A Green *Lewis* Development Model

Area 6: Theory, methods and practice

Subarea 6.1: Heterodox, post-Keynesian and ecological economics: connections and contradictions

Ecological and environmental economics has been paying scant attention to macroeconomic issues. One notable exception is the *Green Solow Model* set forth in Brock and Taylor (2010). This contribution is an elegant combination of Solow's (1956) model and the empirical evidence on the Environmental Kuznets Curve (EKC).

The authors start with a Cobb-Douglas technology that combines capital and labor to produce a single good, which in turn generates emissions that must be mitigated. Thus, income is taxed and a third sector slaughter pollution. As the production function is concave, given the assumption of diminishing returns of capital, externalities also exhibit a non-linear pattern in the inverted *U*-shaped format: the EKC.

Regarding developing countries, the model illustrates that it may be sufficient to tax emissions while accumulating capital along the transition to long-run equilibrium, characterized by high levels of income and low levels of *per capita* emissions. In other words, the environmental policy does not prevent these economies to achieve the maturity. Meanwhile, this implication of the model collides with the political argument of many countries that conceive of restrictive instruments for environmental control as obstacles to economic development and as posing an unequal distribution of costs and benefits of climate change (Kahn and Franceschini, 2006).

In this sense, the political views that have been gaining prominence is that without international compensation emerging countries would be unable to achieve higher growth rates and at same time mitigate their emissions (Verbuggen, 2009). By showing that the qualitative convergence process towards maturity is unaffected by taxation, the *Green Solow Model* seems to imply that the design of compensation policies to developing countries is not necessary.

However, it is known that Solow (1956) described the pattern of economic growth in mature economies, unlike the pioneers of economic development, such as Rosenstein-Rodan (1943) and Lewis (1954). In their views, in developing economies, the labor force is not a binding constraint, capital accumulation is not necessarily subject to diminishing returns and natural resources have an important role. These structural characteristics are still found, *mutatis mutandi*, in many countries.

Therefore, a question that emerges from the standard prediction of the *Green Solow Model* is as follows: are developing countries different? In other words, is the dynamics of long-run convergence any different in a developing economy, in the sense that a simple environmental policy, such as taxation in Brock and Taylor (2010), can prevent them from achieving the sustainable maturity?

Motivated by these considerations, this paper contributes to the ecological and development macroeconomic literature by develop an environmental extension of the Lewis's dual economy model, in which the macroeconomy and the environment interact, thus illustrating some characteristics reported above.

In the model, the economy is closed and a single good is produced by two sectors: *Modern* and *Traditional* (Ros, 2013). The traditional sector houses all surplus labor in the economy, whose remuneration is given by the average product of labor, and does not pollute. The Modern sector uses capital and hires labor to produce. As a consequence, generates negative externalities on the environment. The dualism is represented by two development phases as far as the supply of labor is concerned: the underdevelopment phase, in which the labor supply is infinitely elastic at a given wage rate; and the maturity phase, in which (as in the model in Brock and Taylor (2010)) the labor supply is inelastic.

The government taxes the externalities and invests all the corresponding tax collection on an endogenous *environmental research* sector (ER). This sector is responsible for minimizing the negative effects of capital accumulation on ecosystems, by hiring labor from the Traditional sector paying a premium over the subsistence wage. In this context, the rise in the share of the labor force employed in this sector increases the *environmental quality*, which is postulated, in keeping with robust empirical evidence (see, e.g., Zivin and Neidell, 2012; Currie e Neidel, 2005) to increase labor productivity of all workers in the economy (through improvements in worker's health, for example).

In the long run, the *capital stock* and the *environmental quality* vary in a way described by a system of differential equations reflecting theoretically sound assumptions. The capital stock varies over time according to a standard capital accumulation function, which depends on the rates of saving, population growth, depreciation and technical change. Capital accumulation also exhibits increasing returns due to *technological learning*, which is an empirical feature of some developing countries.

In turn, environmental quality varies over time according to a logistic function, in which the environment has a carrying capacity point. In addition, we assume a harvest rate which varies positively with the capital stock. The ER sector is incorporated to the differential equation as a

mitigator of this negative impact from capital stock. As there are two phases in terms of elasticity of the labor supply and increasing returns are present, the model exhibits multiple equilibria (one in the underdevelopment phase, the other in the maturity phase), which are analyzed qualitatively.

One result from our analysis is that the long-run equilibrium in the underdevelopment phase is characterized by an *ecological trap*, since it is saddle-point unstable. This trap is binding when the economy modeled in the paper either does not exceed a certain minimum level of capital stock per worker, or does not have much environmental quality and has to allocate a share of the Modern sector's profits on environmental taxes, which depends on the level of the corresponding negative externalities. The ecological trap is aggravated by the assumption of increasing returns of capital. Therefore, even facing an infinitively elastic labor supply, which do not constrain capital accumulation, the developing economy, if left to the free play of its structural forces, can be prevented from achieving the sustainable maturity by a simple environmental taxation.

Unlike in Brock and Taylor (2010), in our model the prediction is that developing economies need an international compensation (exogenous) mechanism, in line with the political discussions. In this sense, our second main result is that, if the economy does not across the level of minimum capital stock, a development alternative is a standard Big Push à la Rosenstein-Rodan (1943), in which the economy is pushed to the sustainable maturity phase of convergence through dirty capital accumulation. Thus, the developing economy chooses to solve its environmental problem once in the maturity, as it seems to be the case in actual developed economies.

The second development alternative involves what call an *Environmental Big Push*. In this situation, it is possible to escape from the ecological trap through an exogenous shock that makes improvements on the environmental quality, which in turn, increases labor productivity and then, economic growth. This may be possible, for example, by an international transference of clean technology or resource funds from trading emission schemes directed to ER. In this development alternative, developing countries choose to solve their environmental problem along the transition to the maturity. The opportunity cost of the Environmental Big Push is slower rate of convergence as compared to the standard Big Push development alternative. Finally, if developing economies have environmental stocks which are close to the maximum carrying capacity point, some level of environmental quality must be sacrificed to allow for economic development.

References

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