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Exploring the theoretical link between profitability and luxury emissions

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Abstract

Given that the richest 10% of the world population is responsible for more than half of global greenhouse gas emissions between 1990 and 2015, understanding the sources of excessive consumption of wealthier households and the ways to reduce them becomes especially important. Indeed, subsistence emissions are the emissions generated to satisfy basic needs, while luxury emissions are those generated to satisfy non-basic needs and that can, thus, be avoided or reduced. We make use of the 'integrated wage-commodity sector' model to study this issue. By using this model, we are able to connect the double role of luxury goods. On the one hand, they are the main reason why profits exist (together with surplus production of other wage-goods), given that profitability stems from surplus production delivered by workers. On the other hand, they are the major constituent of wasteful luxury consumption and, hence, major drivers of CO_2 emissions. Three different scenarios ('green growth', 'reformist', and 'just transition') are depicted and connected to the possible policy actions to be undertaken to address social and environmental predicaments. The just transition scenario seems to be the only viable option to respect both social and environmental boundaries.

JEL Codes: Q57, Q52, B24

Keywords: rate of profit, luxury goods, GHG emissions, decent living standard, climate change

1. Introduction

The sixth assessment report of the IPCC (2021) has finally settled a debated issue: climate change is caused by human actions. The bad news is that climate extremes are already affecting every region across the globe and the acceleration of rising global temperatures is much faster than expected up to now. The good news is that there is still time to act for the sake of limiting global warming within the limit of 1.5°C or 2°C if we drastically drop greenhouse gas (GHG) emissions by the next two decades. It is therefore more urgent than ever to take actions, and to design suitable targets to move in the most appropriate direction. The objective of this paper is to contribute to the understanding of the origins of profits in a capitalist economy, and how this point is tightly linked to the empirical evidence showing that luxury consumption by richer classes is a major determinant of CO_2 emissions[1] (Kenner, 2015; Lynch *et al.*, 2019). In so doing, we aim at contributing to fill a theoretical gap, given that a heterodox framework linking ecological issues to how a whole capitalist economic system works is still missing (Pirgmaier, 2021).

In the paper we show that, by means of a Sraffian-inspired model such as the 'integrated wage-commodity sector' (IWCS) (Garegnani, 1984, 1987; Fratini, 2015, 2019; Di Bucchianico, 2019, 2020, 2021; Martins, 2021; Yoshihara and Veneziani, 2021) it is possible to relate the determination of the normal rate of profit, the emergence of a physical surplus produced by workers beyond their subsistence real wage, and the carbon-intensive luxury consumption that such surplus allows richer classes to enjoy. In a nutshell, surplus physical production in the IWCS on the one hand allows the formation of a normal rate of profit that rules the economy due to free competition, and on the other hand is the source of environmentally harmful consumption made possible by the provision of luxury goods and services.

Starting from such considerations we discuss three alternative scenarios (green growth, reformist and just transition) that can describe, albeit in a stylised way, the direction to be pursued in order to keep the economy within a social and an environmental boundary. According to our viewpoint, the most effective way would be that of a just transition in which the scale and composition of production are deliberately designed to maintain production within 'sustainable consumption corridors' (Di Giulio and Fuchs, 2014), which allow consumption not to trespass ecological limits, while fulfilling social needs. In such an economy, a boundary imposed is that on production, which would be limited to carbon-neutral (or low-carbon) goods, that consumers would be fully free to choose to consume. For this to be possible, physical surpluses devoted to environmentally-harmful consumption of any nature and, with them, a positive normal rate of profit, cannot be allowed.

The paper is structured as follows. Section 2 reviews the literature on the connection between luxury consumption and environmental degradation. Section 3

[1] It is worth noting that, for the sake of simplicity, we will refer hereafter to CO_2 emissions, but the same implications apply to other greenhouse gases as well as to other environmental aspects.

discusses the major theoretical points that are touched by our contribution and sets out the model we use to investigate the nexus among profitability, luxury goods and CO_2 emissions. Section 4 discusses three fundamental stylised scenarios that can be envisaged grounding on the model. Section 5 concludes.

2. Literature related to luxury consumption and environmental degradation

The risks to the future of humanity posed by human societies themselves through unlimited growth of population, economies, resources depletion and pollution have been known since almost 50 years now. In 1972, the famous report "The limits to growth" (Meadows *et al.*, 1972) by the Club of Rome already warned about the sudden and uncontrollable consequences an unsustainable population and economic growth would have. Several researchers have expressed their concerns that ecological limits may already have been exceeded by human actions or are close to the point of no return (Röckstrom *et al.*, 2009). Recent studies (e.g., Roberts and Parks, 2006; Jorgenson and Clark, 2012; Galli *et al.*, 2012; Toth and Szigeti, 2016; Weidmann *et al.*, 2020; Ivanova *et al.*, 2020) have shown that, unlike common thinking, major risks are posed by unsustainable and excessive consumption (or overconsumption) and, to a lesser extent, by population growth.

Hungarian ecologist Takács-Sánta (2004) identified six major transitions, denoted as "big jumps", related to the transformation of the biosphere induced by human activities. Toth and Szigeti (2016) argue that there has been a "Seventh Jump" since 1970s, which is the result of overconsumption and not of population growth, which had been the engine of all previous jumps. Until two decades ago, material wealth accumulation followed population growth; in this last period, the rate of accumulation of material wealth has sensibly outpaced the rate of population growth, becoming the first driver of ecological disruption (Toth and Szigeti, 2016). A recent article by Elhacham *et al.* (2020) estimates that, in 2020, anthropogenic mass has outweighed global biomass and is expected to exceed 3 Tt by 2040, were current trends to continue. Toth and Szigeti (2016) further show that current levels of population would be sustainable in terms of ecological capacity with 1950 levels of per capita GDP. Accordingly, the authors suggest that, instead of estimating the number of people the Earth can sustain, "we can formulate the right question: How many people the Earth can support at what level of average consumption?" (Toth and Szigeti, 2016, p. 286).

Given the high energy- and resource-intensity of consumption, a sustainable transition, as well as the attainment of the Sustainable Development Goals (SDGs), will not be possible without changing consumption patterns in such a way as to stick to the ecological limits posed by planetary boundaries and resources availability (Röckstrom *et al.*, 2009; Steffen *et al.*, 2015; Toth and Szigeti, 2016; O'Neill *et al.*, 2018). This must happen, of course, while ensuring social limits in addition to ecological limits (Raworth, 2017). Research performing scenario analysis demonstrates that decent living standards (DLS) can be met for all without exceeding 2°C global warming (Grubler *et* *al.*, 2018; Burke, 2020) and redistribution can be the key to ensure wellbeing to all while minimising energy use (Steinberger and Roberts, 2010; Otto *et al.*, 2019; Oswald *et al.* 2020). Some authors advise that reducing income inequality may reduce the impacts suffered from natural disasters (Cappelli *et al.*, 2021) and relieve environmental stress (e.g., Wilkinson and Pickett, 2010; Laurent, 2014), for instance making cleaner products affordable to a greater number of people (Berthe and Elie, 2015).

Arguably, inequality influences the level and content of aggregate consumption, causing increased environmental pressure (Berthe and Elie, 2015). This is confirmed empirically in a study by Jorgenson *et al.* (2017), who demonstrate that higher income and wealth inequalities in USA counties are correlated with higher average CO_2 emissions. Xu *et al.* (2016) conduct a similar analysis and find that inequality in household carbon emissions in urban China is more pronounced than in higher levels of aggregation. Such inequality is firstly ascribable to residential consumption, followed by food consumption and consumption of cultural, educational and recreational services.

Jorgenson (2015) studies the effects of income inequality on the carbon intensity of human wellbeing in both OECD and non-OECD countries from 1990 to 2008. His results show that within-country income inequality has a positive, and increasing over time, effect on the carbon intensity of wellbeing in both groups of countries. According to the author, wealthier households, compared to poorer households, consume higher-than-necessary amounts of energy that are not corresponded by additional benefits in terms of wellbeing. Several other studies (e.g., Niccolucci *et al.*, 2007; Easterlin *et al.*, 2010; Kahneman and Deaton, 2010; Kerekes, 2011; Kasser, 2017; Hickel, 2020) have highlighted how higher GDP and consumption levels usually increase wellbeing only up to a certain threshold, after which they no longer contribute to life-satisfaction. This has led to researching ways to increase wellbeing sustainably while consuming less (Jackson, 2005; Alfredsson *et al.*, 2018).

Henry Shue (1993) distinguishes between subsistence and luxury emissions. As the word says, subsistence emissions are the emissions generated to satisfy basic needs; on the other hand, luxury emissions are the emissions generated to satisfy non-basic needs and that can, thus, be avoided or reduced. However, while the poor, even when they are aware of the environmental impact of their own consumption, do not have the possibility to choose which goods to consume because they have to adopt economic convenience as the only relevant criterion, the rich have this possibility, hence choosing to consume environmentally harmful goods constitutes a responsibility for them. Arguably, the richest 10% of the world population is responsible for more than half of global greenhouse gases emissions between 1990 and 2015 (Chancel and Piketty, 2015; Gore, 2020), even more so if accounting also for emissions embedded in the goods imported from other countries (Arto *et al.* 2016). Of these super-rich individuals, about a fifth are located in the European Union (Chancel and Piketty, 2015), where the top 1% of households have a carbon footprint of about 55 tCO_2eq/cap, 22 times higher than per capita climate targets (Ivanova and Wood, 2020).

For this purpose, understanding the sources of excessive consumption of wealthier households – also known as “the polluter elite” or “high net worth individuals” (hereafter, HNWIs), i.e., those individuals with at least US$1 million in investable income-generating assets – and the ways to reduce them becomes especially important. Accordingly, their lifestyle is a matter that concerns the whole global population: were the present consumption patterns of HNWIs to continue unaltered, the 1.5°C global carbon budget will be fully depleted by 2030, even if everyone else achieved net zero emissions tomorrow (Gore, 2020). Furthermore, while plenty of research exists on poorer households’ consumption patterns and climate change impacts, very few scientific publications inquire consumption patterns and ecological footprints of HNWIs, and no representative survey specifically targeting this group exists on the topic (Otto *et al.*, 2019). Possible reasons for this may be related to their greater capacity to avoid and react to adverse climate impacts, as well as to their disconnection from the reality of the ecological and climate crises favoured by the bubble they live in (Kenner, 2015).

According to some estimates, the average couple of HNWIs has a carbon footprint of about 129.3 tCO2eq per year (Otto *et al.*, 2019). Luxury emissions are especially related to air travel, tourism, luxurious private vehicles and large private mansions (Brand and Preston, 2010; Gössling, 2019; Kenner, 2015; Lynch *et al.*, 2019). These consumption categories, being highly energy-intensive, tend to be more elastic, increasing the energy footprint of HNWIs (Oswald *et al.*, 2020). On a disaggregated level, inequality in energy consumption is mainly concentrated in the transport sector (Gössling, 2019; Oswald *et al.*, 2020), with air travel being the leading emission contributor (Otto *et al.*, 2019). Lynch *et al.* (2019) estimate that one average super yacht in use produces the same amount of CO2 emissions as 202 average cars in the USA, without accounting for carbon emitted in the production phase. Similar figures apply to passenger cars.

In this context, especially worrisome is the conspicuous consumption postulated by Veblen (1934), according to whom the wealthy consume on purpose luxury goods and, in general, excessive quantities of goods, as “[i]t becomes indispensable to accumulate, to acquire property, in order to retain one’s good name” [Veblen, 1934, p.15]. The so-called “Veblen effect” is not just speculation but has important empirical support: in the USA in 1998, when income inequality had notably increased, the number of families filed for bankruptcy was four time higher than in the 1980s, despite the booming of the American economy (Frank, 2007). This leads to what Di Muzio (2015) calls a consumptive ‘arms race’ in which HNWIs compete in the construction of super-polluting mega-yachts and the world’s largest home. Further, the presence of widespread inequalities also favours the spreading of emulative consumption behaviours for households in the middle class, who emulate consumption of the wealthy to distinguish from people in lower classes (Wilkinson and Pickett, 2010), contributing to increased energy and resource use and carbon emissions (Di Muzio, 2015; Jackson, 2016). Given the relevance of emulative consumption behaviours, specifically targeting the polluter elite when designing climate policies and involving them in climate-friendly practices and lifestyle behaviours may have beneficial repercussions on the rest of society as well. Finally, there is also empirical evidence that investigates if and how the rate of profit is connected with environmental degradation. Soener (2019) provides empirical evidence precisely on the role that profitability and exploitation have in causing GHG emissions. According to the author, the relationship is positive and hence higher exploitation and profit rates are systematically associated with higher emissions.

From this literature the linkage between affluence, inequality and wealth (all of them being a direct or indirect consequence of the existence of profits) on one hand, and environmental degradation on the other, clearly emerges. This notwithstanding, the structural determinants of income distribution that systematically cause a tiny portion of the population to enjoy disproportionate incomes must be directly linked to environmental issues also at a theoretical level.

3. Where does profit stem from?

3.1 – Theoretical discussion

While the journey towards a full reconstruction of ecological economics on different basis with respect to those of neoclassical economics is far from being finished, heterodox economics is increasingly engaged with widening its reach to include ecological issues (Nadeau, 2015). Among the various strands of thought involved in the discussion, post-Keynesians and Marxists are particularly active (Kronenberg, 2010; Foster *et al.*, 2011; Fontana and Sawyer, 2016). The terrains of discussions are obviously many, involving topics such as, among others, inequality, the working of a monetary system, the different roles of consumption and production, labour and employment, how to measure well-being, structural change, and so forth (Hardt and O'Neill, 2017; Ciarli and Savona, 2019). Among those, the issue of what determines the normal rate of profit in an economy, namely the rate of remuneration that investors expect to earn on newly-installed capital goods when employing the dominant technique and by running capacity at a normal degree of utilization, is of utter importance.[2] In fact, not only "[t]o determine the laws which regulate this distribution [between rent, profit and wages], is the principal problem in Political Economy" (Ricardo, 1821, p. 5), but such an issue can be directly linked to various debates in ecological economics. There are at least three points of view that can fruitfully interact with such a discussion.

First, whether an economy in a long-run equilibrium position can feature a positive normal rate of profit. Cahen-Fourot and Lavoie (2016) showed the possibility, conditional on the levels of the rate of interest and of the propensity to save out of profits, for profits to be positive even in the case of a stationary economy. Their model, grounded on the Cambridge and Kalecki equations and meant to refute the alleged necessity for the rate of interest to be zero in a stationary economy, focused on the

[2] Cfr. Garegnani (1992).

monetary features of modern economies. In our model, we will see that, beneath the monetary values in which prices, wages and the rate of profit are expressed, normal profitability stems from surplus physical production delivered by workers.[3]

Second, the theoretical analysis can be seen as an additional exercise with respect to the one of Kemp-Benedict (2014).[4] The author investigated in a neo-Ricardian framework the possibility to treat natural resources as the basis on which the entire economy can build, thereby providing a clear picture of how those resources give rise to an 'inverted pyramid' made of successive rounds of mark-up pricing. Our analysis therefore provides new avenues of application to simple structural Sraffian-inspired models that are based on vertically integrated productive sectors and further illustrates the possibility to use them to study environmental issues. This confirms the validity of Martins (2013, 2016, 2018) proposal to explicitly use the (modern) classical circular conception of the economy to address environmental problems.[5]

Third, the role of the theories of value in investigating ecological topics. As vocally stated by Pirgmaier (2021), the choice of the theory of value to is far from being a negligible point, given that it heavily shapes the initial understanding of how the whole economic system works and also the design of the strategies meant to address environmental problems. In this respect, we will show that, together with the case of Marxian analysis stressed by Pirgmaier (2021), also Sraffian theory is at the same time far from being mainstream and also potentially useful to tackle subjects belonging to ecological economics.

We develop our argument within a Classical-Sraffian standpoint, as revived by Sraffa (1951, 1960) and Garegnani (1960). In a nutshell, in such a framework income distribution and relative prices are determined once a set of three intermediate data are taken as given: the social product, the techniques of production, one distributive variable (Pasinetti, 1977).[6] We use a theoretical device, namely Garegnani's (1984, 1987) 'integrated wage-commodity sector', which explains the emergence of profits and of the normal rate of profit through the Marxian categories of the rate of surplus value and of the technical conditions of production, albeit mediated by a Sraffian-type analytical setup. The model is very flexible and can accommodate the analysis of various issues.[7] As in the classical-Marxian tradition, the real wage rate to be given to

[3] In our case the long-period equilibrium position is best characterized as a normal position, rather than a steady-state, but we are going to neglect the differences for the sake of simplicity (see Petri, 2004, Ch. 1 and 4).

[4] For an empirical analysis using input-output techniques, see Cahen-Fourot *et al.* (2020).

[5] For other examples, see Hosoda (2020).

[6] In the Sraffian tradition there is another main route that allows to close the model by exogenously setting one distributive variable. That possibility is to fix exogenously the rate of profit through the nominal rate of interest (Panico, 1988; Pivetti, 1991).

[7] One example is the study of the phenomenon of financialization carried out by Di Bucchianico (2019, 2020, 2021) by means of the IWCS. In these contributions, the IWCS accommodates the study of financial innovations, rising household debt and a growing share of financial profits. Another recent discussion took place on the possibility to formalize technical change within this

workers is fixed exogenously according to the level of the socially recognized level of subsistence and decent living (Stirati, 1994; Levrero, 2013). Once the subsistence physical real wage is assigned to workers (and reintegration of worn out capital goods is accounted for), it is possible to derive what the economic system produces as surplus: "production can be divided into a part which is necessary for the reproduction of the existing economic system […], and another part which is not necessary for the reproduction of the existing economic system […]. The social surplus is constituted by the latter part of production […]" (Martins, 2013, p. 227).[8] This was a crucial point in the classical analysis:

> "The key question to address, as it was for the classical authors, concerns whether the surplus, that is, the part of production above whatever is necessary for achieving a certain standard of living, is distributed and used (indeed, recycled) in an efficient way, or whether it merely creates economic waste (that is, wasteful luxurious consumption, which was much criticized by the classical authors), and physical waste (with negative impact on ecosystems)" (Martins, 2016, p. 38)

As Garegnani (1960, p. 3) maintained, "in the classical theories of distribution, the central problem is the determination of the circumstances which rule the size of the social surplus", rather than price theory *per se* (Arena, 2013, p. 98). The model expands the intuition beneath Ricardo's rationalisation of the concept that the sector in which the normal rate of profit is determined is agriculture because in that sphere of production product, wages and seed-capital are physically homogeneous (Sraffa, 1951). Given that price valuations do not serve therein to set the rate of profit, free completion will ensure that such rate will also rule throughout the whole economy:[9] "it is the profits of the farmer that regulate the profits of all other trades" (Sraffa 1951-1958, IV, p. 23; VI, p. 104). The IWCS analysis generalises that concept to a more complex economy in which the social product, wages and capital goods are made up of a list of heterogeneous items, but preserves the intuition according to which "the rate of profit is determined by the conditions of production of wage goods, and of their direct and indirect means of production alone" (Garegnani, 1984, p. 313). Such an intuition could also be proved to hold through alternative formalizations (Steedman, 1977), but in the IWCS it is also related to the construction of a subsystem (Sraffa, 1960). This is done by resorting to the setting up of a vertically integrated sector (Pasinetti, 1980). Indeed, the IWCS can be defined as the "vertically integrated sector whose physical net product is the amount of

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theoretical scheme and how this influences the analysis of the long-run pattern of the normal rate of profit (Martins, 2021; Yoshihara and Veneziani, 2021).

[8] We are here neglecting for simplicity the troubled question of what surplus is, besides a purely technical viewpoint. Indeed, the issue is contested and there are long discussions among anthropologists and archaeologists on how to assess whether the concept is useful, and how to measure its magnitude (Cesaratto and Di Bucchianico, 2021a, 2021b).

[9] This of course does not prevent the possibility to introduce different sectorial mark-ups to take into account the presence of sectors with different degrees of monopoly, as in Kemp-Benedict (2014).

the composite wage commodity required for the workers of the economy as a whole" (Fratini, 2015, p. 534). In this picture, consistently with the Marxian view on the subject, profits derive from the exploitation of labourers, who are forced to deliver surplus production (Garegnani, 1984, pp. 313-320; 1987, pp. 19-23). In addition to this, as we will see, what emerges clearly is the fact that the economic and the physical (environmental) waste caused by surplus that takes the form of luxury consumption are intimately related. Therefore, this analysis easily accommodates the prescriptions about the urgent necessity to curb wasteful luxury consumption so as to let it stay within environmentally sustainable limits, as for examples the consumption corridors purported by Di Giulio and Fuchs (2014).

3.2 – The model

From Garegnani (1984, 1987), we take the general idea of a normal rate of profit determined once the price equations of the goods entering the wage basket and of their direct and indirect means of production, plus the wage-commodity used as numéraire, are isolated (at the abstract level) within the whole economy (this concept can also be found in Steedman 1977). The analysis is based on the fully-fledged IWCS set up provided by Fratini (2015, 2019). In what follows we recall the steps to derive the normal rate of profit.

$$\begin{gathered} p_a = (1+r)(p_a \cdot a_a + p_b \cdot b_a + \cdots + p_n \cdot n_a) + w \cdot p_w \cdot l_a \\ p_b = (1+r)(p_a \cdot a_b + p_b \cdot b_b + \cdots + p_n \cdot n_b) + w \cdot p_w \cdot l_b \\ \cdots \\ p_n = (1+r)(p_a \cdot a_n + p_b \cdot b_n + \cdots + p_h \cdot n_n) + w \cdot p_w \cdot l_n \\ p_w = p_a \cdot \lambda_a + p_b \cdot \lambda_b + \cdots + p_n \cdot \lambda_n \\ w \cdot p_w = 1 \end{gathered} \tag{1}$$

In system (1) we have in the first *n* equations *n* products and their prices *p*: this is the list of all the products and services the economic system produces. The technical coefficients of production $a_i, b_i, \dots, n_i, i = a, b, \dots, n$ have been normalized by the quantities produced of each good $A, B, \dots, N$ so as to get unitary coefficients. The technical coefficients of production and the quantities produced of each good are taken as given. The coefficients $\lambda_a, \lambda_b, \dots, \lambda_n$ represent the components of one unit of the wage-commodity while *w* stands for the units of the wage-commodity acquired by workers; both are taken as given. Wages are paid *post factum*. The equation of p_w serves to calculate the price of the wage-commodity. The last equation sets the numéraire to be the labour commanded by *w* units of the wage-commodity.

We can now transform price system (1) into an IWCS schema. By doing so, we can show how in an economy the normal rate of profit emerges as a non-price phenomenon, as it is rather the result of surplus production. First step, the branch of the economy composed of the industries engaged in the production of both the wage-commodity and its direct and indirect means of production must be isolated. In the list of *N* goods produced it is possible to distinguish among the goods and services entering the real wage, those that enter its (integrated) production process, and those that are luxury-goods. For simplicity, we suppose that all the goods that enter the real wage are also used as direct or indirect means of production of the wage basket. To formalize it, we suppose that in the vector $\boldsymbol{\lambda_v} = [\lambda_a, \lambda_b, \dots, \lambda_n]$ representing a single unit of the wage commodity some elements are equal to zero. Those zero elements are the luxury goods produced by the economy. Hence, the economy uses up to *H* (out of the total *N*) goods in the integrated production process of the wage basket. Examples of wage-goods can be food, clothing, shelter and so forth. Examples of luxury-goods include intercontinental flights, yachts, large swimming pools, and so forth. The lines of production of luxury-goods are not necessary for the system's reproduction, so we can omit them. In the end we get a system of $h + 2$ equations in $h + 2$ unknowns (*h* prices, p_w the value of the wage bundle, and *r* the normal rate of profit) that determines relative prices and distributive variables.

Second step, the industries are rescaled in such a way that the IWCS net product corresponds only to the wage-commodity. The gross product of the IWCS is the wage-commodity plus the other goods used in the integrated process of production.

$$
\begin{aligned}
NP_v &= L \cdot w \cdot \boldsymbol{\lambda_v} \\
W_v &= L_v \cdot w \cdot \boldsymbol{\lambda_v} \\
A_v &= a_a \cdot Q_a + a_b \cdot Q_b + \cdots + a_h \cdot Q_h \\
B_v &= b_a \cdot Q_a + b_b \cdot Q_b + \cdots + b_h \cdot Q_h \\
&\dots \\
H_v &= h_a \cdot Q_a + h_b \cdot Q_b + \cdots + h_h \cdot Q_h \\
L_v &= l_a \cdot Q_a + l_b \cdot Q_b + \cdots + l_h \cdot Q_h
\end{aligned}
\tag{2}
$$

In (2) we have the IWCS net product NP_v, the amount of physical wages paid to the workers employed in the IWCS W_v, the $A_v, B_v, \dots, H_v$ means of production used in the integrated process of production, and the amount of labour employed in the IWCS L_v. The terms $Q_i, i = a, b, \dots, h$ stand for the gross outputs of the IWCS. The net product of the IWCS is the total amount of wages in physical terms to be distributed to all labourers employed in the entire economy, while the gross product also comprises the means of production consumed during the process. Third step, the rate of surplus-value must be derived.[10]

$$\Pi_v = NP_v - W_v \tag{3}$$

$$\Pi_v = L \cdot w \cdot \boldsymbol{p} \cdot \boldsymbol{\lambda}_v - L_v \cdot w \cdot \boldsymbol{p} \cdot \boldsymbol{\lambda}_v = (L - L_v) \cdot w \cdot \boldsymbol{p} \cdot \boldsymbol{\lambda}_v \tag{4}$$

$$w \cdot \boldsymbol{p} \cdot \boldsymbol{\lambda}_v = 1 \tag{5}$$

From (3) we see that surplus-value Π_v is calculated as the wage bill paid to all labourers minus the wage bill paid to labourers employed in the IWCS. Equation (4) sets the numéraire to be the labour commanded by *w* units of the wage-commodity. By coupling equation (3) and (4), we see surplus-value (hence, the amount of profit) emerge from the difference between labour employed in the whole economy L and in the IWCS L_v. It can be calculated without recurring to price valuations, given the physical homogeneity between the net product of the sector and the wages given to its workers. The rate of surplus-value π_v is

$$\pi_v = \frac{L - L_v}{L_v} \tag{6}$$

Fourth step, the value of capital per unit of labour v_v, expressing the investment in capital advances needed to start the production process, must be derived. Surplus-value in the IWCS divided by the value of capital per unit of labour delivers the normal rate of profit.

$$v_v = p_a \cdot \mu_a + p_b \cdot \mu_b + \cdots + p_h \cdot \mu_h \tag{7}$$

$$\begin{gathered} p_a(r) \equiv l_a + \sum_{t=1}^{\infty} l_{at}(1+r)^t \\ p_b(r) \equiv l_b + \sum_{t=1}^{\infty} l_{bt}(1+r)^t \\ \dots \\ p_h(r) \equiv l_h + \sum_{t=1}^{\infty} l_{ht}(1+r)^t \end{gathered} \tag{8}$$

[10] For the sake of precision, in this framework it would be more correct to refer to the concept of *profit per unit of labour in the IWCS* (Fratini, 2019). There are in fact two differences between the Marxian concept and that of Garegnani. First, Marx's formulation referred to the whole economy, Garegnani's referred to the sub-sector producing the wage-commodity. Second, Garegnani used the 'labour commanded' standard instead of the 'labour embodied' standard (Garegnani 2018). In spite of these differences, we retain Marx's original *rate of surplus-value* label.

$$\mu_i = \frac{a_i \cdot Q_i}{l_i \cdot Q_i}, i = a, \dots, h \tag{9}$$

In equation (7) we have the prices p of each mean of production multiplied by each respective ratio between means of production and labour μ. In (8) the prices are then reduced to dated quantities of labour (Sraffa, 1960, Ch. VI, pp. 40-47): they are shown to depend on two factors, namely the technical conditions of production (described by the labour coefficients l) and the normal rate of profit r (the wage rate being the numéraire). In (9) we find the ratios between means of production and labour μ, obtained by recalling the technical coefficients in the last $A_v, \dots, H_v$ equations of (2). At this point we multiply the reduced terms by the respective means of production per unit of labour μ, and by summing all the factors we obtain the value of capital per unit of labour v_v as a function of the normal rate of profit.

$$v_v(r) \equiv \sum\nolimits_{i=a}^{h} l_i \cdot \mu_i + \sum\nolimits_{t=1}^{\infty} \left[\sum\nolimits_{i=a}^{h} l_{it} \cdot \mu_i \right] \cdot (1+r)^t \tag{10}$$

Fifth and last step, we multiply v_v by r and we equate the term obtained to the rate of surplus-value in (6):

$$\frac{L - L_v}{L_v} = r \cdot \left\{ \sum\nolimits_{i=a}^{h} l_i \cdot \mu_i + \sum\nolimits_{t=1}^{\infty} \left[\sum\nolimits_{i=a}^{h} l_{it} \cdot \mu_i \right] \cdot (1+r)^t \right\} \tag{11}$$

In (11) r is the only unknown, which can be calculated by means of this single surplus equation. A graphical representation in Fig. 1 shows the rate of surplus value as a horizontal straight line that crosses only once the term on the right-hand side, which is convex and monotonically increasing in r; R is the maximum rate of profit (see Fratini, 2019, pp. 13-15).

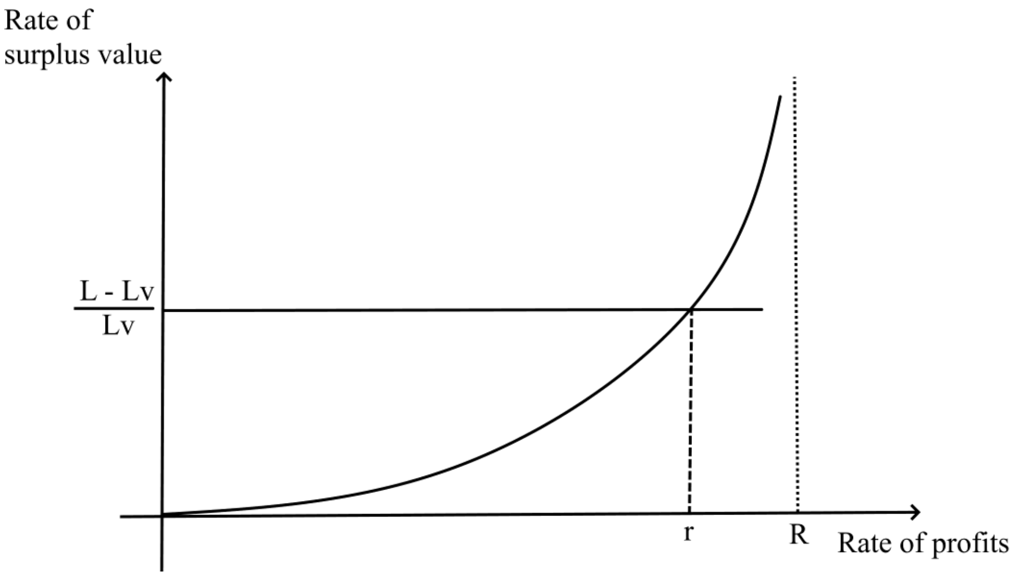

Figure 1 – The determination of the profit rate in the 'integrated wage-commodity sector'. *Source*: Garegnani (1984), Fratini (2019).

Through the lenses of the IWCS we can see that the origin of profits has to be traced back to the productivity of labour that allows the emergence of a physical surplus. Workers employed in the IWCS produce physical wages that are delivered also to workers employed in surplus production. This is compatible with what Pirgmaier (2020, p. 276) recounts: "Profits from production result from societies producing a surplus. Surplus manifests as a surplus product, which is an additional amount of commodities produced above what people need for their subsistence, and surplus value, which is the additional amount of value these surplus commodities contain". Generally speaking, such surplus can materialize in two forms: either wage-goods in excess of what is consumed by workers, or 'luxury' goods (or, of course, both). At a purely logical level, there is hence no need for the economic system to produce luxury-goods in order to have positive profits and a positive rate of profit. If there is a portion of the employed labour force that produces, say, a certain quantity of milk, bread, and clothes that are not going to be consumed by labourers themselves, then there is room for the emergence of a positive rate of profit. However, in reality the norm is for an economic system to produce a great deal of luxury-goods and services, as the literature reviewed in Sec. 2 shows. Those are the main elements that in reality feature the consumption patterns of social classes that do not earn labour incomes.

4. Three alternative scenarios

At this point, we can use the picture the IWCS provides to get some hints at what the directions in which the economic system could be steered might be. For such a sake, we must at first define two objectives that the community may wish to target: the desire to live in an economy that respects social and ecological boundaries.

In recent years, several theoretical approaches have been proposed to ensure an ecologically and socially sustainable consumption pattern. Among these (but not limited to), we find the maximum ecological boundary and minimum ethical boundary theorized by Daly (1977), the sustainable consumption corridors proposed by Di Giulio and Fuchs (2014), the doughnut postulated by Raworth (2017). All these approaches aim to define “a safe operating space for humanity” (Röckstrom *et al.*, 2009), where “individuals are free to consume as they wish” (Fuchs, 2019). The main difference among these approaches lies in the criteria adopted to define the lower (i.e., the social boundary) and the upper limit to consumption (i.e., the ecological boundary).

The social boundary is meant to ensure everyone an equitable and sufficient access to resources, adequate to ensure personal well-being and satisfy individual desires. Some of these theories (e.g., the sustainable consumption corridors) refer to the capability approach formulated by Sen (1996) and Nussbaum (1992) to define it. Others (such as the doughnut) adopt the human needs theory that grounds on the works by Max-Neef (1991) and Doyal and Gough (1991). In a similar vein, a more recent contribution is given by the theory of Decent Living Standards (DLS) (Rao and Min, 2018), which elaborates a universal set of material goods and services requirements to achieve basic human wellbeing. Several studies (e.g., Steckel *et al.* 2013; Lamb and Rao 2015; Lamb and Steinberger, 2017) have provided estimates of the energy requirements to meet DLS for all and to stay within 2°C global warming (Grubler *et al.*, 2018).

The ecological boundary is needed to impose an upper limit to consumption (and production) so as to allow the regenerative capacity of the Earth. Two main approaches have been proposed to quantify this upper limit. The first is that of planetary boundaries (Röckstrom *et al.*, 2009), which consist of nine critical processes that allow the Earth to maintain the conditions of the Holocene. For each of these processes, scientists identified a critical threshold above which stability that guarantees the maintenance of such conditions is threatened. Four of these critical thresholds have already been trespassed. The second approach concerns the comparison between the ecological footprint and the biocapacity of a given economy. The former indicates the environmental pressure (in the forms of GHG emissions, water removal, land occupied, natural resources extraction, and so on) exerted by human activities for the consumption of goods and services, while the latter refers to the maximum availability of natural resources in a given area.

We are going to illustrate three possible scenarios that stem from the initial situation, and through them we will see what is the best combination of policy actions that allows to respect both boundaries at the same time. It is important to stress two things before moving forward. First, there is obviously no naïve policy prescription to be taken from these scenarios. Reality is much more complex than our stylized model allows to see. Second, our model does not permit a dynamic encompassing analysis of transition paths. For that kind of study, there are numerous contributions employing techniques such as stock-flow consistent modelling, as in the case of, among others, Dávila-Fernández and Sordi (2020), Carnevali *et al.* (2020), Botte *et al.* (2021). This being said, we can start with the brief description of the three scenarios.

Case 1: the 'green growth scenario'. Social boundaries not respected, ecological boundaries respected.

In this first scenario, production decisions are scheduled so as to progressively achieve more sustainable consumption patterns by reducing the carbon (and environmental) footprint of production and consumption. This can be achieved, for instance, by progressively banning the production of carbon-intensive luxury goods.

This scenario can therefore bring about an amelioration of the violated environmental boundary condition since all the goods produced have a low carbon content. Imagine an extreme situation in which only (low-carbon) wage-goods are produced. Workers in the IWCS produce physical wages that are distributed also to workers who are employed in the production of surplus wage-goods. In this case, however, the social boundary would still remain violated: while the policy action would impact directly the concrete forms surplus production takes (i.e., composed of only wage-goods), surplus itself would still remain unscathed. Note that in our model the economy is in a long-run normal position in which by supposition all the surplus is consumed. Things may be rendered even worse by supposing a growing economy, so that problems related to the expanding scale of the economy should be also accounted for.

An alternative way to reduce the carbon footprint of production and consumption would be producing luxury goods with a reduced carbon content, making them more sustainable (for example, by designing a new type of yacht that consumes a certain percentage less of fuel to travel a given number of miles). We will not focus on this case as, in terms of our stylised model, technology is taken as given. Although this is undoubtedly a strong assumption, it is becoming increasingly recognised that we cannot rely solely on technological improvements to solve the climate crisis for several reasons (e.g., Wilkinson and Pickett, 2010; Hickel *et al.*, 2021). According to the well-known rebound effect (Jevons, 1866), the increasing efficiency and carbon savings that green technology induce is often (at least, partially) eroded by higher living standards that increase consumption and, in turn, emissions. Evidence shows that absolute decoupling has been experienced by a limited number of countries (e.g., the UK and Denmark) for a short period of time (Haberl *et al.*, 2020), and mainly due to delocalization of production to other countries (Moreau and Vuille, 2018). Moreover, renewable technologies are not a panacea for all ills: their construction is highly energy-intensive and requires the extraction of large quantities of rare minerals that is cause of ecological degradation and social and environmental conflicts (e.g., McLellan, 2019; Pitron, 2020; Sovacool, 2021). Further, we cannot rely on negative emissions technologies as well. Arguably, the urgent time constraint that we face, as well as the unexpected acceleration in climate change impacts (IPCC, 2021), call for more immediate solutions to the ecological crisis compared to still-to-be-developed technologies, whose feasibility now and in the future is openly questioned by several scientists[11] (e.g., De Coninck and Benson, 2014; Anderson and Peters, 2016; Heck *et al.*, 2018). In any case, even considering this alternative way of reducing the carbon footprint of production and consumption, would lead to a situation in which social boundaries are not respected, given the existence of profits due to the exploitation of labour, and ecological boundaries (partially or fully) respected.

Case 2: the 'reformist scenario'. Social boundaries respected, ecological boundaries not respected.

In the passage from the initial system of price equations to the construction of the IWCS carried out in Sec. 3.2, we made two suppositions once we took the scale of the economy and the composition of production as given. First, the composition of the real wage was such that it involved positive amounts of wage-goods, and zero amounts of luxury-goods. Second, the physical surplus produced by workers beyond the reproduction of their wage bill was appropriated by people not belonging to the workers' class. Let us therefore suppose that workers enjoy a particularly favourable socio-political environment (strong unions, low unemployment, a pro-labour State) so that they progressively obtain to introduce both additional types of goods into their wage-commodity composition $\boldsymbol{\lambda}_v$ and also to experience a constant rise of the *w* wage-commodity units they acquire.

$$w_1 = w_0(1 + x) \rightarrow L_{v1} > L_{v0}$$

$$\pi_{v1} = \frac{L - L_{v1}}{L_{v1}} < \pi_{v0} = \frac{L - L_{v0}}{L_{v0}} \qquad (12)$$

$$\pi_v = \frac{L - L_v}{L_v} = 0 \rightarrow L = L_v$$

Considering a wage-commodity that includes all *N* goods produced, if we suppose a rise in the wage-unit such that it increases by a certain positive percentage *x*, this causes the amount of labour in the IWCS to rise, because now more workers out of the entire labour force are needed to produce the physical wages to be distributed to all workers (first equation in 12). The rate of surplus value is falling given that the difference between total workers employed and those engaged in producing wages is shrinking (second equation in 12). Let us focus on the situation in which the rate of profit falls to

[11] Additionally, Zickfeld *et al.* (2021) have demonstrated that, contrary to common assumptions on which negative emissions technologies are based, the relationship between climate response to emissions and removals is in fact asymmetrical (i.e., a tonne of carbon in is not equal to a tonne of carbon out).

zero.[12] This situation comes about when the rate of surplus value falls to zero, hence when the entire labour force is engaged in producing what workers consume (third equation in 12). Physical surplus production ceases to exist, and with it the normal rate of profit. Indeed, "[i]f workers only produced what was necessary for their own subsistence, there would be no surplus, no basis for profits and no good reason for capitalists to employ anyone" (Pirgmaier 2021, p .8). Therefore, the social boundary is respected in this second scenario. This notwithstanding, the environmental boundary appears to be violated as much as it was in the initial situation. The problem in this case rests in the physical composition of production. In fact, the presence of luxury-goods in the input-output structure of the economy does not allow to get rid of environmentally unsustainable wasteful consumption. The fact that workers appropriate the swimming pool they produced is certainly appealing from a socio-political viewpoint, but the negative environmental impact it causes is still there.

Case 3: the 'just transition scenario'. Social and ecological boundaries respected.
In the third scenario, the policy action is informed by altogether different directives. Indeed, the reasoning starts from different premises. Instead of asking ourselves how to make the current economic system more sustainable (case 1) or how workers can reach a situation in which there is no exploitation anymore once we consider given the scale and composition of production (case 2), the starting point should be radically different. The logic guiding the implementation of far-reaching changes should be the one that recognizes how "[…] biophysical processes have a logic of their own to which human beings must adapt if necessary, which means that it is biophysical processes, rather than subjective preferences, that must be seen as the ultimate and irreducible data in any theory of value" (Martins 2016, p. 38). From this it follows that "we are forced to radicalise the notion of the 'socialisation of investment' into that of the 'social production economy': the challenge in front of us is indeed about the 'how', 'what', 'how much' and 'for whom' to produce" (Bellofiore 2021, p. 395). The limits of the former two scenarios have highlighted how the social and the ecological boundaries necessarily need to be addressed jointly. For an effective ecological transition to take place, the reduction of carbon emissions has to be informed by criteria of fairness and sufficiency. Sufficiency is needed to put a cap on consumption (and production) so as not to exceed the Earth's regenerative capacity. Fairness is necessary, in a first place, in order to allow every individual to achieve human wellbeing. Second, it also ensures sufficiency is respected and is not felt as a coercive imposition, by discouraging the

[12] For a given composition of the wage-commodity, the progressive rise in w lowers the rate of surplus value and hence the rate of profit. However, on the other hand, the profit function is changing form: given that it is built by considering the (direct and indirect) technical conditions of production of a specific wage-commodity, if we change the composition by introducing also luxury-goods, its form is bound to change. Such change in the profit function may bring about also situations in which the rate of profit rises in spite of the fall in the rate of surplus-value. This notwithstanding, if we focus on a situation in which the rate of profit is zero, the general reasoning holds irrespective of the form of the profit function.

compulsive consumption of goods not because effectively needed but for their social value (the Veblen effect). As Wiedmann *et al.* (2020) posit:

> "[…] the strongest pillar of the necessary transformation is to avoid or to reduce consumption until the remaining consumption level falls within planetary boundaries, while fulfilling human needs. Avoiding consumption means not consuming certain goods and services, from living space (overly large homes, secondary residences of the wealthy) to oversized vehicles, environmentally damaging and wasteful food, leisure patterns and work patterns involving driving and flying. This implies reducing expenditure and wealth along 'sustainable consumption corridors', i.e. minimum and maximum consumption standards" (Wiedmann *et al.* 2020, p. 3)

Therefore, a construction of the model which would be in line with the above-mentioned principles could not but begin with the definition of given 'decent living' wage-commodity bundle $\boldsymbol{\lambda}_v^{dl}$ (first row in 13).

$$\begin{gathered}\boldsymbol{\lambda}_v^{dl} = [\lambda_a;\ \lambda_b; \dots ; \lambda_h] \\ w = w^{dl} \\ L_{fe} \cdot w^{dl} \cdot \boldsymbol{\lambda}_v^{dl} = W_v \rightarrow W_v = NP_v \\ w^{dl} \cdot \boldsymbol{p} \cdot \boldsymbol{\lambda}_v^{dl} = 1\end{gathered} \tag{13}$$

In such a bundle there would be no place for the kind of carbon-intensive luxury goods and services that cause much trouble to the environment. As for its composition, the decent living wage-commodity bundle will evolve over time, changing together with changing needs. On the same footing, also the number of units w^{dl} of the decent living wage-commodity must satisfy precise environmental constraints (second row in 13). As an example, in a transition towards this regime, besides completely cutting down surplus wasteful goods and services, also a drastic reduction of the meat content in workers' diet must be implemented (Springmann *et al.* 2018).

At this point, the social production is not taken as given in scale, but it is derived from what are the needs of the society: the provision of a decent living wage-commodity to all the available workers. Therefore, by multiplying the full-employment number of workers L_{fe} by the given physical decent living real wage we obtain the whole wage bill produced by workers W_v, which in this case precisely coincides with the net product of the IWCS NP_v. At last, the numeraire is analogous to the usual one (last two rows in 13). Two things may be noted. First, by changing the logics on which this scenario is built we guarantee workers' full employment, while in the first two scenarios in which we took L as the number of workers employed, this was not guaranteed (the usual conditions are far from full-employment). Second, in the economy constructed in this third way there is, actually, no IWCS contained within the whole economic system: the economy completely overlaps with the vertically integrated sub-sector devoted to the direct and indirect production of the wage-commodity given to the whole labour force.

What is most important, it is now apparent how in an economy built on such principles both profits and emissions caused by wasteful consumption disappear. On the one hand, profits disappear because the economy is structurally meant to only provide workers with the physical real wage they produce for their own sake. This does not univocally mean that such an economy shall never produce a surplus. It can, but it would be produced to ameliorate available capital goods, to increase the operating scale were population to grow, and so forth, and not to consent wasteful forms of consumption. Indeed, there is evidence to maintain that while in less developed countries a high share of productive capacity is devoted to produce essentials, "advanced countries have a considerably larger surplus […] for an urgent, all-embracing, system-wide transformation of the economic system and energy infrastructure to mitigate climate change" (Işıkara 2021, p. 109). On the other hand, wasteful consumption arising from carbon-intensive luxury goods and services cannot materially arise because those goods and services are deliberately neither produced nor enjoyed by anyone. This does not automatically solve environmental issues, but it would constitute a decided step in a radically new direction.

5. Conclusions

While the model proposed in this paper is certainly a stylized representation of reality, it still offers some useful implications with real applicability in modern societies. First, our model shows that the existence of a physical surplus of production that, as we have seen, constitutes the source of profits, is both directly responsible for excessive CO_2 emissions and arising from workers' exploitation. According to Otto *et al.* (2019) there is room for reducing HNWIs' emissions by 20% through the employment of renewable energies to power their large private homes and using electric vehicles for road transport. Nonetheless, as shown in the first scenario, greening the composition of production is not sufficient: on the one hand, reducing the scale of production is also necessary to achieve an effective ecological transition (Berthe and Elie, 2015); on the other hand, improving income distribution is required to ensure such transition is just. A fairer distribution of income is also essential to increase wellbeing and counter the pervasive consumerist logic based not on concern for the environment and the common good but rather on individualistic considerations and social status (Wilkinson and Pickett, 2010): when lifestyles and consumption patterns do not favour the use of clean energy, they tend to exert greater pressure on the environment (Berthe and Elie, 2015).
However, reducing inequality alone is not enough as well: our second scenario demonstrates that, in spite of a complete redistribution of surplus to workers, luxury goods would still be produced, hence the ecological transition would be far from being undertaken. Our third scenario (the just transition scenario) combines compliance with both social and ecological boundaries and shows that emissions reduction and improved

income distribution go hand in hand. It proposes to rethink production in order to reverse the logic guiding the production process itself. So, instead of producing a certain amount of goods and services (with different carbon contents), production is scheduled so as to ensure the right amount of (low-carbon) goods and services to allow each worker to fulfil a decent living standard.

In theory, however, a limited amount of surplus can be allowed but conditioned on a total reinvestment of such surplus aimed at pursuing a social and ecological benefit, in order to avoid situations of "profit without prosperity" (Lazonick, 2014). In any case, for such a transition to be enacted, central States need to play as key actors to define the lines of production that can be allowed in compliance with ecological boundaries and to expand the welfare state to guarantee social boundaries are respected. As argued by Mastini *et al.* (2021), there is room in the Green New Deal for policies aimed at jointly addressing compliance with both boundaries.

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