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The natural interest rate of the forest: Macroeconomic requirements for sustainable development

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Abstract

The goal of sustainable development implies a society that is both economically and environmentally reproducible in the long run. The assumption of reproducibility of forests, a renewable resource, has important implications for a market economy.

A profit-maximizing owner will let a forest continue to grow, or regenerate after harvesting, if that choice yields a greater net present value than immediate harvesting without regeneration. The choice depends in part on the relationship between the forest's growth rate and the owner's discount rate. For each forest, there is a threshold interest rate above which the owner will prefer harvesting without regeneration.

The interest rate thus is not only the market price of capital; it must also stay below a critical level if the market is to allow forest conservation. This reflects the dual nature of forests, as both marketable assets and as parts of natural ecosystems. Such cases of dualism are important in the development of ecological economics, and can be seen as parallel to the dual nature of labor and wages in Marxian theory.

For long-run sustainability, interest rates must be low enough to allow forest conservation. This might threaten disequilibrium in capital markets, and cause inflationary pressure. The solution is to lower the marginal rate of profit on new investments, bringing markets back to equilibrium at a lower interest rate – with the likely long-term consequence of slower economic growth due to slower capital formation.

Key words: Forest preservation; Sustainable development

1. Introduction

The widely discussed goal of sustainable development has sweeping, but as yet poorly defined, interactions with economic institutions and policies. This essay shows that one aspect of sustainability – the preservation of forests – may require constraints on interest rates, macroeconomic policy, and long-term economic growth.

To say that a development path is sustainable means, at least, that its patterns of production and consumption can be reproduced indefinitely without doing increasing or irreparable damage to essential natural ecosystems. In the case of renewable resources such as forests, sustainability implies long-term preservation of some minimum resource levels; the determination of those minimum levels is largely external to economic theory.

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What are the economic requirements for a predetermined minimum level of forest preservation? Under what conditions could the market limit itself to sustainable levels of forest use? Section 2 shows that for any forest there is an interest rate above which continued forestry will no longer be profitable. Section 3 contrasts the resulting dual economic and environmental meaning of interest rates to a classic case of dualism in economic theory. Section 4 turns to the implications of environmentally driven interest rate ceilings for short-run macroeconomic policy, while Section 5 speculates on the long-run implications of low-interest economic and environmental sustainability.

2. Forest growth and interest rate ceilings

"Any commercially valuable species... whose rate of reproduction for all population sizes remains below the interest rate, will be exploited to extinction." (Daly and Cobb, 1989, p. 156)

Economic models of forest harvesting decisions are more than a century old (the classic is Faustmann, 1849), and continue to be updated and extended (see, for example, Hellsten, 1988). Despite many important differences in scope and detail, forestry models generally share certain features. In particular, the forest owner's decisions are generally assumed to be influenced by the rate of growth of the forest and by the interest rate, among other factors. The interactions of biological growth rates and interest rates turn out to have surprising implications for a sustainable economy.

Consider a privately-owned natural forest with the owner free to choose between harvesting trees now or letting them continue to grow. If governed solely by market criteria, the owner will make the choice which maximizes the net present value of the income stream from the forest.[1] The harvesting decision depends in part on the relationship between present and expected future timber prices and harvesting costs, on the growth rate of the forest, and on the forest owner's discount rate – the interest rate, or the rate of return on alternative investments.

For simplicity, assume that marginal revenues from timber sales, net of harvesting costs, are expected to remain constant in real terms. (This assumption makes the rate of growth in the forest's market value equal to the rate of growth in physical volume. Relaxation of this assumption is discussed below.) Then it is more profitable to harvest and sell now if the discount rate exceeds the growth rate of the forest; on the other hand, it is more profitable to let the forest keep growing if its growth rate exceeds the discount rate. If forest preservation is important, then the forest's growth rate sets a discount rate ceiling for sustainable development.

The volume of wood growing on a fixed area follows an S-shaped curve (as do many other biological growth phenomena). In the long run, wood volume approaches a fixed upper bound and annual growth rates approach zero. In other words, the growth rate of a natural forest will eventually fall below any positive interest rate, making it more profitable to cut the forest than to preserve it. From the narrow perspective of private profit, it is therefore profitable to engage in nonsustainable rates of logging, sometimes described as forest "mining", of old-growth forests in North America and rain forests in the tropics.[2]

If selective harvesting is practical, the oldest trees will be cut first while younger, faster-growing trees will be allowed to grow. But even with selective harvesting, there is an interest rate ceiling above which the fastest-growing trees in the

[1] The choice depends as well on the non-timber revenues obtainable from the forest – for instance, from recreational uses or from fruit or nut crops. The present analysis assumes that timber sales are the only important sources of forest revenue, a reasonable assumption for some, but not all forests. For a mathematical model incorporating recreational as well as timber values, see Snyder and Bhattacharyya (1990).

[2] A corollary to this argument is that market-based justifications for preservation of old-growth forests (including tropical rain forests) must rest on the forests' non-timber values. Of course, there are also numerous important non-market issues raised by nonsustainable forestry practices in old-growth forests.

forest are not growing fast enough. At that interest rate, immediate harvesting of the entire forest is the profit-maximizing strategy.

For managed forests with repeated cycles of harvesting and replanting, a higher interest rate will lead a profit-maximizing owner to select a shorter growth cycle (the number of years from planting to harvesting).[3] As the interest rate rises and growth cycles become shorter, the net present value of the forest falls. At a high enough interest rate, the net present value of the forest falls below the rent obtainable from other uses of the land. Once again, there is an interest rate ceiling above which the market dictates immediate harvesting without replanting.

The discussion thus far has relied on the simplifying assumption of constant timber prices. However, the same qualitative result, the existence of an interest rate ceiling based *in part* on forest growth rates, holds under more general conditions.

Algebraically, let v be the growth rate of a forest's timber value, p be the growth rate of the timber price net of harvesting costs (i.e., net revenue), and q the growth rate of the physical quantity of wood. Then

$$v = p + q.$$

Let the interest rate be r. Continued forestry becomes unprofitable when the interest rate exceeds the growth rate of timber value, or

$$r > v. \tag{1}$$

The previous argument compared r to q. Since q is biologically determined, a high enough value of r ensures that $r > q$, which is equivalent to Eq. 1 under the simplifying assumption that $p = 0$. But in the general case, Eq. 1 is equivalent to

$$r - p > q. \tag{2}$$

Is Eq. 2 true for all values of r above some threshold? The answer is yes if, as seems plausible, increases in r do not cause equally great increases in p. That is, Eq. 2 is eventually satisfied if, for r above some level, $(r - p)$ is an increasing function of r, or equivalently

$$dp/dr < 1. \tag{3}$$

If Eq. 3 is true, then above some level of r, Eq. 2 and hence Eq. 1 are always true. It is clear, moreover, that the threshold value of r at which Eq. 2 becomes true depends in part on q, i.e., on the physical growth rate of the forest. This is qualitatively similar to the conclusion reached in the simpler case: each forest has an interest rate ceiling, depending in part on its physical growth rate, above which its survival is not profitable.

The interest rate ceiling identified in this analysis may be called the natural interest rate of the forest: it is the highest interest rate at which a profit-maximizing forest owner will ever choose continued growth or regeneration. It is a "natural" rate in two very different senses of the word: it is based in part on natural growth processes; and it can be viewed as analogous to the "natural rate of unemployment" of macroeconomic theory. The latter is defined as the lowest rate of long-run unemployment at which inflation can be avoided.

The natural interest rate differs from one forest to another, and depends on expectations about future prices, harvesting costs, and other variables.[4] But, all else being equal, the natural interest rate of a particular forest also depends on the forest's growth rate. It represents an intrusion of biophysical constraints into the world of economic theory.

3. A lumber theory of value?

Biophysical constraints on economic theory, in this instance, are due to the dual nature of renewable resources such as forests. The same objects, trees, are both marketable assets and integral parts of natural ecosystems. There is a corresponding duality in the meaning of the rate of

[3] This is a standard result in the field, derived in textbooks such as Hartwick and Olewiler (1986), Chapter 11 and Appendix I.

[4] The "natural rate of unemployment" similarly depends on many macroeconomic variables and is only a constant under strong ceteris paribus assumptions.

interest. On the one hand, the interest rate is the price of capital, determined by supply and demand; on the other hand, it must not exceed a critical level if forests are to survive.

The dualism of economic and environmental interpretations stands in contrast to the reductionism of neoclassical economics, which sees each resource only as a marketable commodity. Analysis of such dual meanings of resources and prices will be important in the elaboration of a theory of ecological economics. It may be interesting to note that another theoretical paradigm, Marxian economics, rests on a similar duality in the significance of labor and wages.

Marx emphasized that labor is both a marketable commodity and an essential human activity. Correspondingly, the wage rate was the market price of labor services, determined by supply and demand, and also could not remain below the subsistence level necessary to sustain and reproduce the working class.

One crucial dynamic of nineteenth-century capitalism, in Marx's view, was the conflict between labor and capital over wage rates: the market frequently threatened to force wages below the level needed for "sustainable development" of the labor force. Today there is likewise a conflict over sustainable use of nonhuman resources, pitting private owners of renewable resources against those who "speak for the trees". The modern conflict, typically expressed in terms of debate over nonmarket regulations, is indirectly caused by market interest rates that exceed the natural rate of the forest.

A more complete analogy to Marxian economics could be created; perhaps it would be based on a "lumber theory of value".[5] In the labor theory of value, labor was said to be unique in its ability to create economic value greater than the cost of its own reproduction. Capitalists controlled and appropriated that surplus value for their own ends while workers struggled against capitalist control and appropriation.

Likewise, natural biological growth of plants and animals creates value beyond what is needed for mere reproduction of the original population. Private resource owners typically control and appropriate that biological surplus, although this is increasingly contested by the environmental movement. However, the limits to the analogy, and indeed the separate limits to both the labor and lumber theories of value, are important topics that go beyond the scope of this paper.

4. Forest growth and macroeconomic constraints

Each individual forest has a "natural interest rate" above which it is profitable to harvest now without regeneration. The rate is based in part on characteristics of the individual forest and thus may differ from one location to another. Allowing the interest rate to vary, we obtain a "supply curve" for forest preservation. As the rate of interest rises, more and more forests become unprofitable to maintain.

Therefore, any predetermined minimum level of forest preservation implies a corresponding ceiling on market interest rates. Theoretical analysis alone cannot determine the level of the ceiling. However, casual observation of the market pressure for nonsustainable timber harvesting around the world suggests that interest rates may be well above the ceiling required for preservation of current forest levels.

What would happen if environmental goals required a permanent lowering of interest rates?

In developed countries manipulation of interest rates is a widely used policy instrument for managing the business cycle. "Tight money" and high interest rates are favorite tunes in the anti-inflationary repertoire of most governments. In addition, having interest rates above those of other countries will frequently attract foreign capital, strengthening a nation's currency and (as in the U.S. in the 1980s) allowing the government to borrow more freely. Thus a cap on interest rates for environmental reasons would require a substantial change in macroeconomic policy.

[5] Strictly speaking, it might be more precise to call it a "timber theory of value", since timber is used for paper, fuel, and other uses as well as lumber. The term "lumber theory" is introduced here as a hopefully provocative analogy, not a statement of theoretical precision.

In developing countries interest rates are often far higher than in developed countries, reflecting greater risk premiums, domestic inflation, and less established capital market institutions. As a result, market pressure for nonsustainable rates of timber harvesting will be even greater than in developed countries. The stabilization programs demanded by international lending agencies do not, in the short run, allow developing countries to lower their interest rates significantly.

In either a developed or a developing economy, simple adoption of an environmentally determined cap on interest rates might well prove destabilizing and inflationary. If the interest rate was simply held below the market rate, demand for capital would exceed the supply; a surge in debt-financed investment could create excess demand for many scarce resources, initiating an inflationary spiral.

5. Lower profits and slower growth

Sustainable development must allow the economy, as well as the environment, to prosper in the long run. If environmental preservation requires an interest rate ceiling, what would be required to make long-run economic growth compatible with that ceiling?

A sustainable economic growth path must include equilibrium in markets for financial and real assets. In particular, the rate of interest on financial assets must equal the marginal rate of profit on productive investment. An inflationary surge of demand due to low interest rates is, more precisely speaking, a result of interest rates being held below the rate of profit. Thus if environmental sustainability requires a low rate of interest, economic sustainability requires a similarly low rate of profit. In order to preserve a sustainable level of renewable resources, it may be necessary to lower the long-run rate of profit through taxes or regulation.

Many classical economic theories anticipated ultimate declines in the rate of profit: Keynes speculated about the eventual "euthanasia of the rentier"; Marx claimed that the falling rate of profit was inherent in the dynamics of capitalism. Environmental limitations on the rate of profit recall the theories of Ricardo, who traced the anticipated decline to the exhaustion of high quality resources (land), and the consequent use of progressively lower-quality resources.

Here the argument is that in order to preserve the future quality and quantity of resources, action must be taken to lower the market rate of profit before the decline in resource quality sets in. This might be accomplished through the monetization and internalization of environmental externalities.

Accounting for externalities would show that the real rate of profit, adjusted for loss of environmental values, is already, in fact, below the apparent market rate. The incorporation of externalities into prices would bring the market rate of profit down toward the true, environmentally corrected rate. Far from being a disaster for the market, the reduction in profit rates would facilitate the achievement of sustainable financial equilibrium.

Reduction in profit rates likely implies a reduction in the rate of growth of output as well. This is difficult to prove with certainty since sufficiently rapid technological change could create additional output ex machina. Environmental restrictions might themselves spur a new wave of green technology breakthroughs.

However, lower profits mean lower investment, slower growth of capital per worker, and fewer opportunities to introduce the many types of new technologies that must be embodied in new capital goods. These factors are likely to dampen the rate of growth of output unless technological change is remarkably and continually buoyant.

In summary, sustainability of renewable resources such as forests requires a ceiling on interest rates tied to natural growth processes. The greater the level of desired forest preservation (a largely noneconomic decision), the lower the interest rate must be. To maintain a long-run limit on the interest rate in a market economy, the marginal rate of profit must be held to the same limit. A reduction in the rate of profit is likely to lead to a reduction in the long-run output growth rate as well. It is no surprise that slower growth is

more sustainable; it may be surprising that a limit on sustainable growth rates is set by the macroeconomic requirements for biological growth.

In one of her early science fiction stories, Ursula LeGuin described a planet where "The Word for World is Forest". On a sustainable planet Earth, the word for economic growth will be the same.

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