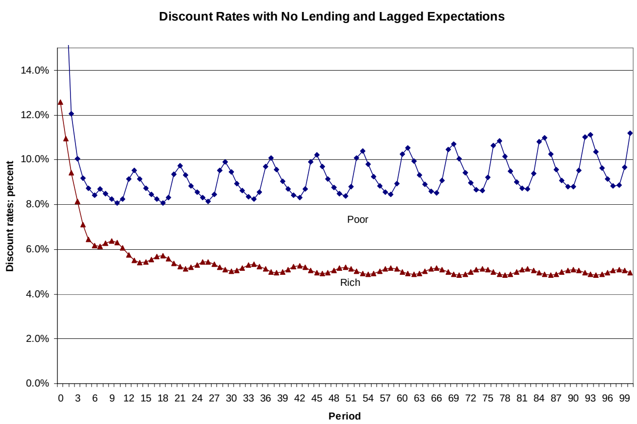


Figure 21

In net the poor sector, which is set at 90% of the population with 10% of land, appears more vulnerable to fluctuations than does the rich sector.

III. Discussion

A. Implications for Macroeconomics

This little model incorporates several features that I think merit more attention in macroeconomics:

1. Distribution of wealth matters, to productivity, and to growth. I have earlier developed general equilibrium models showing that the greater the inequality between rich and poor, and the higher the barrier of transaction costs between them,

the lower an economy's productivity and growth (Mary M. Cleveland 1984). In the present model, a rich and poor sector exist side by side like two separate countries, connected only by lending. In effect, transaction costs exclude any trade except in the most mobile factor, capital. Production would be higher and growth faster were the two sectors combined.

2. Distribution of wealth matters to stability. Lending depends not on the productivity of investment, but on the value of collateral. The value of collateral in turn depends on discounted projections of future net income. Both discount rate and projected income can change, sometimes quickly and dramatically. Lenders are cautious—less so in an upturn when collateral value is growing, and more so in a downturn when collateral value is shrinking. So lending expands during an upturn, and contracts during a downturn, pushing the burden of adjustment from lenders to borrowers. Combining the two sectors of the model would eliminate the additional instability, and burden on the poor sector, arising from fluctuations in lending over the business cycle. (Remember that, in this model, the poor sector is 90% of the population.)

3. The "real" economy matters. This is after all a corn model—eat up all your corn before the harvest and you're dead. The high tech and dot com boom of the late '90's wasted resources in misguided investments—the high-talented time of engineers and programmers, and the physical investments such as the thousands of miles of useless fiber-optic cable laid by Lucent Technologies. Boom-time "overconsumption" compounded the waste. While my corn model can't (yet) demonstrate malinvestment, it does generate over-consumption in that consumption, like lending, depends in part on wealth—and therefore may overshoot if wealth is overestimated. Keynesian macroeconomics, with its focus on insufficient demand, omits any consideration of waste.

4. The "financial" economy matters too—even without money. The rich sector of the corn model controls the terms of lending to the poor sector, and thus can affect the overall functioning of the combined economy. Imagine a model with a hierarchy of sectors ranging from rich to poor, each lending to the sector below it. The model is a pyramid, with many sectors in the lower levels, but only one on top. Lending among the lower sectors can be regarded as "market," because sectors at the same level compete with each other in lending to lower sectors. But if the top sector includes a policy-making "central bank," clearly that top sector can deliberately affect interest rates throughout the economy by its lending to the next sector down. This suggests that both the "banking school" and the "currency school" may be right. Per the banking school, money—as credit, is endogenous. Per the currency school, money is controlled by the central authority. In this model, both can be true. See (Perry Mehrling 2005).

5. Growth increases prices—again, even without money. Wages, rents, and land prices rise, because the marginal products of labor and land rise. In a sense, there must be "natural" prices underlying nominal prices as measured in a particular currency. And the central bank can manipulate the relationship between natural and nominal prices.

6. Factor proportions matter. In the Solow model, the capital to labor ratio locks into a single exponentially growing ratio along an optimal growth path. In the present model, rich and poor sectors maintain their initial land and labor proportions, but accumulate capital at different rates. In the model with endogenous growth, the poor sector initially accumulates capital faster but reaches diminishing returns sooner than the rich sector. The rich sector always enjoys a higher capital to labor ratio, but a lower capital to land ratio than the poor sector.

B. Implications for Further Development

The model is very much a work in progress. Here are some possible developments and improvements.

1. Unemployment. The model so far does not include unemployment. However I can add unemployment by incorporating "sticky wages," that is, by requiring labor to be hired at the prior period wage. As a consequence, over the business cycle, hiring would be tight on the upswing, and unemployment would result on the downswing.
2. Investment in fixed capital. I plan to add fixed capital investment to the model by permitting sectors to choose between applying labor to current corn output, or investing in "labor-saving" or "land-saving" fixed capital. Labor-saving fixed capital would increase labor productivity over a number of future periods, while land saving fixed capital would do the same for land productivity. The rich sector would of course invest in labor-saving technology, and the poor sector would invest in land-saving technology.
3. Improved boom and bust modeling. If the sectors incorporate growth into their projects, they will overinvest and overconsume on an upswing, creating a sudden shortage of liquid capital and a dramatic retrenchment—which may include abandonment of investments in labor and land-saving technology. I have not yet refined the model to the point it will produce an economic crash without a simultaneous program crash.

This simple two-sector model can be expanded to build a hierarchical macro pyramid, with a dominant module on the top, and layers of modules below. Modules at each layer advance capital to the layer below—at ever increasing rates of interest, forming a hierarchical structure of interest rates.

The same model can be applied at different levels and scales. It can be applied to the hierarchy of nations, with the United States (maybe) on top of the developed nations, on top of the less developed nations on top of the "failed" nations. It can be applied to the banking hierarchy in the US, with the Federal Reserve on top of the major banks on top of the regional banks on top of businesses. It can be applied to regions within the US, with the New York City Standard Metropolitan Statistical Area on top. It can be applied to New York City itself, with Manhattan dominating the other four boroughs, and midtown dominating Manhattan.

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