A green investment integration in a growth model[1]

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Abstract

The purpose of this paper was to investigate the relationship between investment and growth from an ecological perspective. To fulfill this purpose the framework of the Bhaduri-Marglin (1990) model was extended by accounting for the role of green capital, a factor which had not been included in the model so far. This was done in the following steps: At first, capital stock was decomposed to “green” and “brown” capital. By saying green capital we refer to the capital stock that is environmental sustainable, where brown capital refers to the conventional one. Afterwards, an environmental variable (x) that indicates green capital share and captures the environmental impacts was defined. Thus, the capacity utilization as also the capital productivity of the economy were determined as a function of green capital share. Green capital share (x) was also introduced in both equations of investment and savings indirectly through capacity utilization. All the original assumptions of Bhaduri-Marglin (1990) model did not change, but in our case we also assumed that investment also depends positively to the share of green capital stock. The outcome was that in an economy where green capital stock is dominant we deal with a stangationist regime (otherwise a wage-led regime) and on the other hand in an economy where brown capital stock is dominant we deal with an exhilarionist regime (otherwise a profit-led regime). A higher green capital stock ensures greater capacity utilization but lower profit share.

[1] This material is based upon work supported by the General Secretariat for Research and Technology (GSRT) & Hellenic Foundation for Research and Innovation (HFRI)
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Introduction

The importance of environment in our lives is great, as the World Commission on Environment and Development (WCED) graphically describes in "Our Common Future" report (1987), "*The Earth is one but the world is not. We all depend on one biosphere for sustaining our lives*." For decades states and their policy makers acted and decided caring only for their prosperity, survival and development and with no regard on the impacts of their actions on nature. As a result, nowadays, we have to face the environmental stress that humanity caused and continues to cause.

Thus the last years, environment has also a significant role in the development of mainstream and heterodox economic thought as a parameter of economic system.

Environmental economics were established as a sub-discipline of economics around '50s and deals with the environment, hence pollution, as an externality of the economy. Actually, it was at this time that the term "environmental economics" was expanding among the scientific world and gradually came to be used in the titles of books and articles, until it was finally formally accepted. For many researchers the origin of "environmental economics" lies in the 1950s when, in the United States, an independent research organization with a large array on environmental issues, approached by applied economics, was founded – its name "Resources for the Future" (RFF). Also in 1974 the "Association of Environmental and Resource Economists", with close associations to RFF was established in USA. In Europe on the other side, it wasn't until 1991 when the "European Association of Environmental and Resource Economics" was established under the pressure of the environmentalism wave.

Through the years of environmental economics research and progress another field of study arises, the field of "ecological economics" which was institutionalized with the establishment of "International Society for Ecological Economics" (ISEE) in 1988. The evolution of ecological economics is based in a quite different perspective from that of environmental economics, even if the cornerstone of both fields is making social decisions about environmental problems and projects. In contrary to environmental, ecological economics are considered to be more multidisciplinary and tend to involve ecologists who have extended their discipline to understand and explain economics. As both disciplines are considered to be current, in contrary with other fields of economic thought, their distinctions are clearly evolving. (Koldstad, 2010)

The traditional neoclassical economics base their approach to sustainable development and environmental issues in three basic assumptions:

1. Reasonable market valuations can be made with non-market environmental goods for cost-benefit analysis.
2. Environmental externalities and other forms of market failure associated with the environment can be corrected by incentive-based policies.
3. Different types of capital can be substituted for each other to achieve sustainable development.

(Krishnan, et al., 1995)

The Post-Keynesian economists despite decades of wide contribution to the heterodox school of thought in topics like macroeconomics, financialization, debt, public policies etc., their contribution on the interdisciplinary field of economics and environmental protection is limited. (Mearman, 2007)

Clive Spash and Anthony Ryan (2012), also, argue that post-Keynesian economists in their attempt to be consistent with the tradition of capital accumulation and full-employment have totally ignored environmental problems likewise resource and energy constrains. They also underline the fact that the heterodox macroeconomics of Post-Keynesian offer good opportunity for a more ecological approach in economics.

The basic Post-Keynesian features, as they are presented by the majority of the post-Keynesian literature[3], can also be used in an environmental post-Keynesian macroeconomic approach. Those characteristics are:

[3] (Davidson, 1981) (Lavoie, 2006)

1. Historical time, stressing the asymmetric and deficient knowledge because of the unknown future
2. Uncertainty, referring to the unknown future
3. The crucial role of economic and political institutions in terms of income distribution and its role in human lives and economic process.
4. Effective demand

Those features allow a more realistic approach to the problem of environmental degradation and give us all the necessary instruments to deal with it from a perspective compatible with the laws of nature and away from the unrealistic framework of mainstream economics.

This section investigates the relation between investment, growth and environment. We will keep all the post-Keynesian economic features and extend them in an ecological perspective, trying to deal with the basic problems of environmental protection: allocation, distribution and scale. To do so, we will extend the Bhaduri/Marglin (1990) model which is eminent among the post-Keynesian theory.

Basic Model

The theoretical fundamentals for the model is the post-Keynesian literature[4] on growth and especially the Bhaduri/Marglin (1990) model as it is approached by Onaran and Stockhammer (2004) and Hein (2016).

Thus, for the basic model, we assume a closed economy without a government activity, which consists of two classes: the working class and the capitalist class. The two main components of the aggregate demand is private expenditure on consumption and on investment and consequently in order to achieve a demand expansion private consumption and private investment should be stimulated. As Keynes (1936) writes: "*Practically I only differ from these schools of thought in thinking that they may lay a little too much emphasis on increased consumption at a time when there is still much social advantage to be obtained from increased investment. Theoretically, however, they are open to the criticism of neglecting the fact that there are two ways to expand output.*" (Keynes, 1936)

The working class offers its labor power to the capitalists and in exchange receives wages which are being funneled in goods' consumption – workers own no property income. So, we assume the familiar post-Keynesian hypothesis of no saving from wages. On the other side, capitalists own and exploit the means of production in order to receive profits. From the amount of profits they receive from production, they consume and they save. In our economy only the capitalists save, so we assume saving from profits to be positive and not zero. They also decide about the investment and they control capital stock. It must be stressed out that workers have greater marginal propensity to consume than capitalists, and that's why it was previously assumed that workers spent all their wages on consumption. (Hein, 2016) (Kalecki, 1971) (Kalecki, 1954) (Bhaduri & Marglin, 1990)

As it was described by Kalecki (1954) "*It is their* (capitalists') *investment and consumption decisions which determine profits, and not vice versa*" (Kalecki, 1954, p.

[4] (Kalecki, 1971) (Kalecki, 1954) (Steindl, 1981) (King, 1996) (Stockhammer, 1999) (Blecker, 1989) (Blecker, 2011) (Hein, 2016)

46) Thus, capitalist's desired accumulation depend on expected profitability because profits are the returns to investment but at the same time they are the primary source of finance for investment.[5] (Blecker, 1989) Therefore, it is clear that the source of a change in rate of profit may be crucial for the investment decisions. (Bhaduri & Marglin, 1990)

Thus, in our model economy, total output (Y) is produced by combining labor force and capital stock provided by capitalist. Rate of profit (r) is defined as flow of profits (Π) over nominal capital stock (K). We can decompose profit rate as we see in equation (1) with Y^p referring to the potential output given by the capital stock. (Hein, 2014)

$$r = \frac{\Pi}{K} = \frac{\Pi}{Y} \frac{Y}{Y^p} \frac{Y^p}{K} \qquad (1)$$

Equation (1) can be also written as follows:

$$r = h\, u\, k \qquad (2)$$

In equation (2) rate of profit (r) is decomposed: in the profit share (h) that relates the flow of profits (Π) with nominal capital stock (K), in the capacity utilization rate (u) that expresses the strength of effective demand in the economy and relates actual output (Y) with potential output (Y^p), and in capital productivity (k). Also, profit share (h) and capacity utilization (u) is between 0 and 1 ($0 < h < 1$ and $0 < u < 1$) (Hein, 2016) (Stockhammer & Onaran, 2004)

[5] The external sources of finance are not considered in this section of the analysis but it should be noted that the availability of internal finance flow is crucial for the acquisition of external finance. (Blecker, 1989)

A green/brown capital model

In the first attempted model extension of Bhaduri and Marglin (1990) model, we will bring into the center of the analysis the factor of the environment. To do so, we will focus on embedding the environmental dimension into the factor of capital stock of the economy. Capital stock is a major factor of production and refers to the total value of equipment, buildings, inventories and other real assets in the economy. Starting from the classical economists until now capital stock is in great concern. In Post-Keynesian literature capital stock is crucial element of the analysis because of its effect on profit share therefore on investment. Capital stock is treated by Post-Keynesian economists to be heterogeneous, in opposition to neoclassical economists who treat capital as homogeneous. (Mearman, 2009) (Felipe, 2002)

The heterogeneity of capital stock allows us to assume that capital stock consists of green capital stock (K_g) and brown capital stock (K_b).

Thus, by saying green capital stock we refer to the capital stock that is environmental sustainable: investments in renewable energy and resource efficiency (manufacturing, waste, buildings, transport, and cities) and in natural capital (agriculture, fisheries, water resources, forests). (UNEP, 2011) Further, brown capital stock refers to the conventional investment where we deal with environmental impacts while green capital stock has no environmental impacts. To be more precise we will give an example. A renewable energy fixture for electricity or hot water inflow for a production line, is considered to be green capital stock, whereas a conventional combustion unit for the same purpose is brown capital stock.

The separation between what is considered to be "green" capital stock and "brown" capital stock could be really complex if it is not well defined. In this paper, green capital stock is considered to follow the features of strong sustainability. The defenders of "strong" sustainability set on priority the human well-being rather than the economic process. Also, the key idea behind strong sustainability is that: "*The substitutability of natural capital by other types of capital is severely limited*." So, according to this core idea, with the intention of being consistent with strong sustainability, we consider that capital in order to be green capital stock apart from no environmental impacts it should also be manufactured with no environmental impacts. Nevertheless, it must be pointed out that the argument in favor of “strong sustainability” does not state that all natural resources, and every ecosystem should stay untouchable. On the contrary it states that every human activity should be carefully planned so that future human life and present human well-being is not jeopardized. (Pelenc, et al., 2015)

So we assume that a transition to a more “green” economy, with less environmental impacts, requires the value of the green capital growing and suppressing the value of brown capital. Also, we capture this assumption by requiring that carbon emissions as we move to green capital stock to be lower than before in order to avoid the devastating effects of climate change.

In the context of transition of the economy we assume that one type of capital cannot be converted to another, in contrast with mainstream economic models which assume that capital can switch from one task to another. (Kemp-Benedict, 2014) (Lecocq & Shalizi, 2014) This assumption arises from the fact, that each type of capital stock (brown and green) has different environmental impacts. Although, at the same time those two types of capital can be added together – as in equation 3 – because they are made of the same “stuff”.

According to the previous example we understand that it is not feasible to convert a conventional energy unit to an environmental friendly one without investing in a new machinery.

$$K = K_b + K_g \qquad (3)$$

We also construct a variable x, so that:

$$x = \frac{K_g}{K} = 1 - \frac{K_b}{K} \qquad (4)$$

The introduction of the share of green capital in the total economy, by constructing variable x, is the cornerstone of this model. As variable x rises from zero to 1, green capital is growing while brown capital diminishes. So, the closer variable x is to 1, the lesser environmental impacts we have. By less environmental impacts we mean less carbon emissions, less use of water resources, less waste and no biodiversity loss. Likewise, when variable x equals 1 we have the case where an economy operates only with green capital stock. The possibility of variable x to reach the value of 1 could be very idealistic for some audiences but the reality is that it is physically possible despite the fact that it could be absolutely challenging. (Pelenc, et al., 2015) (Costanza & Daly, 1992)

According to equation (4) we can define average capital intensity in terms of x, as follows:

$$k(x) = (1-x)k_b + xk_g \qquad (5)$$

We also define the composition of the capacity utilization in terms of x, as follows.

$$u(x) = (1-x)u_b + xu_g \qquad (6)$$

In the model presented in this paper, variable x plays a significant role as it changes across the transition to a green economy. As indicated in equations (5) and (6) we assume that green capital productivity/capacity utilization and brown capital productivity/capacity utilization are not affected by the mix of green capital x but they can change in the long run through clumpsy investments. [6]

The decomposition of capital stock to brown and green allows us to deal with two different capacity utilization rates and two different capital productivity rates.[7] We use different capital productivity rates (k_b, k_g) and different capacity utilization rates (u_b, u_g) for each type of capital because of the earlier assumption that each type of capital has different environmental impacts. In both cases, we consider green capital stock to be more productive than brown capital stock, so for the same amount of

[6] Afterwards, we will examine the possibility of brown and green capital productivity to vary with x. In other words the case where the green capital share affects the performance of both brown capital and green capital activities, thus the economy as a whole.
[7] In this case depreciation rate of both types of capital stock should be taken into account but in the present section we deliberately detach from all financial compilations because this is not our immediate purpose, for the time being.

capital, green capital productivity and green capacity utilization is greater. Nevertheless, in an economy that green capital stock is dominated by brown capital stock brown capital stock appears to be more productive. Accordingly, when green capital stock of an economy is greater than brown capital stock ($K_b < K_g$) we observe that capacity utilization rate of green capital is greater than capacity utilization of brown capital ($u_b < u_g$), while the same applies for capital productivity ($k_b < k_g$). We further assume that brown capital stock depreciates more rapidly, through early retirement, than green capital stock as it considered to be older and technologically obsolete.

We, also, adopt that profit share (h) remains unaffected as, in Kalecki's distribution theory, profit share is explained by relative economic powers of capital and labor affecting the mark-up pricing, or otherwise profit share is determined by the degree of monopoly. (Kalecki, 1954) (Hein, 2014) (Sawyer, 1985) So we can rewrite equation (2) as:

$$r = h\,(u_b k_b + u_g k_g) \quad \text{(7a)} \qquad \text{or a general case:}$$

$$r = h\,u(x)k(x) \qquad \text{(7b)}$$

In the center of the analysis stands the relation of profit rate and capacity utilization with investment. What is new in the present framework of the model here, is that we deal with two different issues: the first is the total volume of the investment and the second is its allocation between green and brown capital.

According, to (Kalecki, 1954) and (Steindl, 1981) the elements of the profit share are included in the investment function. Also, Bhaduri and Marglin (1990) were the first who contradicted the Robinsonian (1962) proposition that investment simply depends on rate of profit and argued that it also depends on the rate of capacity utilization. (Araujo & Teixeira, 2012) (Stockhammer & Onaran, 2004) (Hein, 2016)

Therefore, we assume that investment depends positively on the rate of profit and the rate of capacity utilization. (Bhaduri & Marglin, 1990) Investment also depends positively to the share of green capital stock through equation (6). Hein (2016) argues that the effect of a rise in capital productivity or potential output – capital ratio on the investment are not clear as on the one hand an increase could lead to a lower profit share which should stifle investment, or on the other hand could lead to an increase in demand and an increase in profit share that should boost investment. In our case, at first, the effect of green capital share on investment is examined through equation (6) that captures its indirect effect on capacity utilization. Secondly, it is clear that a growing share of green capital stock in the economy means ex ante a boost for the investment, whether it means a transformation of the existing capital stock or an acquisition of new one. As it is stated before conventional capital or brown capital cannot be converted to green capital stock without new investment.

$$g = g(r) = g(h, u(x), k(x))$$

$$\frac{\partial g}{\partial h} > 0,\ \frac{\partial g}{\partial u} > 0,\ \frac{\partial g}{\partial k} >< 0, \frac{\partial g}{\partial x} > 0 \qquad (8)$$

So, investment decisions will positively depend on the profit share, the rate of capacity utilization and the share of green capital stock. Each of the above will increase the expected rate of profit, ceteris paribus. In what follows we will discard any direct effect of changes in the average capital productivity on investment, because there are not clear ex ante. (Hein, 2016) Therefore, we have included profit share and capacity utilization into the Bhaduri/Marglin (1990) accumulation function, as follows:

$$g = g(r) = g(h, u(x)) \qquad (9)$$

Our assumption regarding savings translates into the following saving equation (S), which is the familiar saving equation of Bhaduri/Marglin model (1990):

$$S = s_\pi\, h\, u \qquad (10)$$

With no saving out of wages, the saving rate (s_π) is determined by the propensity to save out of profits and by the profit rate ($0 < s_\pi < 1$). We reformulate equation 10, using equations 5 and 6, and we get:

$$S = s_\pi h u(x) \qquad (11)$$

In the familiar equilibrium condition, savings have to equal investment. The question that arises here is how the model is closed or in other words how savings and investment can be equal at the level of the whole economy. The neoclassical school of thought assumes wage flexibility that adjust in the labor market. According to this there is a market-clearing wage that equals the marginal productivity of labor. Firms make the appropriate modifications in their capital-labor mix to achieve this equality. In the contrary, post-Keynesian literature does not accept the wage-flexibility. The equilibrium condition between investment and savings is achieved by the adjustment of utilization rate. (Blecker, 2002)

So, the equilibrium condition is:

$$g^* = S^* \qquad (12)$$

We can reformulate equilibrium condition (12) to get expression (14), according to the usual equilibrium condition of Bhaduri/Marglin (1990) as it is shown in equation (13).

$$g(h,u) = s_\pi hu \qquad (13)$$

$$g(h,u(x)) = s_\pi hu(x) \qquad (14)$$

In the original model (Bhaduri & Marglin, 1990), total differentiation of equation (13) and some manipulation gives equation (15) which is the slope of the IS-curve:

$$\frac{du}{dh} = \frac{g_h - s_\pi u}{s_\pi h - g_u} \qquad (15)$$

To be consistent with the well-known Keynesian stability condition, the growth model requires saving to be more responsive to variations in capacity utilization than investment. This imposes that the denominator of equation (15) have to be positive:

$$s_\pi h - g_u > 0 \qquad (16a) \quad \text{or}$$

$$s_\pi h > \frac{\partial g}{\partial u} \qquad (16b)$$

So, the sign of the numerator determines the sign of equation (15). When the reaction of investment to a rise of profit share is greater than the reaction of savings ($g_h > s_\pi u$) the IS-slope is positive, and this case of the demand regime is called exhilarationist ($\frac{du}{dh} > 0$). (Bhaduri & Marglin, 1990) In addition, a positive slope of equation (15), means that a higher profit share (h) is associated with higher capacity utilization (u) is characterizing a profit-led regime. (Bhaduri, 2008) Alternatively, when the reaction of savings to a rise of profit share is greater than the reaction of investment ($g_h < s_\pi u$) the IS-slope is negative, and this case of demand regime is called stagnationist ($\frac{du}{dh} < 0$). (Bhaduri & Marglin, 1990) Furthermore, a negative slope of equation (15) correlating a lower profit share (h) with higher capacity utilization (u) is characterizing a wage-led regime. (Bhaduri, 2008)

Results

In our case, capacity utilization is given by equation (6) and depends on the share of green capital stock (x). Thus, with proper calculations we can substitute equation (6) in equation (15) using the equilibrium condition as it is expressed in equation (14). The purpose is to investigate the relationship between the profit share (h) and the share of green capital stock (x). So respectively to equation (15) that captures the change in capacity utilization after a change in profit share ($\frac{du}{dh}$), we will calculate $\frac{dx}{dh}$ to capture the change in green capital stock after a change in profit share. In this case we get the following expression:

$$\frac{dx}{dh} = \frac{g_h - [s_\pi((1-x)u_b + xu_g)]}{s_\pi h(u_g - u_b) - g_x} \qquad (17)$$

Note once again that instead of $\frac{du}{dh}$ we have $\frac{dx}{dh}$ now. Whether we work with $\frac{du}{dh}$ or $\frac{dx}{dh}$ does not make a difference in the effects and the assumptions of the original model, but it is the contribution of this chapter. Subsequently, we have to examine both the cases where $\frac{dx}{dh}$ is positive and negative. Furthermore, it will be examined the case where an economy has greater green capital stock than brown capital stock and vice versa.

The numerator of equation (17) is basically still the same as in the Bhaduri/Marglin model, the only difference is that capacity utilization is expressed in terms of x.

When $\frac{dx}{dh}$ is positive, profit share restrain will have an effect on green capital share that moves it the same direction, i.e. x will also go down. Whether the numerator is positive depends on the responsiveness of investment to a rise in profit share (due to a green capital share restrain). Only if additional investment is larger than the loss in consumption $(s_\pi((1-x)u_b + xu_g))$ it will be positive. There is no change in this respective compared to the original model.

What has really changed is the denominator, which is now affected by the composition of capacity utilization. We notice that instead of just the capacity utilization (u) in the familiar Bhaduri/Marglin model now we have the difference $(u_g - u_b)$. Also instead of $\frac{\partial g}{\partial u}$ now it appears $\frac{\partial g}{\partial x}$.

In this framework, the Keynesian stability condition must hold, i.e. the reaction of saving to a rise in capacity utilization must always be greater than the reaction of investment:

$$\frac{dS}{du} > \frac{dg}{du} \quad (18)$$

Calculating the differentials[8] of saving and investment with respect to capacity utilization and substituting into equation (18) yields, because of the additional influence of the share of green capital stock on the capacity utilization,

$$s_\pi h > g_x \frac{1}{u_g - u_b} \qquad (19)$$

Hence, the denominator of equation (17) cannot turn negative for stability reasons. We recall equations (8) and we also notice that the relative prices of u_b and u_g do not

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$\frac{dS}{du} = s_\pi h$ & $g_u = g_x \frac{1}{u_g - u_b}$

affect the stability condition. Accordingly, the introduction of the green capital share did not change the fact that the denominator has to be positive.

However, we have to examine when the numerator of equation (17) is negative or positive. According to the theory of Bhaduri/Marglin model, the economy is said to be stagnationist or to have wage-led demand when derivative ($\frac{dx}{dh}$) is positive ($\frac{dx}{dh} > 0$), and it is exhilarationist or has profit led demand when it is negative ($\frac{dx}{dh} < 0$). In other words, the relation between profit share and the share of green capital stock, as it is expressed in equation (17) can be negative or positive depending on the relative response of investment to the share of green capital in the numerator and the relation between u_b and u_g.

The first case is when the numerator of (17) is positive:

$$g_h - \left[s_\pi\left((1-x)u_b + xu_g\right)\right] > 0 \qquad \text{(20a)} \quad \text{or}$$

$$g_h > \left[s_\pi\left((1-x)u_b + xu_g\right)\right] \qquad \text{(20b)}$$

In this case the private investment responds actively to a higher profit share. This means that the factor g_h is sufficiently large to ensure (20b) condition which in conjunction with (19) makes relation (17) positively sloped.

The second case is when the numerator of (17) is negative:

$$g_h - \left[s_\pi\left((1-x)u_b + xu_g\right)\right] < 0 \qquad \text{(21a)} \quad \text{or}$$

$$g_h < \left[s_\pi\left((1-x)u_b + xu_g\right)\right] \qquad \text{(21b)}$$

In this case we deal with a relatively weak response of investment to profitability, and as a consequence consumption has the dominant role in effective demand.

The contribution of this paper is that the sign of equation (17) depends on the variable x that represents the green capital share of the economy. So, we have to examine two possible compositions of an economy: an economy were the brown capital stock is greater than green capital ($K_b > K_g$) or an economy were green capital stock is greater than brown capital stock ($K_b < K_g$). Reword, we deal with a low x or a greater x.

Hence, for the case where $K_b > K_g$, the possibility of condition (20b) to be valid is greater, because the green capital share variable (x) is low and also because in this case $u_b > u_g$. This means that in an economy that runs with a greater amount of brown capital, with greater environmental impacts, the possibility of dealing with an exhilarationist ($\frac{dx}{dh} > 0$) demand regime is greater. Accordingly to Bhaduri/Marglin model in this case low green capital share (x) is associated with higher capacity utilization (u(x)) and higher profit share (h). As an alternative, a positive slope of equation (17) corresponds to profit-share regime.

Similarly, for the case where $K_b < K_g$, the possibility of condition (21b) to be valid is greater, because the green capital share variable (x) is high and also because in this case $u_b < u_g$ This implies that in a more green economy, where the majority of capital stock is green, with less environmental impacts, the possibility of dealing with a stagnationist ($\frac{dx}{dh} < 0$) demand regime is greater. Once again, correspondingly to Bhaduri/Marglin model in this case a high green capital share (x) is associated with higher (lower) profit share (h) and lower (higher) capacity utilization (u(x)). Alternatively, a negative slope of equation (17) corresponds to wage-led regime.

The discussed outcomes are summarized in table 1.

Nature of Demand Regime	
Stagnationist	**Exhilarationist**
$g_h < \left[s_\pi\left((1-x)u_b + xu_g\right)\right]$	$g_h > \left[s_\pi\left((1-x)u_b + xu_g\right)\right]$
$K_b > K_g$	$K_b < K_g$
$\frac{dx}{dh} < 0$	$\frac{dx}{dh} > 0$

Table 1. Summary of the results.

The distinction between the stagnationist and the exhilarationist regimes, as it is approached by Bhaduri/Marglin model (1990), captures two different possibilities of economic growth. In the stagnationist regime, or otherwise in the wage–led regime, a higher real wage produces higher capacity utilization and higher employment. This motion undoubtedly favors working class in terms of more employment opportunities and a higher real wage. In addition, a lower profit share does not necessary mean less profits for the capitalists as the per unit profit loss can be compensated by the increased amount of sales. (Bhaduri & Marglin, 1990) (Hein, 2016)

In the model expansion presented here we can approach this distinction in terms of environment. As presented above it is clear that in an economy that operates on green capital stock – high green capital share (x) – the working class is favored. This means that there are more employment opportunities and higher real wage shares with better environmental conditions.

Nevertheless, as Bhaduri/Marglin (1990) proposed "*Capitalism is not necessarily a zero-sum game.*" (Bhaduri & Marglin, 1990, p. 382). The major difference in terms of the environmental interpretation, that we need to emphasize here, is that better environmental quality, obtained by green capital stock, favors both classes. Better environmental quality provides for everyone better living conditions, better health while at the same time reduces conservation costs. Thus it could be argued that a stagnationist regime favors both classes' well-being.

This aspect strengthens the idea that stagnationist regime can establish a cooperative relation between capital and labor, or otherwise capitalist and working class. To ensure such a condition equation (22) must hold:

$$u(x)\ g_u > h\ g_h \quad (22)$$

By making or the proper calculations in equation (22) we end up with equation (23):

$$u(x)\ g_x \frac{1}{(u_g - u_b)} > h\ g_h \qquad (23)$$

By equation (23) – and equation (22) – it's implied that investors respond more strongly to a variation of green capital stock that in the profit/margin share. Of course when in a stagnationist regime equation (23) fails, economic cooperation becomes ambiguous too.

Paradox of the costs

It is interesting that the "paradox of the costs" applies here. (Rowthorn, 1981) (Hein, 2016) Additional production costs because of green capital stock, will reduce the amount of profit at a given capacity utilization level. However, such a cost increase will also increase output, as green capital stock is considered more productive, and as a consequence the capacity utilization rate will rise. And since, the response of investment in an increase of capacity utilization is positive ($g_u > 0$) will cancel out higher costs. As a consequence profit rate will increase. So, keeping in mind all the assumptions higher costs of green capital stock will lead to higher profits.

The paradox of the costs can apply here because it is irrelevant to the nature of the cost increase. (Rowthorn, 1981) Here additional cost may emerge from high green capital share (x).

Conclusions

The aim of this section was to take the framework of the Bhaduri/Marglin model and to embed an environmental parameter in it. At first, the environmental impact of the composition of capital stock was considered. Capital stock was decomposed to green capital stock and brown capital stock to capture the different environmental impacts of each case. In this context we introduced a new variable (x) that represents the green capital share of the economy.

Continuing in the second step of the model extension we introduced green capital share (x) in both equations of investment and savings indirectly through capacity utilization. This implication changed the outcome of Bhaduri/Marglin model as a result of the inclusion of the green capital share, making now possible to examine the motion of the investment in relation to the green capital share.

The outcomes of the interpretation were really interesting. It was shown that in an economy where green capital stock is dominant we deal with a stangationist regime or otherwise a wage-led regime. On the other hand an economy where brown capital stock is dominant we deal with an exhilarionist regime, or otherwise a profit-led regime. A higher green capital stock ensures greater capacity utilization but lower profit share.

Like it is stated by UNEP (2011): "*the greening of economies is not generally a drag on growth but rather a new engine of growth; that it is a net generator of decent jobs, and that it is also a vital strategy for the elimination of persistent poverty*" and OECD (2011): "*investing in green activities has significant job creation potential*", we have shown that a transition to a more green economy would definitely favor the working class with more job opportunities but also it could favor both classes – the working class and the capitalist class – with better environmental quality.

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