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Towards an Inclusive Model of Sustainable Growth

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Towards an inclusive model of sustainable growth

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Abstract

Models of economic growth are typically based on the use of one or more stocks of productive assets to create goods for utility-generating consumption. The roles played by man-made capital, natural capital and human capital have been explored, often separately, in the literature, and more recently the notion of social capital has been brought to the fore. This paper provides an attempt to construct an inclusive model of growth that considers the different available assets, analysing sustainable consumption possibilities.

JEL Classification: O13, O15, O41, Q20.

Keywords: Human Capital, Social Capital, Natural Capital, Produced Capital, Economic Growth, Sustainability.

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1 Introduction

Models of economic growth are typically based on the use of one or more stocks of productive assets that are drawn upon to create goods for utility-generating consumption. The role of natural resources, or, more generally, environmental resources, as assets has been thoroughly analysed by many authors, of which Smulders [20] gives an excellent non-technical summary. Whether non-renewable or renewable resources are considered, the crucial factors initially seen to determine the possibility of growth (in the sense of a sustained increase in consumption) were the substitutability between natural resources and produced capital, and the drive provided by technical change. Additionally, environmental resources often have a public good character, so that without proper policies markets are unable to ensure their proper allocation, thus jeopardizing growth opportunities.

Outside the realm of environmental economics, growth theory has emphasized the contribution of human capital, or knowledge, which unlike produced capital is not subject to diminishing returns since current knowledge builds on previous knowledge and it is a nonrival factor of production. It should be noted that most authors do not even refer to resources, pollution, or energy in their work, as if economic activity wasn't rooted in the natural world. Still, when such models do take natural capital into account, knowledge can supply the thrust to keep consumption rising in spite of the bounds placed on humanity by the natural environment. As noted by Rodrigues et al [17], the "material" side of the economy can stop growing, achieving a biophysical steady state, while the intellectual side continues to rise "at the pace allowed by knowledge formation and dematerialization".

More recently, the notion of social capital has been brought to the fore as a potential source of economic growth. The most usual definition is from Putnam [16], who presents social capital as the "features of social organization, such as trust, norms, and networks, that can improve the efficiency of society by facilitating co-ordinated actions." Several empirical studies attempt to quantify the contribution of social capital to growth. For example, Knack and Keefer [12] establish a causal relationship between trust and growth. Controlling for other variables, they find that a level of trust that is 10 pp higher is associated with an annual growth rate that is higher by 0.8 pp. Temple and Johnson [23] use an index composed of several measures of social capital, and find it a useful predictor of economic growth. Other empirical studies estimate a robust relationship between social capital and growth (e.g. Beugelsdijk et al [2]; Whiteley [24]; and Rupasinga [18]), although the estimates vary widely.

A few theoretical developments have been proposed, namely Beugelsdijk and Smulders [3] where social capital is modelled as participation in two distinct networks, a closed one (family and friends) and an open one that bridges across different communities. The model is tested using data from the European Values Survey and the conclusion is that higher values attached to family life reduce output growth. Although Bartolini and Bonatti [1] also find a negative relationship between growth and social capital, most authors model social capital as an asset that contributes to production (Glaeser et al [11], Bisin and Guaitoli [4]). Few papers explicitly model the links between social and human capital and, to our knowledge, none consider natural capital as well.[1] This oversight is particularly glaring since studies such as Wright and Czelusta [26] and Easterly and Levine [9] have pointed out that resource endowments can even bring adverse effects, the so-called "resource curse", when there is corruption and institutions are weak. Constantini and Monni [6] present additional empirical results that confirm the importance of good institutions and human capital investment for growth with natural resource abundance .

The importance of developing a complete asset-based framework is highlighted when the focus is on achieving sustainable development. Pearce et

[1] Exceptions are Bisin and Guaitoli [4], Sequeira and Ferreira-Lopes [19], and Dinda [8].

al [14] argue intuitively that the value of changes in an economy's aggregate capital stock can be seen as a measure of sustainable development, since it represents the total wealth bequeathed to the next generations. Thus, a decreasing stock of assets (negative genuine savings) is a sign of unsustainability, although the converse isn't necessarily true. In particular, two warnings must be issued. First, the natural capital stock is heterogeneous and parts of it perform critical functions that may not be replaceable using other capital types. Moreover, due to the pervasive market failures associated with many environmental goods and services, actual asset prices cannot be expected to be efficient, much less to embody "sustainability prices" (see Pezzey and Toman [15] for a more detailed exposition).

In spite of serious data shortcomings, the World Bank has attempted an empirical estimation of the value of wealth for a large set of countries [25]. The report clearly acknowledges the above-mentioned connection between wealth and sustainability, for instance noting in the Foreword that the estimation "yields important insights into the prospects for sustainable development in countries around the world". Direct estimates are provided for produced capital and natural capital (although only some components are included), whereas intangible capital, which includes human and institutional factors, is obtained indirectly. One of the main conclusions is that the intangible component almost always accounts for the largest share of countries' wealth.

In this paper we provide a general model of the relationships between all relevant assets, i.e. natural capital, produced capital, social capital, and human capital, in an attempt to provide an inclusive theoretical view of their potential contributions to economic growth in an endogenous growth framework.[2] The goal is to contribute to the development of analytical tools that yield useful policy implications. The following section presents the model, whereas section 3 shows the main relationships between variables from a so-

[2] A recent short paper by Dasgupta [7] also uses the term inclusive wealth.

cial planner point of view. Section 4 presents the decentralized equilibrium and section 5 concludes.

2 Model

In this section the several types of capital mentioned in the Introduction will be modelled, along with the assumptions on their evolution. The accumulation of produced capital, K_P, arises through production that is not consumed, and is, as usual, subject to depreciation:

$$\dot{K}_P = Y - C - \delta_P K_P \tag{1}$$

where Y denotes production of final goods, C is consumption, and δ_P represents depreciation.

We propose that human capital K_H is produced using human capital allocated to schooling as well as the total amount of social capital, Ks, according to:

$$\dot{K}_H = \xi H_H + \alpha K_S - \delta_H K_H \tag{2}$$

where H_H are school hours, $\xi > 0$ is a parameter that measures productivity inside schools, $\alpha \geq 0$ measures the sensitivity of human capital accumulation to the stock of social capital, and $\delta_H \geq 0$ is the depreciation of human capital. This expression captures the idea of Coleman [5] and Teachman et al [22] according to which social capital is important to the production of human capital. It also ensures that human and social capital are substitutes in the production of human capital.

Individual human capital can be divided into skills in final good production (H_Y), school attendance (H_H), and networking for social capital accumulation (H_S). Assuming that the different human capital activities aren't done cumulatively, we have:

$$K_H = H_Y + H_H + H_S \tag{3}$$

Social capital accumulation requires human capital to be allocated to its production but at each point in time it will also depend on the current stock of social capital, i.e.:

$$\dot{K}_S = \omega H_S + \Omega K_S \tag{4}$$

where ω measures the productivity of human capital in the production of social capital and $\Omega \lesseqgtr 0$ measures the dynamic effect of social capital on its own production. If $\Omega > 0$ existing social networks are strong enough to keep growing without additional human capital. If $\Omega < 0$, on the other hand, there is a net depreciation effect.

Natural capital, K_N, can be thought of as an aggregate measure of natural amenities composed of all environmental assets, including traditional natural resources, waste disposal, and environmental services. This stock variable behaves like a renewable resource, with:

$$\dot{K}_N = R(K_N) - P \tag{5}$$

where $R(K_N)$ is the regeneration rate and P represents the negative effects of pollution and resource depletion. Regeneration is assumed to follow a logistic function, attaining a zero value when the stock is zero and when it approaches its carrying capacity, CC. A possible functional form is:

$$R(K_N) = iK_N(CC - K_N) \tag{6}$$

where i is a growth parameter and CC is constant (for a more complex model where carrying capacity depends on stock size, see Rodrigues et al [17]).

The production of final goods will draw upon man-made capital, use of the environment, knowledge, and networking (or trust), so that all inputs are required. Assuming a Cobb-Douglas technology, so that each exponent is the production elasticity of the associated input, we have:

$$Y = K_P^{\beta} K_S^{\sigma} P^{\nu} H_Y^{\eta} \qquad \beta + \sigma + \nu + \eta = 1 \tag{7}$$

While K_P and K_S fully contribute to final goods production, but only the part of natural capital that is removed from the stock variable is included (this represents resources that are used up or actions that decrease environmental quality, such as pollution emissions). Thus, only the flows of matter that are being transformed contribute to production. For a more complete explanation of the distinction between the role of Nature as a transformative fund and as a transformed resource flow, see for example Kraev [13].[3] In a similar manner, only the portion of human capital that is specifically dedicated to production is considered, since the rest is used for different activities, as stated in equation (3).

To capture the multi-faceted character of natural capital and social capital the model for household preferences specifies both of them, along with consumption, as arguments of the intertemporal utility function:

$$U(C, K_N, K_S) = \frac{\tau}{\tau - 1} \int_0^\infty \left(C_t K_{Nt}^{\phi} K_{St}^{\psi} \right)^{\frac{\tau-1}{\tau}} e^{-\rho t} dt \tag{8}$$

where ϕ represents the preference for Nature, ψ the preference for social capital, and ρ is the utility discount rate, so that a higher ρ indicates more impatient consumers. The t subscripts are dropped in the remaining sections for ease of notation.

3 Optimal Growth

It is clear that when assets directly provide utility, while simultaneously acting as inputs to the production function, the decentralised equilibrium will in general not maximize aggregate welfare. Thus we must solve a social planner's problem. In this section we derive the conditions associated with the maximization of (8) subject to the production function (7) as well as the transition equations for the different types of capital (1)-(5).

[3] However, both Kraev [13] and England [10] emphasize complementarity of natural capital in production.

The problem gives rise to the following Hamiltonian function:

$$\begin{aligned}\mathcal{H} &= \frac{\tau}{\tau-1}\left(CK_N^{\phi}K_S^{\psi}\right)^{\frac{\tau-1}{\tau}} + \lambda_P\left(K_P^{\beta}K_S^{\sigma}P^{\nu}H_Y^{\eta} - C - \delta_P K_P\right) + \\ &\quad +\lambda_H\left(\xi H_H + \alpha K_S - \delta_H K_H\right) + \lambda_S\left(\omega H_S + \Omega K_S\right) + \lambda_N\left(iK_N(CC - K_N) - P\right)\end{aligned} \tag{9}$$

where the λ_j are the co-state variables for each stock K_j, with $j = P, H, S, N$. Considering choice variables C, P, H_Y, and H_S (and substituting H_H using (3)), the first order conditions yield:

$$\frac{\partial U}{\partial C} = \lambda_P \tag{10}$$

$$\lambda_N = \frac{\lambda_P \nu Y}{P} \tag{11}$$

$$\lambda_H = \frac{\lambda_P \eta Y}{\xi H_Y} \tag{12}$$

$$\lambda_H = \frac{\lambda_S \omega}{\xi} \tag{13}$$

as well as:

$$\frac{\dot{\lambda}_P}{\lambda_P} = \rho + \delta_P - \frac{\beta Y}{K_P} \tag{14}$$

$$\frac{\dot{\lambda}_H}{\lambda_H} = \rho + \delta_H - \xi \tag{15}$$

$$\dot{\lambda}_S = \rho\lambda_S - \left(\frac{\partial U}{\partial K_S} + \frac{\lambda_P \eta Y}{K_S} + \lambda_H \alpha + \lambda_S \Omega\right) \tag{16}$$

$$\dot{\lambda}_N = \rho\lambda_N - \left(\frac{\partial U}{\partial K_N} + \lambda_N \frac{\partial R}{\partial K_N}\right) \tag{17}$$

with $\frac{\partial U}{\partial C} = C^{-\frac{1}{\tau}} K_N^{\phi\left(1-\frac{1}{\tau}\right)} K_S^{\psi\left(1-\frac{1}{\tau}\right)}$, $\frac{\partial U}{\partial K_S} = \psi C^{\left(1-\frac{1}{\tau}\right)} K_N^{\phi\left(1-\frac{1}{\tau}\right)} K_S^{\psi\left(1-\frac{1}{\tau}\right)-1}$ and $\frac{\partial U}{\partial K_N} = \phi C^{\left(1-\frac{1}{\tau}\right)} K_N^{\phi\left(1-\frac{1}{\tau}\right)-1} K_S^{\psi\left(1-\frac{1}{\tau}\right)}$ representing the marginal utilities of consumption, social and natural capital, and where $\frac{\partial R}{\partial K_N} = i(CC - 2K_N)$ is the impact of an additional unit of natural capital on its regeneration. This impact may be negative or positive, depending on whether K_N is above or below its maximum sustainable yield value.

Conditions (10)-(13) tell us that for each control variable marginal benefits will have to be equated to marginal costs for efficiency to be achieved.

For instance, condition (10) balances the marginal utility of consumption with the shadow price of produced capital (since one unit of production that is consumed is no longer available for capital accumulation); condition (11) shows the cost of using P in terms of the shadow price of natural capital, on the left-hand side, and the value of the corresponding benefit to production, on the right hand side; likewise, condition (12) equates the shadow price of human capital to its value in production, whereas equation (13) equates the same shadow price (as human capital can be put to different uses) to its value in social capital accumulation.

On the other hand, conditions (14)-(17) show the factors influencing the dynamic evolution of the shadow prices for each one of the capital types. Namely, condition (14) reflects that giving up a unit of K_P yields a benefit (from the discount rate and the avoided depreciation) as well as a loss equal to the value of the marginal productivity of produced capital; condition (15) tells a similar story except the loss is in the accumulation of human capital; condition (16) shows that, for each unit of K_S that is relinquished, the value foregone includes the direct impact on utility, the value of the marginal productivity of social capital, and its contribution to both human and social capital accumulation. Finally, condition (17) highlights the value of the natural capital stock to utility as well as its role in future regeneration.

Following Smulders [21], we now apply time differentiation to conditions (10) and (14) and solve to obtain:

$$\frac{\beta Y}{K_P} - \delta_P = \rho + \frac{1}{\tau}\frac{\dot{C}}{C} - \phi\left(1 - \frac{1}{\tau}\right)\frac{\dot{K}_N}{K_N} - \psi\left(1 - \frac{1}{\tau}\right)\frac{\dot{K}_S}{K_S} \tag{18}$$

which states that the net return to capital (on the left hand side) will be equal to the corresponding rate of return in terms of lost utility. This last term now includes the effects of social capital and it is a new version of the "Keynes Ramsey rule". However, it can be shown through conditions (10), (11), (14), and (17) that the optimal environmental policy, as given by the equality between the net return to capital and the rate of return on investment in natural capital, will be the same as in a model without social capital, i.e.:

$$\frac{\beta Y}{K_P} - \delta_P = \frac{\dot{\left(\frac{Y}{P}\right)}}{\frac{Y}{P}} + \frac{\partial R}{\partial K_N} + \phi \frac{\frac{C}{Y}}{\nu} \frac{P}{K_N} \tag{19}$$

We can also analyse the optimal share of human capital used in production through:

$$\frac{\beta Y}{K_P} - \delta_P = \xi + \frac{\dot{\left(\frac{Y}{H_Y}\right)}}{\frac{Y}{H_Y}} - \delta_H \tag{20}$$

and that of social capital from:

$$\frac{\beta Y}{K_P} - \delta_P = \frac{\frac{\psi C + \sigma Y}{K_S}}{\frac{\eta}{\omega} \frac{Y}{H_Y}} + \frac{\dot{\left(\frac{Y}{H_y}\right)}}{\frac{Y}{H_Y}} + \Omega + \frac{\omega \alpha}{\xi} \tag{21}$$

At the steady state we can expect natural capital to be stable, $\dot{K}_N = 0$, so that P is constant. Other growth rates will, by definition, be constant, so equation (1) tells us that K_P, Y and C all grow at the same rate. Furthermore, K_s and K_H components will also be growing at that same rate. Denote the first growth rate as g_Y and the second as g_H. From equation (7) we can see that $g_Y = \frac{\sigma+\eta}{1-\beta} g_H$. Since $1 - \beta = \sigma + \eta + \nu$, the growth of production (and subsequently, of consumption) is now lower than in models where natural capital is absent and where it would coincide with the growth of human capital. Also, the difference between the two increases for larger values of ν.

Moreover, equation (18) yields the long run optimal savings rule:

$$s^* = \beta \frac{g_Y + \delta_P}{\delta_P + \rho + g_Y \left(\frac{1}{\tau} + \psi \frac{1-\beta}{\sigma+\eta} \left(\frac{1}{\tau} - 1 \right) \right)} \tag{22}$$

where s is the share of produced capital that is not used for consumption, $s = \left(1 - \frac{C}{Y}\right)$. Note from equation (1) that $s = \frac{g_Y + \delta_P}{\frac{Y}{K_P}}$. In order to assess the effect of the preference for social capital in the savings rule, we have to determine the optimal output growth rate. In the steady-state, we can obtain the output growth rate as follows. From (12) $g_{\lambda_H} = g_{\lambda_P} + g_Y - g_{H_Y}$. Using the optimal growth rates for λ_P and λ_H (equations (14) and (15)) as well as the fact that in the steady-state $g_{H_Y} = g_H$, we obtain:

$$g_H = \xi + \delta_P - \delta_H + g_Y - \frac{\beta Y}{K_P} \tag{23}$$

Thus, for an economy in which natural resources are used in production (i.e. $\nu \neq 0$), we reach:[4]

$$g_Y = \frac{\sigma + \eta}{\nu}\left(\xi + \delta_P - \delta_H - \frac{\beta Y}{K_P}\right) \tag{24}$$

From (18), with $g_{K_N} = 0$, and using (24), the following equation for $\frac{\beta Y}{K_P}$ is obtained:

$$\frac{\beta Y}{K_P} = \frac{\rho + \delta_P + \Psi\left(\xi + \delta_P - \delta_H\right)}{1 + \Psi} \tag{25}$$

where $\Psi = \frac{\sigma+\eta}{\nu}\frac{1}{\tau} + \frac{\sigma+\eta+v}{\nu}\psi\left(\frac{1}{\tau} - 1\right)$. Using (24) and (25), we find the output growth rate as a function of the parameters that characterize the economy:

$$g_Y = \frac{\sigma + \eta}{\nu}\frac{1}{1 + \Psi}\left(\xi - \delta_H - \rho\right) \tag{26}$$

Naturally, the output growth rate positively depends on the shares of human and social capital in production, yet it depends negatively on the share of natural resources in production. Since natural capital cannot grow without bounds, unlike other capital types, it is understandable that the larger its role in production the lower the achievable rate of output growth. It is interesting to note that the preference for social capital also has a negative influence on the output growth rate (through Ψ), which would also happen in a model without natural capital. However, in this case the effect is not monotonic. The following proposition gives the result.

[4] It is worth noting that without natural resources, we would reach that $\xi + \delta_P - \delta_H = \frac{\beta Y}{K_P}$.

Proposition 1 *The preference for social capital decreases the output growth rate if* $\psi > \frac{\sigma+\eta}{\sigma+\eta+\upsilon}$.

This means that the use of pollution in production decreases the value of the prefence for social capital above which its effect on growth is negative. If $\nu = 0$, $\psi > 1$ would be sufficient to have a negative effect of ψ on g_Y.

Finally, we can analyse what would be the solution if the goal was to achieve the maximum long run utility level. This analysis is often performed as a complement to the discounted utilitarian solution since it embodies the notion of sustainability. The level of natural capital stock, generally called the "Green Golden Rule" level, can then be compared to the steady state achieved in the traditional social planner problem. Using equations (18) and (19), the Modified Green Golden Rule for this model will be given by:

$$\left[\rho + g_Y\left(\frac{1}{\tau} - 1\right)\left(1 + \psi\frac{1-\beta}{\sigma+\eta}\right) - \frac{\partial R}{\partial K_N}\right]\nu\frac{K_N}{P} = \phi(1 - s^*) \tag{27}$$

The equations that were presented in this section provide a basis for a complete analysis of all the relationships between the different capital stocks.

4 Decentralized Equilibrium

In the decentralized equilibrium both consumers and firms have choices to make. Consumers maximize their intertemporal utility function:

$$\frac{\tau}{\tau-1}\int_0^\infty \left(C_t K_{Nt}^{\phi} K_{St}^{\psi}\right)^{\frac{\tau-1}{\tau}} e^{-\rho t} dt$$

subject to the budget constraint:

$$\dot{a} = (r - \delta_p)a + W_H H_Y - C \tag{28}$$

where a represents the family physical assets, r is the return on physical capital, and W_H is the market wage. The market price for the consumption good is normalized to 1. Since it is making an intertemporal choice, the family also takes into account equations (2) and (4), which represent human and social capital accumulation, respectively. Note that, although natural capital influences utility, there is nothing in the consumer choice affecting K_N directly. This will be a source of externalities from the production to the consumption side. The choice variables for the consumers are C, H_Y, and H_S (H_H is again substituted using (3)), so the first order conditions for the consumer problem yield:

$$\frac{\partial U}{\partial C} = \lambda_a \tag{29}$$

$$\lambda_H^{'} = \frac{\lambda_a W_H}{\xi} \tag{30}$$

$$\lambda_H^{'} = \frac{\lambda_S^{'}\omega}{\xi} \tag{31}$$

as well as:

$$\frac{\dot{\lambda}_a}{\lambda_a} = \rho + \delta_P - r \tag{32}$$

$$\frac{\dot{\lambda}_H^{'}}{\lambda_H^{'}} = \rho + \delta_H - \xi \tag{33}$$

$$\dot{\lambda}_S^{'} = \rho\lambda_S^{'} - \left(\frac{\partial U}{\partial K_S} + \lambda_H^{'}\alpha + \lambda_S^{'}\Omega\right) \tag{34}$$

where λ_a is the co-state variable for the budget constraint, and $\lambda_H^{'}$ and $\lambda_S^{'}$ are co-state variables for the stocks of human and social capital respectively.

The firm maximizes profit, π:

$$\pi = K_P^{\beta} K_S^{\sigma} P^{\nu} H_Y^{\eta} - W_H H_Y - W_N P - rK_P \tag{35}$$

where W_N is the market price of the use of natural capital. The markets for purchased production factors are assumed to be competitive. However, we assume that the firm cannot buy social capital, as there is, in effect, no market for it. Social capital is treated here as exogenous, although it affects the firm's production. Hence, consumer decisions will carry social capital externalities.

From this problem we know that returns on production factors equal marginal productivities, as follows:

$$W_H = \frac{\eta Y}{H_Y} \tag{36}$$

$$W_N = \frac{\nu Y}{P} \tag{37}$$

$$r = \frac{\beta Y}{K_P} \tag{38}$$

Applying time differentiation to the logs of conditions (29) and (32) and solving, we obtain the "Keynes Ramsey Rule":

$$r - \delta_P = \rho + \frac{1}{\tau}\frac{\dot{C}}{C} - \phi\left(1 - \frac{1}{\tau}\right)\frac{\dot{K}_N}{K_N} - \psi\left(1 - \frac{1}{\tau}\right)\frac{\dot{K}_S}{K_S} \tag{39}$$

Since $r = \frac{\beta Y}{K_P}$, this equation corresponds to equation (18) in the social planner solution. We can also derive the decentralized share of human capital used in production:

$$r - \delta_P = \xi + g_{W_H} - \delta_H \tag{40}$$

and the social capital equation is the following:

$$r - \delta_P = \frac{\frac{\partial U}{\partial K_S}\omega}{\frac{\partial U}{\partial C}W_H} + g_{W_H} + \Omega + \frac{\omega\alpha}{\xi} \tag{41}$$

Substituting $\frac{\partial U}{\partial K_S}$ and $\frac{\partial U}{\partial C}$ in the equation, we reach:

$$r - \delta_P = \frac{\psi\frac{\psi C}{K_S}}{\frac{\eta}{\omega}\frac{Y}{H_Y}} + g_{W_H} + \Omega + \frac{\omega\alpha}{\xi} \tag{42}$$

This equation compares with (21) in the social planner problem. The only difference from that equation is the term σY. This is the externality from social capital: while the social planner equates the marginal productivity of social capital to that of human capital, as a market for social capital does not exist, the firm faces social capital as a positive externality.

The externality of natural capital (the firm captures neither the regeneration process of the environment nor the utility benefits) can be seen when comparing equations (11) and (37) from the social planner and the decentralized equilibrium, respectively. In the decentralized equilibrium, the firm is likely to choose a higher level of pollution than the social planner.[5]

5 Conclusion

Achieving economic growth has always been a major concern of economic theory and policy. Several significant developments have appeared in the literature, especially in the last two decades. In particular, human capital has been included as an essential force for growth and the role of natural capital has been discussed thoroughly. More recently, attention has been drawn to the notion of social capital, seen as the level of trust, social norms, and social networking, as an additional explanatory factor for growth. Nonetheless, existing models typically include only two or, rarely, three types of capital, so that at best they can provide a partial view of the growth trends.

In this paper we propose an intertemporally efficient model containing the four categories of assets that can be defined, namely produced capital, natural capital, human capital, and social capital, in an attempt to emphasize the relationships between them in an inclusive model of sustainable growth. We derive some rules for optimal paths that show the contribution of the different capital types. We identify two types of externality: one linked with social and another linked with natural capital. While firms face the positive externality of social capital accumulated by families, they impose a possible negative externality on the environment.

[5] Alternatively, P could be modelled as an explicit function of production (as in Rodrigues et al [17]), possibly considering benefits from human and social capital. This indicates an interesting extension.

Further work should be both empirical, using recently available data to ascertain the validity of the model's assumptions, and theoretical, in the search for intuition for general results with these or other functional forms. The use of specific values would also allow the study of the transition dynamics.

Finally, work on inclusive sustainable growth must also be undertaken for models where uncertainty exists, in particularly when systems are complex and unstable. System resilience is turning out to be a key property in the search for sustainability and its consideration should be sought in discussions about economic growth in the real, natural world.

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