Cars and Carrots: Funding Pensions in a Degrowing Economy

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Abstract

This article explores the possibilities for funding pensions with a pay-as-you-go scheme, in an economy which is « degrowing ». Aggregate demand is assumed to be progressively diminishing as a result of profound ecological changes that affect the economy's infrastructure, the structure of production, and lifestyles. Various policies are considered regarding the response of the government to the budget deficit that arises from the reduction in consumption : (i) no response, (ii) a decrease in pensions and (iii) an increase in contribution rates. In terms of consumption behaviour, two cases are distinguished : households either have a « satiety » behaviour, or they do not. All these cases are examined in terms of their macroeconomic implications (consumption, budget deficit, public debt) but also with respect to two key indicators : one for intergenerational inequality and one environmental indicator. We use the SFC modelling approach and build the simplest model that can tackle the issues described earlier. Our simulation results show that the best policy is an increase in contribution rates, and that an ecologically induced reduction of aggregate consumption can yield environmental benefits without bringing more inequality, an ever-increasing public debt or massive unemployment, which are usually the predicted catastrophes associated with degrowth.

Keywords: Pensions, Income distribution, Ecological transition, Degrowth, Autonomous consumption expenditures.

1 Introduction

Around the globe, ecological degradation keeps worsening, year after year. The "rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems" called for by the IPCC (2018) in order to limit global warming to 1.5°C may have started in some sectors and places. Yet they have not reached a speed nor a range necessary to deliver on time the "unprecedented" change that is needed. For instance, global emissions of greenhouse gases have risen by 2.7% in 2018 and the Nationally Determined Contributions of the Paris Agreement would lead to a 3.3°C increase in global temperatures by 2100.[1] Several planetary boundaries have been overshooted, such as biodiversity loss and nitrogen and phosphorus cycles, and some like land-system change are on their way to be crossed (Rockström et al. 2009; Steffen et al. 2015).

Currently the dominant paradigm referred to and used in order to deal with these issues is the so-called "green growth" strategy. Although the idea that the fundamentals of the growth paradigm and society do not need to be changed may be reassuring or appealing to some, biophysical and institutional realities suggest that green growth is a “misleading” theory (Hickel and Kallis 2019, p. 7) which cannot solve the intertwined ecological challenges humankind is facing.[2] As new empirical and theoretical research comes out (Alier 2009; Briens 2015; Hickel and Kallis 2019; Jackson 2009; Kallis 2011; Kallis, Kerschner, and Martinez-Alier 2012; O’Neill 2012; P. A. Victor 2012), it appears clearer and clearer that the rate of growth of rich industrialised countries will have to become negative for some time before stabilising close to zero, if ecological targets are to be met.

This leads to considering alternative paradigms to growth. Among others,

[1] ‘Climate Scoreboard’, Climate Interactive. Cited in Hickel and Kallis (2019).
[2] This point is presented in more detail in the next section.

degrowth, as a social movement, an ensemble of ideas and principles and now a well established academic field, aims at offering such an alternative. Some of its strengths come from its holistic approach to ecological, social and political issues, which prevents from replacing one problem with another or to propose technological solutions that cannot be scaled up to a meaningful extent due for instance to resource availability. Thus it clearly corresponds to the idea of strong rather than weak sustainability. Degrowth is also one of the very few paradigms that explicitly consider a reduction of GDP, not simply lower rates of growth. Kallis (2011) clarifies the long-standing debate about GDP: 'The goal of sustainable degrowth is not to degrow GDP. GDP will inevitably decline as an outcome of sustainable degrowth, but the question is whether this can happen in a socially and environmentally sustainable way'.

Though GDP is nearly irrelevant in rich countries as an indicator for well-being (Easterlin et al. 2010), which means well-being can be sustained or improved while GDP is reduced, such a reduction may indeed pose some strain on socio-economic and political systems that have been designed during periods of growth, with the aim of fostering growth. For instance national social protection systems, where they exist, have been designed and calibrated so that their budgets are kept relatively balanced over time, *under the assumption of economic growth*. Keeping the setting and parameters of socio-economic systems constant and reducing economic activity, on which the financing of social protection is mostly based, would lead to higher public deficits. As post-Keynesian economic theory shows, such deficits may not be an issue for growing economies[3] - or even be required in order to reach a steady state with growth (Godley and Lavoie 2016, pp. 95-98). In a non-growing or de-growing economy however, public deficits lead to ever-increasing levels of public debt to GDP ratios. While there is no theoretical limit to this ratio, the political sustainability of its constant increase is questionable and one might prefer finding a way to stabilise it and reach a proper

[3]This is more the case for countries (i) which can issue their own currency, (ii) whose currency is high enough in the international hierarchy of currencies (de Paula, Fritz, and Prates 2017) and (iii) which have an economy that is structurally less dependent on imports of capital goods.

stationary state after the degrowth transition has been completed.[4,5] This requires to find ways to finance social protection without relying on ever-increasing public indebtment.

This article focuses on one aspect of social protection: the pension system. Indeed in countries where pensions are part of a social security system (as opposed to a private system), they are the largest transfer of income between two categories of households. Since the distributional issues involved are considerable and the financing of pensions is mostly based on economic activity, considering a socially just reduction of production and consumption requires taking a close look at the pension system. Although the model and discussion are theoretical and do not correspond to one country in particular, the analysis is meant to deal with the case of rich industrialised economies in which the pension system is mostly organised as a pay-as-you-go scheme, such as in continental Western Europe. The essential questions of the article are the following: "(i) Can a pay-as-you-go pension scheme be financially sustained in the context of a degrowing economy? (ii) What are the different policy options, and their implications especially in terms of inequality[6] and environmental damage?[7]"

To explore these issues, we build a simple macroeconomic model rooted in post-Keynesian economic theory. The focus is put on a change in consumption patterns and mode of living, resulting in a progressive reduction in the consumption of the most ecologically damaging goods and services. Consumption is partially disaggregated and divided into three categories of goods and services which, for the purpose of clarity of exposition, we will

[4]In the next section, more detail is given regarding the content of this degrowth transition.

[5]The distinction is made between a steady state, in which some variables or ratios may increase or decrease steadily, and a stationary state where all flow and stock variables remain constant over time.

[6]We will here focus on intergenerational inequality, leaving aside the issue of intragenerational inequality.

[7]By environmental, or ecological damage, we mean a much broader concept than the emissions of greenhouse gases alone. This would include issues like air, water and soil pollution, deforestation etc. However since the analysis is conducted at an aggregate macroeconomic level, we will simply use general "ecological damage intensities" as theoretical composite indicators.

refer to as "carrots", "cars" and "miscellaneous goods and services" (MGS). A detailed description of these categories is given in section 2. The economy is assumed to undergo an exogenous negative shock in the consumption of "cars", the most ecologically damaging category of goods and services. This negative consumption shock initially provokes a reduction in overall pension contributions from active people, resulting in the apparition of a public deficit. We investigate three types of government behaviour with respect to this deficit: (i) no particular response, (ii) a reduction in the pensions given to retirees and (iii) an increase in contribution rates from active households.

We find that one of the policy options, namely the increase in contribution rates for pensions, provides a satisfying response to the challenge described above. It allows for, at the same time, avoiding the rebound effect and the associated rise in ecological damage, stabilising the debt-to-GDP ratio and reaching a stationary state while containing intergenerational inequality and preserving the income of pensioneers. By doing so we show that there is not necessarily a trade-off between ecological, social and economic concerns, at least for the issue of pay-as-you-go pension schemes considered here.

This work is situated at the crossroads of two large strands of economics: ecological and post-Keynesian economics. The dialogue between the two was established thanks to common theoretical grounds (Holt, Pressman, and Spash 2009; Jackson 2009; Kronenberg 2010) and has given birth to a field called "ecological macroeconomics"(Fontana and Sawyer 2016; Hardt and O'Neill 2017; Harris 2008; Rezai and Stagl 2016; Røpke 2011; Stagl 2014). Ecological macroeconomists have dealt with a number of issues, ranging from sustainable consumption (Jackson 2005; Røpke 2001, 2005, 2009), work itself, work-sharing, and productivity (Jackson and P. Victor 2011; Schor 2005; Stagl 2013; Zwickl, Disslbacher, and Stagl 2016), the conditions for a zero-growth economy (Padalkina 2012; Rosenbaum 2015), interest rates and debt (Cahen-Fourot and Lavoie 2016; Jackson and P. A. Victor 2015), the monetary system (Dittmer 2013, 2014, 2015) to economy-environment interactions and monetary policy (Dafermos, Nikolaidi, and Galanis 2017, 2018) and employer-of-last-resort policies (Alcott 2013; Godin 2012). The issue of social protection in a degrowing economy, however, has not yet been dealt

with from a macroeconomic perspective (if at all). The present work intends to give a start to this area of research and to propose a first contribution in the direction of filling the gap. It is done in the spirit of investigating a "third way" beyond austerity and stimulus policies (Røpke 2016), with the aim of opening up space for academic debate as well as political space.

The article is organised as follows: section 2 presents the methodology, the considered change in consumption patterns and an overview of the model we use. Section 3 lays out the model in more detail and explains its behaviour in the absence of the negative shock on consumption. Section 4 presents six scenarii with various behaviours for the government and for households, and discusses the results of simulations. Section 5 concludes.

2 Methodology and overview of the model

2.1 The modelling approach

The transitions that are needed in order to reach strong sustainability are numerous and far-reaching. Nearly all aspects of our mode of living and production and consumption patterns are to be affected. In order to study such complex systems and changes, two main approaches can be distinguished. The first one is a systemic type of approach and consists in trying to integrate as many dimensions as possible in generally very large models such as the well-known integrated assessment models (IAMs). This approach has been used extensively, there exist now hundreds of IAMs around the globe. However they generally suffer from the "black box" syndrom, meaning it is so complex that the understanding of simultaneously interacting mechanisms and the interpretation of results can become highly difficult or uncertain. Georgescu-Roegen (1971) raised this concern, arguing that such complex models move beyond "our mental control", which is problematic in social sciences where one cannot rely on perfectly precise measurements (ibid.). The second approach is referred to by Georgescu-Roegen as (ibid.) "simple-minded" models which he considers to be more informative. This approach requires to "pick up a few but significant elements from the multitude

of cluttering facts" (Georgescu-Roegen 1971, p. 340).

Following the second approach, we build the simplest model that is able to illustrate the issues we wish to focus on, namely the financing of pensions in a degrowing economy with a pay-as-you-go scheme. The parts of the economy that are not directly related to it are left as simple as possible in the model in order to keep clear the interpretation of results and the narrative, without hampering the pertinence of the mechanisms put forward.[8] Thus, our model remains a theoretical tool which we use for a limited number of purposes only. Morgan (2008) proposes a typology of the functions of models: "fitting theories to the world", "modelling as theorising" and "investigative instruments". Our position here is to use the last two functions only, both because of skepticism with respect to the first function in social sciences, and because there is no such thing, yet, as an experience of degrowth at a macroeconomic scale. More precisely, we use a model in order to (i) check the theoretical consistency of our reasoning, (ii) explore various assumptions and parameter values for which it would not necessarily be straightforward to guess the results in a dialectical approach, (iii) illustrate the narrative of the article and its conclusions, and (iv) make more explicit some potentially counterintuitive results.

As usual for such toy models, numerical values for parameters and initial conditions for exogenous variables are chosen without aiming for a precise representation of the reality of any particular economy. Nevertheless the model is calibrated to represent, roughly, a country or group of countries from continental Western Europe.[9] This is done in order to show that the model is not an absurd abstraction totally decorrelated from reality. It is realistic enough for the reasonings to be significant, but not enough to give numerical results a great importance. Consequently, we do not claim any quantitative relevance for our results. The interest of our results lie in the qualitative observations, comparisons and discussions.

[8] This approach is in line with the one adopted by Godley and Lavoie (2016) and Le Heron and Mouakil (2008). The latter focuses on the banking system and therefore unfolds this sector in great detail, leaving the rest of the model as simple as possible in order to keep it workable and understandable)

[9] Details about the calibration are given in which section?

2.2 Two phases, two processes, and three categories of goods and services

2.2.1 Two phases

As stated above, the transition to strong sustainability is highly complex and needs some degree of simplification in order to conduct and communicate reasonings in an understandable manner. Thus, we conceive an (artificial) separation between two phases of the transition, which in reality would partially overlap.

During the first phase, key systemic changes and so-called "enabling" investments are carried out. This includes investment in green infrastructure for transportation and for energy production, housing refurbishment, the extension of lifetime of durable goods, and material and energy efficiency improvements in all possible production processes. Because of the widespread and systemic nature of these changes, and because they require a pace and a degree of coordination that market forces have not been able to deliver so far, the intervention of public authorities seems highly necessary.[10] This first phase, therefore, is close to what has recently been termed the "Green New Deal". GDP may increase over this period of time. This is not an issue however, since the increase is only temporary (maintaining infrastructure requires much less work than building or converting it) and the subsequent decrease in the CO_2 and material intensity of the economy makes the overall ecological and climate impact of these investments positive in the medium and long-run.

[10]With respect to rapid widespread thermal insulation of buildings for instance, it is both illusionary and highly inefficient to expect hundreds of millions of people around the world to individually look for and compare technical solutions and companies to carry out the work, look for and take out a loan, bear the risks etc. This would be much slower, more expensive and technically less efficient than coordinated actions where for instance, a whole shared building is entirely refurbished at once rather than bit by bit. Moreover, renters generally do not want to refurbish a home they do not own, and landowners generally do not want to pay for it when the benefits of lower utilities bills are going to renters. Public authorities can organise, finance and potentially carry out this Herculean task, just as they are currently doing for the installation of smart-meters for electricity, gas and water across Europe for much lower expected ecological benefits than building insulation.

This part of the ecological transition has been thoroughly studied already and several limits have been pointed out, showing that it is a necessary but not sufficient component of the overall transition. First, it has been shown that rebound effects can cancel out part of or all the benefits of systemic changes (Barker, Dagoumas, and Rubin 2009; Saunders 2000), if collective and individual behaviours do not substantially depart from those promoted and adopted in modern consumer societies. Typically, if the money saved on heating homes is spent on long-distance travels on airplanes, the ecological balance is negative. Second, efficient and widespread infrastructure for public and smooth modes of transport may exist while a majority of people still prefer to use their car, be they fossile-fueled or electrically powered. Third, the pace and extent of the required changes make it highly unlikely if not impossible to happen without a complementary reduction in material and energy demand which, due to the difficulty or impossibility of absolute decoupling, can only come from a reduction in aggregate demand (Hickel and Kallis 2019). In this respect, the issue of ecological damage due to the extraction of minerals is key to understand the limits of a strategy that would focus only on the first phase and therefore decide on the size of the "green" investments without anticipating nor planning a reduction in the demand for energy and materials (Svartzman, Dron, and Espagne 2019). This is particularly true for widespread, privately owned electric vehicles, which cannot provide an ecologically satisfying means of transportation for several billion people on earth. Hence, in order to achieve strong sustainability the first phase should be thought upon and designed in a systemic ecological approach and in accordance with a necessary second phase of changes in consumption patterns and modes of living.

Consumption patterns and modes of living can (and should) start evolving during the first phase, but the extent to which they can is limited as long as some "enabling" investments coming from the first phase have not been completed: "consumers are, for a large part, 'locked-in' in infrastructures, social norms, and habits that severely limit consumer choice, in practice." (Tukker et al. 2008). Summarising results from a research program on sustainable consumption and production, Tukker et al. (ibid.) come to a similar

conclusion:

> "[...] all evidence shows that since actors are trapped in systemic interdependencies, such routes for change have limits. Bottom-up and market based action can only result in lasting fundamental change if backed up by top-down support and framework changes".

To sum-up, the first phase is necessary but not sufficient, the complementary second phase is necessary as well and can start partly during the first phase but can only really "take-off" once the first phase is close to being completed. Because of this dependance of the second on the first, and because consumption patterns and modes of living will take time to evolve, the second phase will continue for a while after the first one is finished. This article focuses on the part of the second phase (which we call the "degrowth transition") that is left after the first phase is finished and during wich the economy is said to be "degrowing".

2.2.2 Two processes

During this degrowth transition, GDP is assumed to go down as a result of two distinct processes. Despite our previous emphasis on the fact that the "second phase" has to do with consumption patterns, the first process is supposed to take place uniformly accross society - regardless of individual and collective behaviours, since it results from production-side changes. It is mostly linked to the extension of the lifetime of durable goods such as large and small household appliances, furniture and other equipment. As time passes by and equipment is worn out, built-in obsolescence and low-quality goods are replaced by long lifetime, higher-quality goods.[11] In a sense, this first process is the "passive", inertial result of changes conducted on the production side during the first phase. As a simplification here, we do not

[11] This does not necessarily mean expensive, luxury goods. For instance, large household appliances made before the era of built-in obsolescence were not luxury goods. In other words, when comparing these low and high quality goods, the ratio of lifetimes is much higher than the ratio of prices.

make the two types of durable goods (with respect to their quality), their lifetimes and their prices explicit. The result of this progressive replacement, however, is that the overall nominal demand for durable goods goes down over time.[12]

The second process, as opposed to the first one, highly depends on individual and collective choices. As said before, so-called "enabling" investments have been completed during the first phase of the ecological transition. The remaining issue is whether people will embrace the newly available ecological mode of living or go on with their previous consumption and transportation habits. Said simply, will people abandon their cars and use the new and efficient public transport system (coupled with smooth modes of transport) or keep using their cars? The second option means that the car industry, and all the activities associated with it (maintenance, advertisement, fueling, electronic devices, insurance...) are maintained, despite the existence of ecological alternatives. The first option means that a substantial part of the economic activity of modern industrialised countries is progressively winded down. The assumption we make is that over time, a growing part of the population is adopting the ecological mode of living.

2.2.3 Three categories of goods and services

Both processes presented above have the effect of reducing aggregate demand, however they do not affect the demand for all goods and services uniformly. The distribution of household consumption goods and services into the three categories of "carrots", "cars" and "miscellaneous goods and services" (MGS) is presented in Table 1.

This categorisation reflects the following logic: "carrots" more or less refers to basic needs, and should not have to decrease ; "cars" refers to the goods and services described earlier and the consumption of which, in nominal value, will decrease ; MGS are all the other goods and services, the

[12]It should be noted that some services, linked to maintenance and repairing of appliances, would probably increase in size. The assumption is made here that the net GDP balance of the decrease in production of these goods and the increase in associated services is negative.

consumption of which may or may not increase. This logic is in line with what Tukker et al. (2008) find when summarising a number of studies:

> "Mobility (car and air transport, including for holidays), food (meat and diary followed by the other types of food) and energy use in and around the home (heating, cooling and energy using products) plus house building and demolition, cause, on most environmental impact categories, together 70-80% of the life-cycle environmental impacts in society."

Clothing and footwear surely correspond at least in part to the category of basic needs, however we chose to put it in the MGS category because of the differences we make between the three categories in terms of specification of consumption functions. Indeed, C_1 will be modelled as autonomous expenditure, meaning that the level of this consumption does not depend on the income of households. On the contrary, C_3 represent all the goods and services for which the levels of consumption depend on income.

Given the nature of goods and services contained in C_2, it seems reasonable to consider the corresponding expenditures as autonomous, or constrained, like for C_1. Indeed, they tend not to depend on occasional consumption decisions but rather on structural matters (e.g. having a washing machine for the first type of process, having a car or not for the second). The differences between "cars" and "carrots" lie in (i) their relative ecological damage intensities and (ii) the fact that the latter should stay untouched while the former need to decrease.[13]

The shock that the economy will undergo, therefore, is a progressive reduction in autonomous consumption expenditures (of the C_2 type) arising from households. The main case we explore is one where only active people progressively change for the ecological mode of living (ie. reducing their level of C_2), and retirees do not. This case is conservative in the sense that

[13]The assumption made here is that overall, an ecologically-oriented transportation system (i.e. public transport articulated with all possible smooth modes of transport and some amount of non-privately owned car system) entails a lower level of economic activity than a system that is mostly based on the privately owned car.

"Carrots" (C_1)	"Cars" (C_2)	MGS (C_3)
Food and non-alcoholic beverages	Furnishings, household equipment and routine household maintenance	Alcoholic beverages, tobacco and narcotics
Housing, water, electricity, gas and other fuels	Transport	Clothing and footwear
Health		Recreation and culture
Communications		Restaurants and hotels
Education		Other miscellaneous goods and services

Table 1: Distribution of household consumption goods and services into three categories

if the "old" lifestyle of retirees can be sustained, financially wise, then it is likely that a more ecological lifestyle that requires less expenses can also be so sustained.

Finally, we shall stress that although we model the degrowth transition as essentially a GDP degrowth, this is a modelling choice made to reflect in a stylised manner more subtle changes in the mode of living as described previously, rather than a blind uniform reduction in GDP. This is one of the many aspects of degrowth that make it very distinct from a recession.

2.3 Overview of the model

The model is built upon the principles and methodology of Stock-Flow Consistent (SFC) modelling developed by Godley and Lavoie (Godley and Lavoie 2016) ; the layout and conventions we use are taken from that framework.

2.3.1 Basic structure: the balance sheet matrix

The economy is divided into three sectors: households, firms, and an aggregate public sector made of a government and a central bank. Households are further divided into active and retired households. Throughout the article, subscript a stands for *active households* and subscript r for *retired households*. As a first approach and in order to isolate our problem from the one of ageing population, we assume away both population growth and the evolution in the active to retired ratio. Thus, each category is made of a constant number of people.

The asset and liability structure is highly stylised as there is only one type of financial asset - high-powered money (HPM) - and one kind of physical, productive, asset. As shown in the balance sheet matrix (Table 2), productive capital is owned by firms .[14] Since firms are supposed not to have retained earnings, at any time their net worth V_f is equal to the value of physical capital K.

Households and the public sector also have a non-zero net worth. The public sector is indebted and its only liability is made of cash H,[15] which is made possible by the consolidation of the government with its central bank. As a counterpart of the public debt H, households hold money deposits which

[14]This simplifying assumption is made in order to avoid the issue of distribution of equity capital, and therefore of dividends, between the two types of households. It allows for the study of the financing of pensions in a pure pay-as-you-go scheme without mixing it with a system of privately-funded pensions. As a simplification one should imagine that due to their participation in the production process, workers are entitled to receiving profits in the form of dividends even though they do not own the capital, neither in its physical nor in its financial form. Thus in our model, there are no transfers of capital between various agents.

[15]This is formally equivalent to having bills as a liability, with a zero nominal interest rate. Introducing a positive interest rate would have required, for a minimum of realism, to also add an extra source of revenue for the public sector (different from contributions for pensions) and therefore a general public spending component as well. In addition, inflation should probably have been introduced then in order to avoid an unduly high real interest rate. Because we do not intend to conduct a detailed analysis of the evolution of public debt, this would have unnecessarily complexified the model. Hence the choice made of a cash-only economy.

	Households		Firms	Gvt/CB	Σ
	Active	Retired			
High-powered money	$+H_a$	$+H_r$		$-H$	0
Fixed capital			$+K$		$+K$
Balance (net worth)	$-V_a$	$-V_r$	$-V_f$	$-V_g$	$-(V_a + V_r + V_f + V_g)$
Σ	0	0	0	0	0

Table 2: Balance sheet matrix

constitute their net wealth V_a and V_r. From Table 2 we have:

$$V_a = H_a \tag{1}$$

$$V_r = H_r \tag{2}$$

$$V_g = -H \tag{3}$$

$$H = H_a + H_r \tag{4}$$

2.3.2 Transactions

The monetary transactions which take place in this closed economy are relatively straightforward. The firm sector produces all three types of goods and services, each of which is consumed both by active and retired household. Active households receive wages and profits, a share of which is given out to the public sector in the form of contributions for the financing of pensions. The contribution rate on the wage bill WB is denoted κ_w, the one on firm profits FP is denoted κ_{fp}. Retired households receive a total amount of pensions Π from the public sector. The difference between contributions levied on wages and profits and the pensions paid to retirees represents the public deficit, which is financed by an issue of cash $+\Delta H$. The difference between income and expenses for each type of household is equal to their flows of saving ΔH_a and ΔH_r, written with a minus sign since the action

	Households		Firms	Gvt/CB	Σ
	Active	Retired			
Consumpt. (carrots)	$-C_{1,a}$	$-C_{1,r}$	$+C_1$		0
Consumpt. (cars)	$-C_{2,a}$	$-C_{2,r}$	$+C_2$		0
Consumpt. (misc.)	$-C_{3,a}$	$-C_{3,r}$	$+C_3$		0
Wages & Contrib.	$+(1-\kappa_w)WB$		$-WB$	$+\kappa_w WB$	0
Profits & Contrib.	$+(1-\kappa_{fp})FP$		$-FP$	$+\kappa_{fp}FP$	0
Pensions		$+\Pi$		$-\Pi$	0
Change in cash	$-\Delta H_a$	$-\Delta H_r$	0	$+\Delta H$	0
Σ	0	0	0	0	0

Table 3: Transactions-flow matrix

of saving is considered as a *use of funds* rather than a *source of funds*. The flow consistency of the model implies that all the variations in cash sum up to zero (this is the redundant equation of the model):

$$\Delta H = \Delta H_a + \Delta H_r \tag{5}$$

The choice of not modelling government expenditure explicitly (except for pension transfers) has been explained previously. One may wonder, however, why firms do not carry out any investment. This is a simplifying assumption as we wish to focus on consumption dynamics. Thus firms are supposed to have inherited from a stock of productive capital K from previous periods. As this capital is assumed not to depreciate and aggregate production will not rise (as we shall see when conducting simulations of the shock and of various policy responses), there is no indispensable need for an explicit modelling of investment.[16]

[16]Due to this absence of depreciation and investment dynamics, our results will tend to overestimate the drop in the rate of profit that is caused by the reduction in economic activity. Indeed, the stock of capital is assumed to be constant whereas in reality it would decrease since, following the drop in the utilisation rate, firms would invest at a rate lower than the rate of depreciation.

3 Detailed presentation and first analysis of the model

3.1 Detailed presentation of the model

Let us start with some straightforward definitional equations related to total consumption of each type of good and total consumption from each type of household:

$$C_1 = C_{1,a} + C_{1,r} \tag{6}$$

$$C_2 = C_{2,a} + C_{2,r} \tag{7}$$

$$C_3 = C_{3,a} + C_{3,r} \tag{8}$$

$$C_a = C_{1,a} + C_{2,a} + C_{3,a} \tag{9}$$

$$C_r = C_{1,r} + C_{2,r} + C_{3,r} \tag{10}$$

Since there is no pure government expenditure, investment nor imports/exports, nominal gross domestic product (or national income) Y is only equal to total nominal consumption C:

$$Y = C = C_a + C_r = C_1 + C_2 + C_3 \tag{11}$$

As commonly assumed in post-Keynesian models, the price level (which is the same for all three types of goods) is constant and equal to a markup over unit cost. Here unit cost is made only of unit labour cost W/pr where W stands for the nominal wage rate and pr for hourly productivity measured in nominal terms:

$$p = (1 + \varphi)W/pr \tag{12}$$

By definition of hourly productivity pr, the average number of hours worked per worker h reads:

$$h = Y/(N_a \cdot pr) \tag{13}$$

Throughout the article, we consider productivity to remain constant. Since the number of active people N_a does not change either, the average number

of hours worked per worker will evolve in proportion with output Y. Furthermore, since the production sector is fully aggregated and unemployment is not included in the model, the assumption is that hours of work are distributed evenly among all active people. Workers, who are all involved in the production of the three types of goods and services, work shorter or longer hours depending on aggregate demand. The wage bill is equal to the constant hourly wage rate W multiplied by the total number of hours worked:

$$WB = WN_a h \tag{14}$$

Let us emphasise here that under the assumptions just mentionned, whenever aggregate demand drops, a working time reduction takes place. This comes with a reduction in the monthly or annual wage received by each worker, which in turn has macroeconomic consequences that are accounted for in the model.

Firm profits are equal to total sales Y minus the wage bill:

$$FP = Y - WB \tag{15}$$

The wage share ws and the profit share ps are defined as follows:

$$ws = WB/Y \tag{16}$$

$$ps = FP/Y \tag{17}$$

The weighted average contribution rate for pensions can now be defined as follows:

$$\kappa = ws \cdot \kappa_w + ps \cdot \kappa_{fp} \tag{18}$$

Disposable income for each type of household is defined as their total income minus taxes and contributions which, in our model, boil down to pension contributions from active households:

$$YD_a = (1 - \kappa_w)WB + (1 - \kappa_{fp})FP \tag{19}$$

$$YD_r = \Pi \tag{20}$$

Saving is equal to disposable income minus consumption:

$$\Delta H_a = YD_a - C_a \tag{21}$$

$$\Delta H_r = YD_r - C_r \tag{22}$$

Public deficit (dissaving), which we denote DEF, is the difference between pensions paid and contributions levied:

$$DEF = \Delta H = \Pi - (\kappa_w WB + \kappa_{fp} FP) \tag{23}$$

Let us now describe the consumption functions for each type of good and household. Denoting c_1 the real consumption of "carrots" per person, we have:

$$C_{1,a} = pN_a c_1 \tag{24}$$

$$C_{1,r} = pN_r c_1 \tag{25}$$

Denoting c_2 the real consumption of "cars" per person, we have:

$$C_{2,a} = p(1 - \sigma_a)N_a c_2 \tag{26}$$

$$C_{2,r} = p(1 - \sigma_r)N_r c_2 \tag{27}$$

where σ_a and σ_r are variables which represent the extent to which the modes of living of active and retired households have changed compared to the initial situation. These parameters reflect the net effect of the two processes presented in section 2.2.2 on the need for "cars". Although it can be reduced through the replacement of appliances and the change in the mode of transport, this type of consumption is still considered to be "constrained" and modelled as autonomous expenditures. This comes from the fact that, for instance, as long as a person has not abandonned her/his personal car and switched to other modes of transportation, this person *needs to* fuel the car, insure, maintain and repair it and buy a new one when the previous is out

of service.

Consumption of MGS is assumed to depend on wealth V_a or V_r and on a slightly modified version of disposable income, which we call "effective disposable income" and is defined as disposable income minus constrained expenditures:

$$C_{3,a} = \alpha_{yde,a} YD_a^{eff} + \alpha_{v,a} V_a \tag{28}$$

$$C_{3,r} = \alpha_{yde,r} YD_r^{eff} + \alpha_{v,r} V_r \tag{29}$$

with

$$YD_a^{eff} = YD_a - (C_{1,a} + C_{2,a}) \tag{30}$$

$$YD_r^{eff} = YD_r - (C_{1,r} + C_{2,r}) \tag{31}$$

This specification for the consumption function is an adaptation from the standard consumption function used in SFC models (Godley and Lavoie 2016). The reason for this choice lies in the distinction made between several types of goods, and in the type of shock considered. Indeed, because the reduction in consumption of "cars" translates into a reduction of disposable income for active households, the standard specification with disposable income and wealth would lead to an initial decrease in consumption of MGS before it can eventually increase again (due to a substitution effect which is explained in more detail in the next section). Such an initial decrease in consumption of MGS as a result of the decrease in consumption of "cars" is not realistic, since households who are getting some spare purchasing power from the reduction in constrained expenditures would in all likelihood tend to increase their discretionary expenditures on MGS. The specification we chose, with the introduction of the concept of *effective* disposable income, seems more sensible and yields an immediate substitution effect from "cars" to MGS rather than a decrease in MGS.

For simplicity reasons, pensions are not calculated according to some complex function of past contribution rates and duration of the working life, rather according to the "needs" in terms of "carrots" and "cars" per person,

multiplied by the number of retired households.

$$\Pi = N_r(1+\gamma)(pc_1 + pc_2) \tag{32}$$

The parameter γ reflects the fact that pensions are calculated in order to cover the needs mentionned above, plus some discretionary expenditures on MGS. This parameter can be subject to changes, for instance if the government decides to reduce pensions in order to bring the deficit down.

Absolute levels of income and consumption, and the financial dimension of the pension scheme, are not the only foci of our work. Ecological and distributional concerns are indeed key aspects of the discussion. Thus we construct the following indicators in order to compare the outcomes of various scenarii.

Ecological damage is modelled in a highly stylised manner. Each category of goods and services i presents a certain intensity β_i of ecological damage. This damage can be viewed as an aggregate measure of emissions of various pollutants and greenhouse gases, of material intensity, of impacts on biodiversity and on land use.

$$ED = \beta_1 C_1 + \beta_2 C_2 + \beta_3 C_3 \tag{33}$$

With respect to distributional issues, or intergenerational fairness, three indicators are proposed. The first one represents the ratio of disposable income per capita for active households to disposable income per capita for retired households (the subscript "pcratio" stands for "per capita ratio"). The same is done for consumption of MGS and wealth.

$$YD_{pcratio} = \frac{YD_a/N_a}{YD_r/N_r} \tag{34}$$

$$C_{3_{pcratio}} = \frac{C_{3,a}/N_a}{C_{3,r}/N_r} \tag{35}$$

$$H_{pcratio} = \frac{H_a/N_a}{H_r/N_r} \tag{36}$$

We find two reasons for focusing on the (absolute and relative) levels of consumption of MGS rather than on the consumption of "carrots"and "cars". First, in all scenarii the consumption of "carrots" will remain constant and the consumption of "cars" will evolve exogenously. Only the consumption of MGS will evolve differently according to macroeconomic effects and policy decisions. Second, due to the discretionary (as opposed to constrained) nature of these expenditures the level of consumption of MGS is thought to be, to a certain extent only, linked to well-being and quality of life. For instance expenditures on culture, leisure or restaurants are included in MGS.[17] The evolution of two other auxiliary variables are examined: the rate of utilisation of productive capacity u and the rate of profit r. The rate of utilisation is defined as the ratio of output Y to full capacity output Y_{fc}. The rate of profit, defined as nominal firm profits FP divided by the stock of productive capital K, can be expressed as a function of the rate of utilisation and two constant parameters, the profit share ps and the capital to full capacity output ratio $\nu = K/Y_{fc}$:

$$r = ps \cdot u/\nu \tag{37}$$

3.2 Analysis of the model without any shock

Before turning to the analysis of various shocks and policy responses (which is done in the next section) let us examine the basic endogenous behaviour of our model.

An important feature of the model is that it converges toward a stationary state.[18] The level of national income at this stationary state is determined by the ratio of the total pension bill Π to the average contribution rate on

[17] We fully acknowledge that well-being and quality of life are not determined by consumption levels only. Moreover, the goods and services suggested here are mentionned only for an illustrative, non-normative purpose.

[18] For the derivation of the stationary state, see Appendix A.

wages and profits κ[19]:

$$Y^\star = \Pi^\star / \kappa^\star \tag{38}$$

A general equation relating total disposable income ($YD_{tot} = YD_a + YD_r$) with national income and the budget deficit can be derived from the budget constraints of both types of households (i.e. the sum of the elements in column 1 and 2 of Table 3):

$$YD_{tot} = Y + \Delta H \tag{39}$$

By definition, the budget deficit is equal to zero at the stationary state (since all stocks must remain constant). Hence, the disposable income of active and retired households makes up the entirety of national income. Their shares are determined by the contribution rate as follows:

$$YD_a^\star = (1 - \kappa^\star) Y^\star \tag{40}$$

$$YD_r^\star = \kappa^\star Y^\star \tag{41}$$

The stationary stocks of private savings H_a and H_r depend on various parameter values:

$$H_a^\star = \frac{1 - \alpha_{yde,a}}{\alpha_{v,a}} \left[\frac{1 - \kappa^\star}{\kappa^\star} \Pi^\star - \alpha_{c,a} \right] \tag{42}$$

$$H_r^\star = \frac{\alpha_{c,r}}{\alpha_{v,r}} (1 - \alpha_{yde,r}) \gamma \tag{43}$$

The stock of public debt, which is the counterpart of private wealth, is simply given by equation (4) taken at the stationary state:

$$H^\star = H_a^\star + H_r^\star \tag{44}$$

[19] This result is comparable to what Godley and Lavoie obtain for the simple model SIM (ch.3). In model SIM, the stationary level of national income is determined by the "fiscal stance" (Godley and Lavoie 2016, pp. 71-72), defined as the ratio of government expenditure G to the tax rate θ. Here, the pension bill is the analogue of government expenditure and the contribution rate is the analogue of the tax rate. Indeed, the structures of both models are very similar.

Given the simplicity of the model, we are able to conduct a formal stability analysis of it.[20] The model is shown to be stable for any meaningful set of parameter values (e.g. propensities to consume between zero and one). The only condition is that for active households, the propensity to consume out of wealth $\alpha_{v,a}$ must be lower than the propensity to consume out of disposable income $\alpha_{yde,a}$, which is a generally verified, common assumption.

It should be noted that the stability analysis we conducted only corresponds to the case where the government does not respond in any way to budget deficits. Nevertheless, it shows that the underlying core dynamics of the model is stable.

4 Scenario analysis: consumption behaviour and policy response to deficits

Cases can be distinguished along the behaviour of the two main sectors: households and the public sector. Indeed we do not investigate various types of behaviour from the part of firms. In our model, firms only play the role of supplying whatever quantity of goods and services is demanded. One the one hand, households can either have the usual keynesian consumption behaviour described in the basic version of our model, or they can have a "satiety" behaviour. In the latter case, households behave as usual but there is a satiety threshold in terms of level of consumption of MGS. Beyond this threshold, households do not increase their level of consumption of MGS and increase their saving accordingly. On the other hand, the government can choose between not responding to budget deficits at all ("passive" case) or implement policies to try and reduce the deficit. In the latter case, we distinguish between two types of responses: (i) a decrease in pensions and (ii) an increase in the contribution rate on wages and profits.[21]

[20] For reasons of space, we do not show the stability analysis here. Please contact the author for supplementary material.

[21] Since all profits are distributed to households and these households are not separated according to levels of income (and therefore to different propensities to consume), it does not matter whether it is the contribution rate on wages or on profits that is increased.

The policy of reducing pensions to close up the deficit translates into the following two equations, with $\eta_\gamma > 0$:

$$\gamma = \gamma_{-1}(1 + g_\gamma) \tag{45}$$

$$g_\gamma = -\eta_\gamma DEF/Y \tag{46}$$

The policy of increasing contributions is modelled with equations (48) to (50):

$$\kappa_w = \kappa_{w,-1}(1 + g_{\kappa_w}) \tag{47}$$

$$g_{\kappa_w} = \eta_{\kappa_w} DEF/Y \tag{48}$$

$$\kappa_{fp} = \kappa_{fp,-1}(1 + g_{\kappa_{fp}}) \tag{49}$$

$$g_{\kappa_{fp}} = \eta_{\kappa_{fp}} DEF/Y \tag{50}$$

4.1 Six scenarii

Simulations are conducted for six scenarii, corresponding to the combination of the three types of responses from the government (including "no response") and the two types of household behaviour, as shown in table 4. For all scenarii, simulations start from the steady state described earlier. After five periods, the progressive negative shock on the consumption of "cars" by active households takes place. This shock is spread over ten periods, during which the parameter σ_a increases from zero to 0.8. There is no shock on the consumption of "cars" by retired households.

In the following subsections, we present and compare the results of the simulations of these six scenarii.

In a more complex model one could distinguish between wage-earner and profit-earner households and consider uneven increases in contribution rates. For instance, population ageing could be introduced and the need for an increase in contribution rates that would arise from it could be met by a stronger increase in the contribution rate on profits than in the contribution rate on wages. This would help with the financing of pensions of an ageing population, while reducing intragenerational inequality.

	No response	Reduction in pensions	Increase in contributions
Without satiety	1a	2a	3a
With satiety	1b	2b	3b

Table 4: The six scenarii considered

4.1.1 Scenario 1a: no policy response from the government, no satiety behaviour

In this scenario, pensions remain untouched. As a result, nothing happens to retired households. They are able to consume the same amounts of carrots, cars and MGS. Their level of wealth stays constant as well.

On the side of active households, what happens is a substitution from the consumption of cars to the consumption of MGS. Indeed as active people see their constrained expenditures go down, their purchasing power available for discretionary consumption tends to increase. However this increase in purchasing power is smaller than the money saved on reduced constrained expenditures. The reason for this is that by consuming less cars, active people lower the level of activity and therefore the total wage bill as well as the profits of firms. This means the income of active households is reduced as a consequence of their change in consumption pattern. Yet, the net macroeconomic effect of these two phenomena is an increase in effective disposable income for active households.

Let us take a numeric example to illustrate the reasoning, which for the purpose of clarity is also shown on figure 1. By consuming 100 units less of cars, active households make the sales of firms go down by 100 units (top left corner of the figure). As a result, firms pay less wages and less dividends to active households. But there is also less contributions paid to the government. With a contribution rate of 0.3 on wages and profits, the result is that total contributions paid go down by 30 units and the disposable income of active households (made up of wages and profits minus the contributions) go down by 70 units. But active households see their *effective* disposable income *increase* (by 30 units), not decrease: the drop of 70 units in their

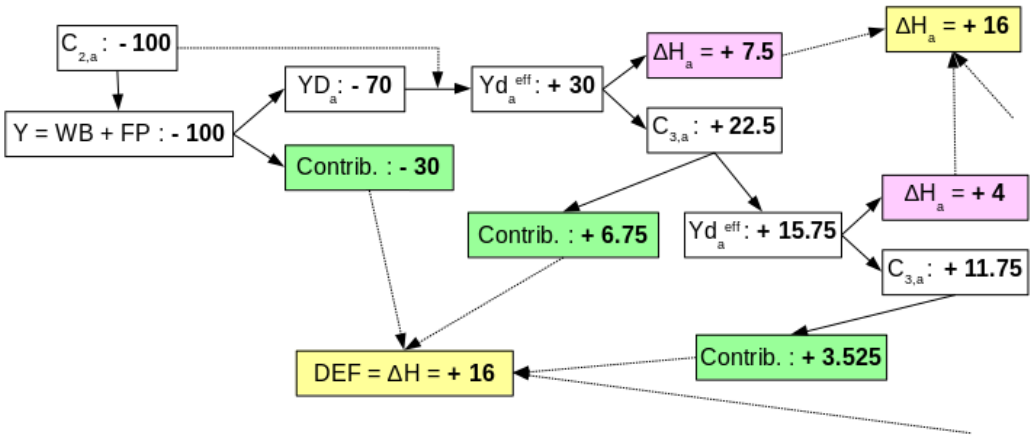

Figure 1: The mechanism explaining how the public deficit appears and how active people can increase their consumption of MGS while their total income is reduced.

disposable income is more than compensated by the 100 unit reduction in their constrained expenditures. In parallel to this, since contributions have dropped by 30 units while pensions have not been modified, a public deficit of 30 units would appear.

As shown in figure 1, the deficit that will actually be observed, even in the very short run, will be smaller that 30 units. This is because of the traditional Keynesian multiplier effect: as active households see their effective disposable income increase, they start consuming more MGS (recall their consumption function). In turn, as economic activity rebounds, this increase in consumption of MGS creates additional disposable income for active people themselves and contributions for the government. This partly counterbalances the loss of disposable income that resulted from the reduction in consumption of cars, and the initial loss of contributions. In parallel, part of the extra *effective* disposable income is saved since the propensity $\alpha_{yde,a}$ to consume out of it for active households is strictly lower than one. As a result, the level of wealth of active people H_a increases. When taking into account the full effect of the multiplier that happens in the very short run, with a marginal propensity to consume equal to 0.75, the observed initial

public deficit as well as the saving of active households would be equal to 16 (rather than 30 without the multiplier effect).

The additional wealth of active people coming from this saving will now trigger a second-round effect of increase in consumption. Indeed, consumption of MGS is assumed to depend positively on accumulated wealth. By further increasing their level of consumption of MGS, active people fill the contribution gap that arose initially and the public deficit starts closing down. Overall, $C_{3,a}$ increases up to the point where the public deficit is back to zero, as can be seen on figure 2. Total consumption of active households C_a comes back to its initial level, as the substitution from $C_{2,a}$ to $C_{3,a}$ is total. In terms of macroeconomic flows, the economy returns to the same stationary state as before the shock. Apart from the change in the proportion of the goods and services consumed, the main change is to be found in the public debt H, which stabilises at a higher level. Ecological damage (ED) has decreased and stabilised at a lower level: the substitution (or rebound effect), although total in nominal terms, has a positive effect on ecological damage. This is due to the assumption that MGS carries a lower ecological damage intensity than "cars".[22]

Finally in terms of intergenerational fairness, the outcome of this scenario is an absolute improvement of the situation of active households (their consumption of MGS and their wealth increase) while the situation of retired households is unchanged. In relative terms, active people are the beneficiaries of the economic transition: the ratios $C_{3pcratio}$ and $H_{pcratio}$ increase. As none of the two categories of people is worse-off, one can argue that this scenario yields a rather positive outcome in terms of intergenerational fairness.

However, the ecological outcome of scenario 1 is not the best one could expect: because of the rebound effect, ecological damage "rebounds" too. We shall see that some scenarii can yield better ecological outcomes.

[22]It should be noted, however, that if the rebound effect is directed towards more consumption of electronic goods or high-carbon-content leisure activities for instance, the result would be reversed. Therefore, consumption patterns should evolve according to a general increase of environmental awareness in order to prevent such counterproductive evolutions.

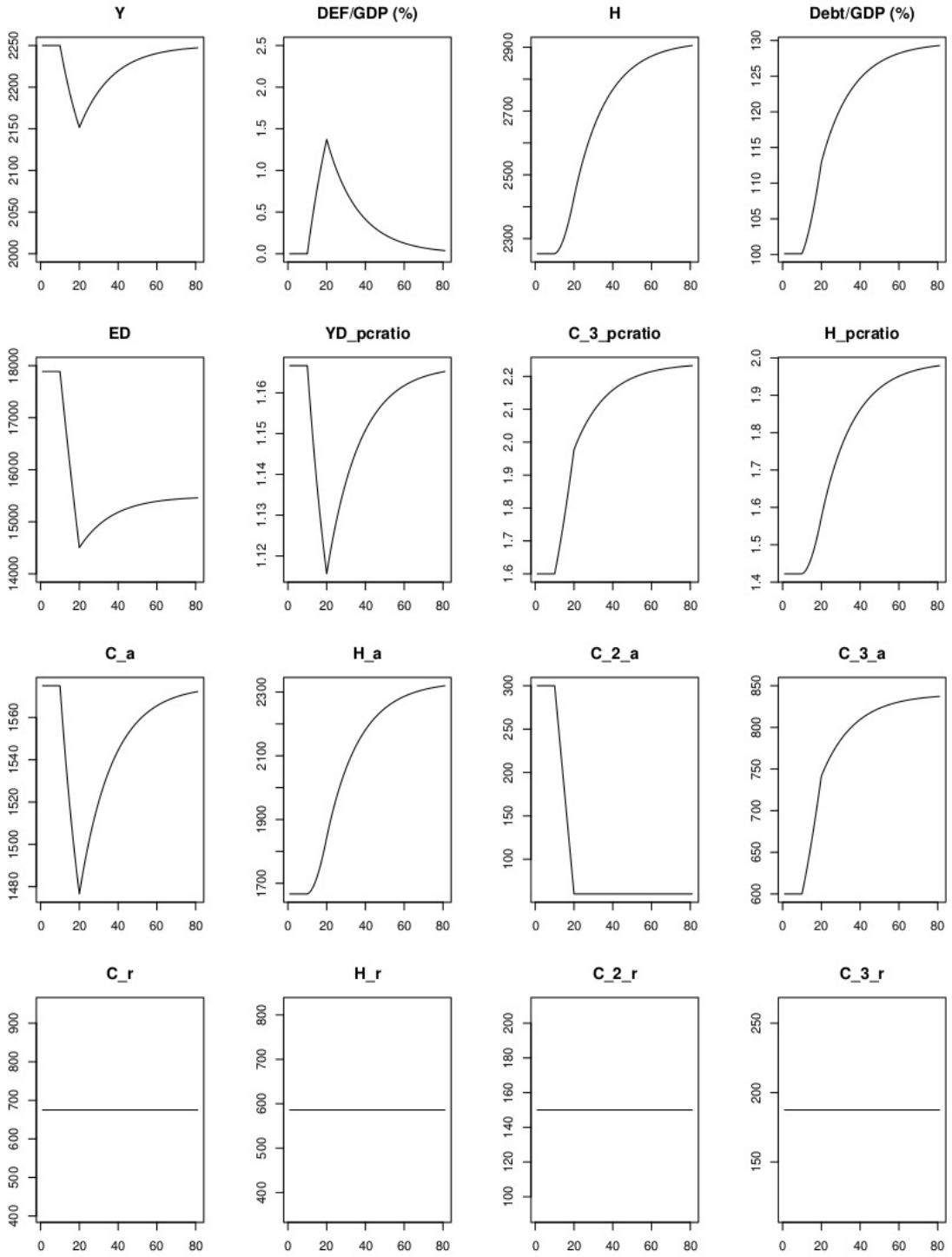

Figure 2: Evolution of key variables for scenario 1a

4.1.2 Scenario 1b: no policy response from the government, with satiety behaviour

We now examine the results of scenario 1b, a variation based on the previous case, where active households now have a consumption behaviour featuring a satiety threshold. The simulation results are presented in figure 4.

In the beginning of the transition after the negative consumption shock, everything evolves like in scenario 1a. Active households substitute cars for MGS. But once they have reached their satiety level of consumption of MGS, these households stop "rebounding" and keep saving. As a result, the public deficit does not close up entirely and remains significantly positive. No stationary state is reached, as the stock of public debt increases steadily just as the stock of private wealth does. This is a steady but not stationary state. Flow variables are stabilised but not stock variables.

This steady increase in public debt and private wealth has no consequence, in this setting with satiety behaviour, on ecological damage which stabilises. In theory, there is no issue of sustainability of public debt in this closed economy where public debt is only held by national citizens. However, the political sustainability of such an increase in stocks may be questioned and, for this reason, we will consider that this scenario is not satisfying with respect to the criterion of the financing of the pension scheme.

4.1.3 Scenario 2a: reduction in pensions, no satiety behaviour

This scenario is relatively straightforward. The simulation results are presented in figure 5. In response to the apparition of a public deficit, the government implements a gradual reduction in pensions. This reduces the effective disposable income of pensioneers, who have to cut on their discretionary expenditures $C_{3,r}$. Active people, on the other hand, benefit from the increase in purchasing power for MGS presented in the description of scenario 1a. Consuming less cars allows them to consume more MGS. The rebound effect, however, is not complete as it was in scenario 1a. The reason for this is the multiplier effect coming from the reduction in consumption by retired households. Indeed, this reduction of $C_{3,r}$ impacts negatively the

wages and profits received by active households.

The reduction in pensions progressively closes the deficit up and a new stationary state is reached, with a level of debt that is higher than initial but lower than in the case of no response from the government. Overall, pensioneers are worse-off both in absolute terms and in relative terms. The ratios of intergenerational fairness show that active people are the "winners" from this type of policy, but unlike in scenario 1a, there are people whose situation worsens. The level of consumption and the savings of retired are forced downwards. The ecological outcome is slightly better than in scenario 1a, but not by a significant amount.

4.1.4 Scenario 2b: reduction in pensions, with satiety behaviour

Here active households do not rebound much. As a result the deficit closes up more slowly and, more importantly, pensions are decreased more than when the rebound effect brings revenues for the government. In this scenario, pensioners bear a double burden from the fact that active households (i) consume less “cars” and (ii) do not wish to consume much more of MGS. Public debt stabilises at a higher level than when active households do not have the satiety behaviour. With the calibration chosen, public debt stabilises around 200% (this depends on the speed of reduction of pensions) compared to 125% without satiety, and consumption of MGS by retirees has to decrease by 40% instead of just 14%.[23]

4.1.5 Scenario 3a: increase in contributions, no satiety behaviour

In this third type of scenario, the government responds to public deficits by increasing the contribution rates on wages and profits. The simulation results are presented in figure 6.

Because pensions remain unchanged, the situation of retired households remains unchanged as well, as it was in scenarii 1a and 1b. For active households, the same substitution and rebound effect takes place as in previous

[23] One should keep in mind that these figures are only a basis for comparison and should not be given more meaning, especially with respect to the level of public debt.

scenarii. However the increase in contributions tends to reduce their disposable income and therefore tames the rebound effect. $C_{3,a}$ still increases somewhat, but less than in the case of no government response. Active people accumulate wealth while its counterpart, the public debt, increases before stabilising (as it is the case in scenarii 1a and 2a-2b). The public debt to GDP ratio stabilises at a lower level than in other scenarii.

Although each of the scenarii 2a and 3a can be compared quantitatively with scenario 1a, such a comparison is not relevant between scenarii 2a and 3a. The reason for this is that the outcome of both these scenarii depend on the pace at which the government decreases pensions or increases contributions. There is a phenomenon of path dependence, or hysteresis. Indeed, the faster the government increases contributions for instance, the faster the deficit is closed up and the less active people can accumulate wealth. As a result, their tendency to rebound on their consumption of MGS is dampened, since the "wealth effect" is lower. Overall, the fastest the government increases contributions, the lower the public debt increases, the better the ecological outcome, and the lower the "divergence" between active and retired households.

Another important remark should be made here. As shown clearly in figure 6, all indicators of intergenerational fairness do not always evolve in the same direction. In this scenario the ratio of disposable incomes decreases, giving the impression that active people are relatively worse-off. On the contrary, the ratios for consumption of MGS and wealth increase, indicating that active people are relatively better-off. Which indicator is more relevant, and what can be said in terms of intergenerational fairness?

Here one should notice that because constrained expenditures evolve, disposable income is not as relevant an indicator as it is normally the case. This relates to the discussion about the relevance of the concept of *effective* disposable income. In reality, active people see their relative situation improving compared to retired households (and in absolute terms as well). The same can be said about the share of national income that each category of household receives, which are equal to $1 - \kappa^\star$ for active and $\kappa^\star$ for retired households. As κ is progressively increased, active people get a lower share of national

income and retired households a higher share. Again one could draw the conclusion that active people are getting worse-off. Looking at these shares without a closer look at what is happening is misleading, since in reality the effective disposable income and levels of wealth and of consumption of MGS for retired households is unchanged, whereas these variables increase for active households, who end up better-off in relative and absolute terms.

4.1.6 Scenario 3b: increase in contributions, with satiety behaviour

This scenario leads to quite similar results as its companion scenario 3a. Therefore, we will not comment it in details. The main difference with scenario 3a is that the rebound effect from the part of active households is voluntarily tamed, rather than curbed by the increase in contributions.

Contributions do increase as well though, since in the absence of a substantial rebound effect the government does need to implement its policy in order to close the deficit up. Active people are not hit really negatively by this increase since they are able to reach their satiety threshold and the increase in contributions only prevents them from accumulating more and more wealth.

4.2 Comparison and discussion of results

The criteria we choose for the comparison of the outcomes of the 6 scenarii are the following: (i) ecological damage should be curbed as much as possible, (ii) if possible, no category of people (active or retired) should be worse-off in absolute terms, meaning their consumption of MGS should not be forced downwards, (iii) the pension system should be fully financed, meaning that the public deficit should be progressively brought to zero and thus the debt-to-GDP ratio should be stabilised after some possible variation.

Figure 3 presents a synthesis of the outcomes of the six scenarii, with respect to the three main criteria mentionned above.

Scenario 1a satisfies criteria (ii) and (iii) but the rebound effect is substantial and therefore criterion (i) is not fully respected. Introducing a satiety behaviour (scenario 1b) solves the rebound effect issue but prevents the debt

		Ecological damage	Distribution (Intergenerational)	Financing (Public deficit & debt)
1a	No response No satiety	Rebound effect		
1b	No response Satiety		Wealth divergence But no loser	Ever-increasing debt/GDP
2a	Pensions reduction No satiety	Rebound effect	Retirees lose purchasing power & wealth	
2b	Pensions reduction Satiety		Retirees lose purchasing power & wealth	Stabilisation at high level of debt/GDP
3a	Contrib. increase No satiety			
3c	Contrib. increase Satiety			

Figure 3: Synthesis of outcomes from the six scenarii according to three main criteria.

ratio from stabilising (and as a result, the wealth of active people keeps increasing and diverging from the wealth of retirees).

Scenario 2a satisfies criteria (iii) but neither criterion (i) nor (ii) active people do increase their consumption (rebound effect), and pensioneers lose income, effective purchasing power and wealth. A satiety behaviour (scenario 2b) would reduce the rebound effect, but slow down the closing up of the public deficit and therefore lead to a much higher debt ratio.

Scenario 3a satisfies all three criteria: because the rebound effect is tamed by the increase in contributions, the ecological outcome is better than for scenario 1a. Scenario 3b gives similar positive results: as opposed to scenario 1b, the deficit is closed up and the debt ratio is stabilised, thanks to the increase in contributions.

From this comparison, the conclusion we draw is that the increase in contribution rates is the best way to manage the degrowth transition in a socially and evironmentally sustainable manner. Whether this takes place

with or without a satiety behaviour from active households does not radically change the outcomes. One could argue, however, that it is preferable and politically more sustainable to have people restraining themselves from "rebounding", thanks to their environmental awareness, rather than having the rebound effect tamed in a more passive manner through the increase in contribution rates (although contribution rates would increase even in the case where active people have a satiety behaviour).

As a side remark, it should be noted that the rate of utilisation and the rate of profit both go down during the transition, and remain at a lower value (except for cases of full rebound effect). However, these changes do not seem to be particularly problematic: in the calibration we made, the rate of utilisation drops from 0.8 to about 0.76 and the rate of profit from 8.9% to 8.2-8.5%.

5 Conclusion

Using a stock-flow consistent macroeconomic model featuring rebound and multiplier effects, and looking at the consequences of a negative consumption shock of "cars" by active households, we have showed that there is a way to satisfy all the criteria we have set for the economy and the environment in this thought experiment. An increase in contribution rates allows at the same time for (i) a positive ecological outcome arising from the reduction in consumption combined with a tamed rebound effect, (ii) a full financing of the pension scheme without relying on public deficits and therefore we achieve a stabilisation of the debt-to-GDP ratio, and (iii) a satisfying outcome in terms of intergenerational fairness. Although active people are the "winners" in this type of scenario, there are no absolute "losers".

Thus, we show that there is no problem for the financing of a pay-as-you-go pension scheme in a context of reduction of consumption and production, even in the case where retired people go on with their previous non-ecological lifestyle. If they decide to reduce their consumption of "cars" like active people do, it can only be better for the environment and for their financial

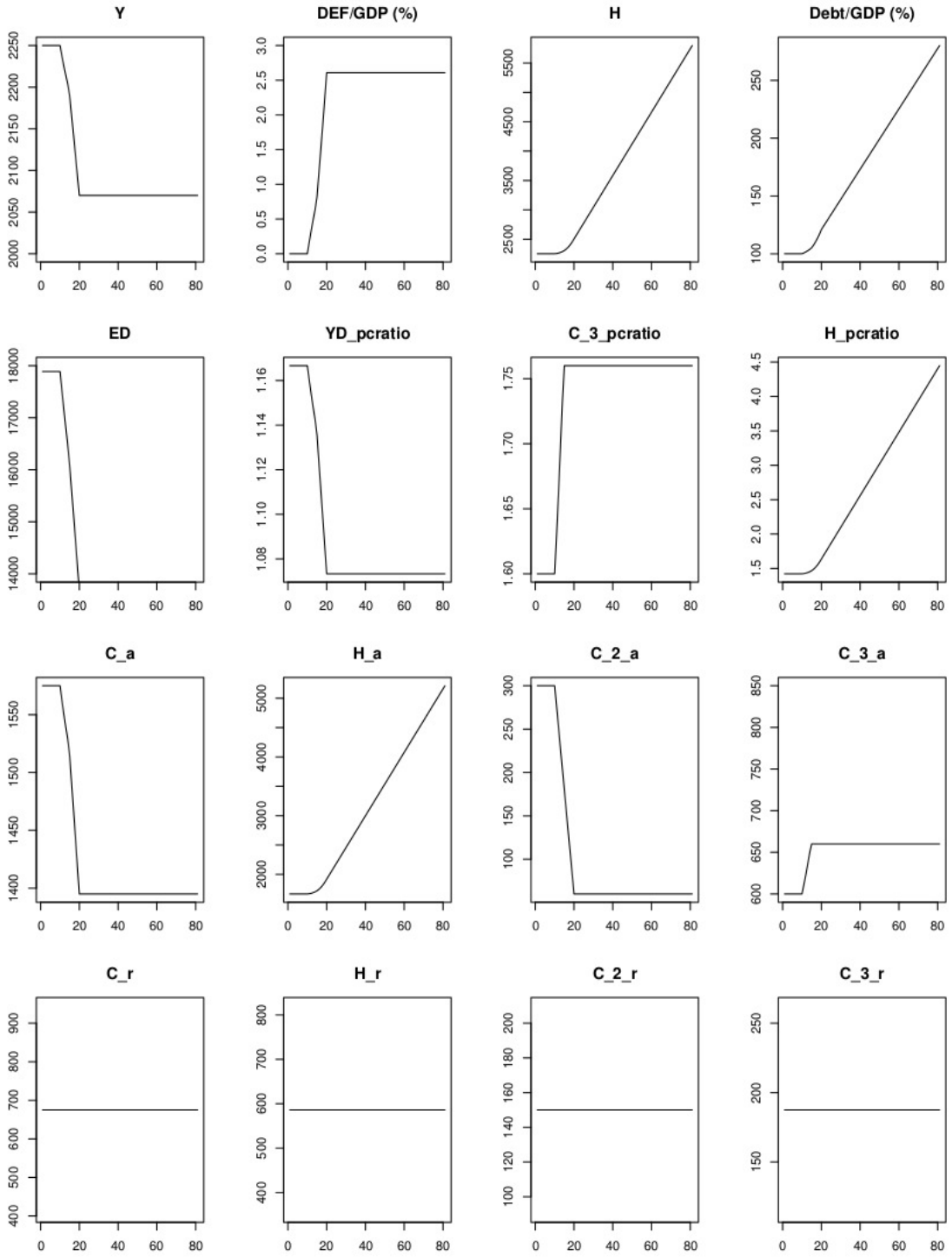

Figure 4: Evolution of key variables for scenario 1b

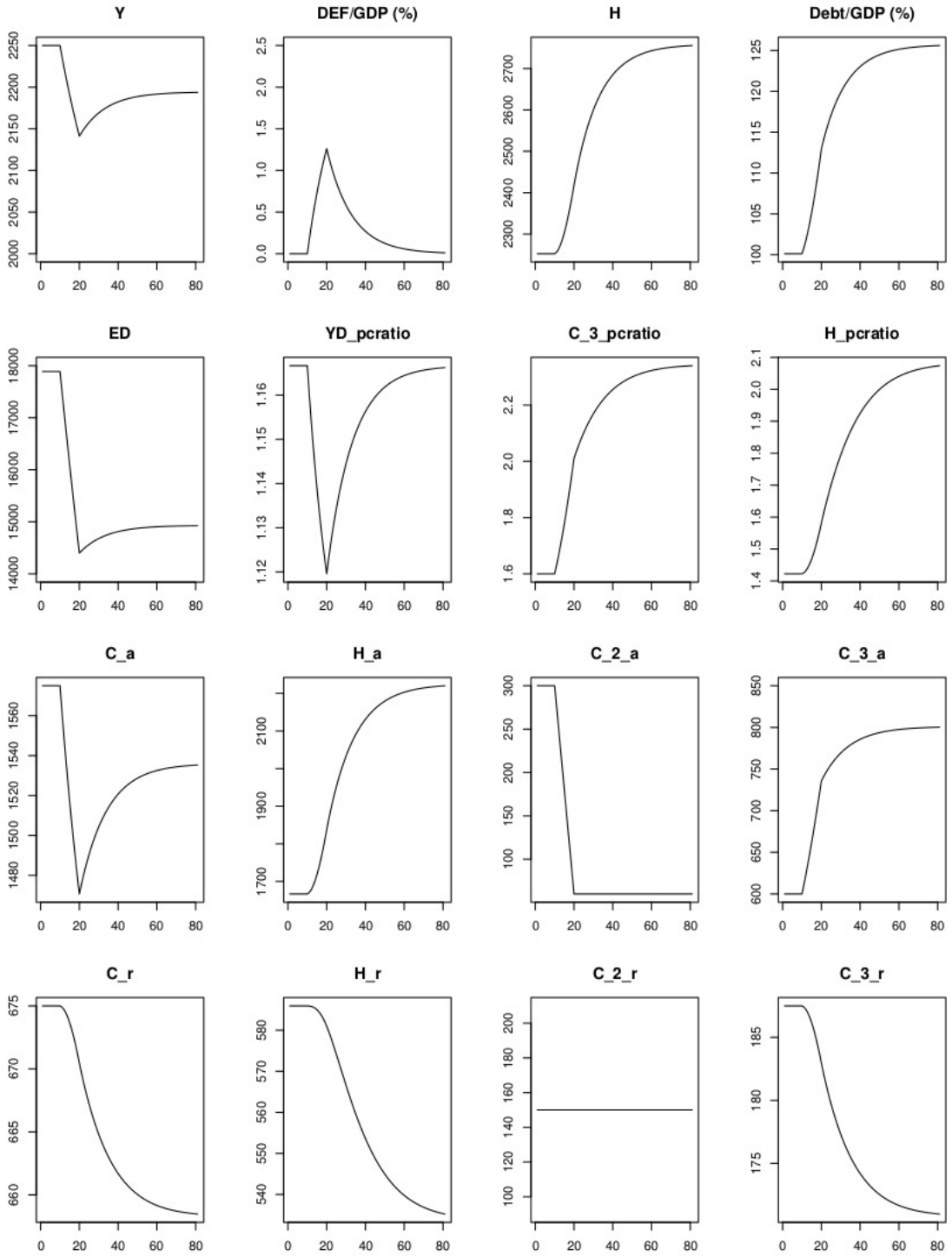

Figure 5: Evolution of key variables for scenario 2a

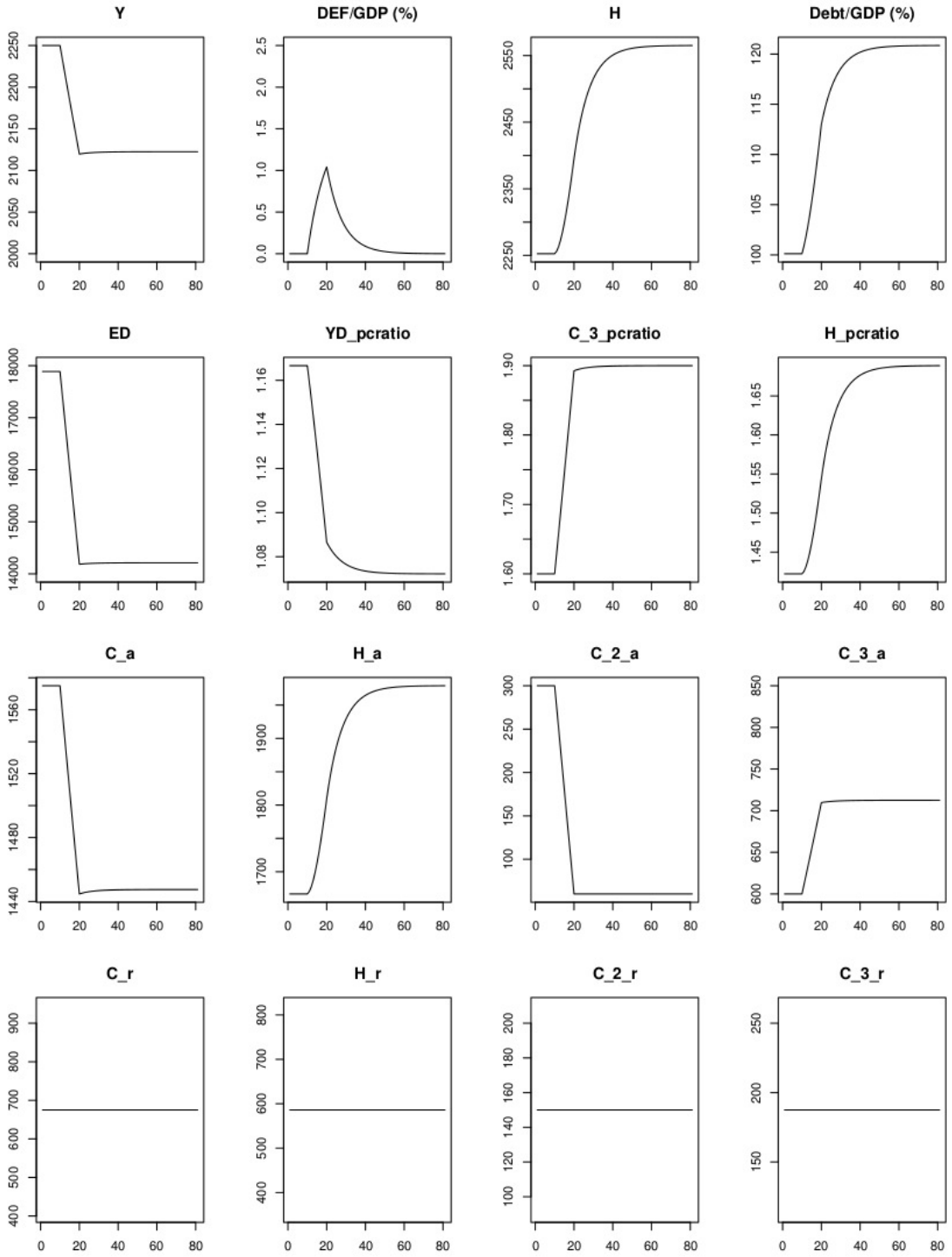

Figure 6: Evolution of key variables for scenario 3a

situation.

To wind up, this article suggests and explores a path toward strong sustainability, where one ecological problem is not replaced with another one since the rebound effect is tamed and aggregate production is not just stabilised but actually goes down. This is done without impacting negatively the well-being of people, since their needs keep being met, and without triggering a distributional conflict between categories of people such as retired and active households. Contrary to a frequent critique made to degrowth-related ideas, such a systemic change does not lead to an economic collapse, nor to an explosion of public debt. Finally, the reduction in working time associated with the reduction of aggregate production prevents unemployment from increasing and improves the quality of life of active people, which increases the acceptability of such dramatic changes.

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Appendix A: Derivation of the stationary state

$\Delta H = 0$ implies

$$\kappa_w^\star \cdot WB^\star + \kappa_{fp}^\star \cdot FP^\star = \Pi^\star$$

$$(ws \cdot \kappa_w^\star + ps \cdot \kappa_{fp}^\star) Y^\star = \Pi^\star$$

Using equation (18) yields equation (38):

$$Y^\star = \Pi^\star / \kappa^\star$$

Combining equations (20) and (38) leads to equation (41) relative to the share of national income that retired households get:

$$YD_r^\star = \Pi^\star = \kappa^\star Y^\star$$

Equation (39) taken at the stationary state reads:

$$YD_a^\star + YD_r^\star = Y^\star$$

Combining the last two equations leads to equation (40) on the share $(1-\kappa^\star)$ of national income received by active people.