

## Analysis

## The Transition to a Sustainable Prosperity-A Stock-Flow-Consistent Ecological Macroeconomic Model for Canada

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## ABSTRACT

This paper presents a stock-flow consistent (SFC) macroeconomic simulation model for Canada. We use the model to generate three very different stories about the future of the Canadian economy, covering the half century from 2017 to 2067: a *Base Case Scenario* in which current trends and relationships are projected into the future, a *Carbon Reduction Scenario* in which measures are introduced specifically designed to reduce Canada's carbon emissions, and a *Sustainable Prosperity Scenario* which incorporates additional measures to improve environmental, social and financial conditions across society. The performance of the economy is tracked using two composite indicators constructed especially for this study: an environmental burden index (EBI) which describes the environmental performance of the model; and a composite sustainable prosperity index (SPI) which is based on a weighted average of seven economic, social and environmental performance indicators. Contrary to the widely accepted view, the results suggest that 'green growth' (in the *Carbon Reduction Scenario*) may be slower than 'brown growth'. More importantly, we show (in the *Sustainable Prosperity Scenario*) that improved environmental and social outcomes are possible even as the growth rate declines to zero.

## 1. Introduction

The defining feature of ecological economics is its rigorous attention to the question of ecological scale (Daly and Morgan, 2019). For this reason, perhaps, it has often found itself at worst ignored and at best in outright conflict with conventional economic narratives framed around the assumption of 'eternal' economic growth (Liebreich, 2018). The former British prime minister, Margaret Thatcher, once famously declared that 'there is no alternative' to growth. Her Tory predecessor in that role, Ted Heath, insisted a decade earlier that 'the alternative to expansion is not, as some occasionally seem to suppose, an England of quiet market towns linked only by steam trains puffing slowly and peacefully through green meadows. The alternative is slums, dangerous roads, old factories, cramped schools, stunted lives.' (ConservativeHome, 2006, Douthwaite, 1992, 20).

The assumption that the only alternative to economic growth is social collapse still occupies such a pernicious hold over economics, politics and public attention that, even today, almost five decades after its publication, the Club of Rome's most influential report (Meadows et al., 1972) on the limits to growth still sustains an extraordinary level of attack or outright denial. Mainstream economists, business leaders and media commentators still prefer to 'debunk the limits to growth'

than to face up to the possibility that economies may not be able to expand forever (WEF, 2020).

In recent years, this position has become increasingly untenable, particularly in the face of accelerating climate change (Lenton et al., 2019; IPCC, 2018) and unprecedented biodiversity loss (IPBES, 2019). It has also come under particular scrutiny since the 2008 financial crisis, partly as a result of persistent social inequalities (Piketty, 2014) and partly because the rate of growth, particularly amongst the most advanced economies appears to have been in decline for several decades (Jackson, 2019a; Victor, 2019).

In this context, it is pertinent to explore the extent to which it may – despite the commonly held view – be possible to manage – and perhaps even prosper – *without* growth (Jackson, 2017; Lange, 2018; Victor, 2019). The concept of 'degrowth' was first coined by the philosopher Gorz (1972) in the 1970s and elaborated extensively by French sociologist Serge Latouche (2007) three decades later. In the years since the financial crisis it has emerged as an articulate and energetic social movement (D'Alisa et al., 2014; Kallis, 2017) sometimes spilling over into an outright rejection of economics as a discipline and an argument that economic models are little better than convenient fiction (Zhengelis, 2017; Reed, 2018).

There is a sense of course in which economic models – like all

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models and most theories – are indeed fiction (Shiller, 2019; Jackson, 2019b). Models are quintessentially tools for questioning our narratives about the world and developing stories about the future (Jackson, 2019c). Clearly such tools should be used with care. But rejecting their use altogether is just as likely to lead to unproductive dialogue as the uncritical use of them.

There are signs that this polarization of attitudes towards economic modelling is beginning to change. Hardt and O'Neill (2017) list twenty-two ecological macroeconomic models, including some that are empirical. Since that time, several further models have been developed (D'Alessandro et al., 2020, Dafermos et al., 2017 eg). Ecological economists have used such models to determine whether important social and environmental objectives can be achieved in a modern economy without necessarily relying on continued economic expansion, defined conventionally as an increase in real GDP. In particular, such models are useful in terms of interrogating the potential to achieve stable, low-growth economies capable of maintaining high employment while meeting stringent environmental targets and reducing income inequality.

This paper describes such a model for Canada. We use the model (LowGrow SFC) both to examine the evolution of the Canadian economy under conventional assumptions about demand, supply and the behaviour of economic actors and also to explore the potential for a transition to a sustainable prosperity – a prosperity that is inclusive, lasting and consistent with the limits of a finite planet. We are particularly interested in the macroeconomic implications of the green investments needed to achieve specific environmental goals and to remain within 'planetary boundaries' (Steffen et al., 2015). Specifically, we want to explore the economic, social and environmental implications of the transition to a low- or net-zero-carbon economy (IPCC, 2018; CCC, 2019).

These implications depend on the nature of the green investment needed to achieve the transition impacts on the economy. We therefore pay close attention to the nature of green investments, distinguishing in particular between investments which increase the long-term productivity of the economy and those which don't; as well as between those that increase short-run aggregate demand and those which don't. These distinctions are often overlooked in conventional analyses of green investment, leading to erroneous conclusions about the feasibility of 'green' growth (Jackson and Victor, 2019a; Victor and Sers, 2019; Victor and Jackson, 2012).

In the following sections we provide a broad overview of the model, expanding in particular on the role of investment and the indicators that we use to assess social progress. We then describe three specific scenarios for the Canadian economy under different assumptions about key macroeconomic, social and environmental variables. Finally, we discuss the implications of these scenarios for prevailing debates about growth, limits to growth and capitalism.

## 2. An Overview of the Model

Our broad approach to ecological macroeconomics is to bring together three primary spheres of modelling interest and explore the interactions between them. Specifically we aim to provide an account of (1) the ecological and resource constraints on economic activity; (2) the processes of production, consumption, employment and public finances in the 'real economy'; and (3) the structure and stability of the financial economy, including the main interactions between financial agents. This section provides an overview of the philosophy and structure of the LowGrow SFC model. A full description of the model architecture is available in Jackson and Victor, 2019b.

Broadly, speaking LowGrow SFC is a post-Keynesian, demand-driven model. Aggregate demand depends on the consumption decisions of households and governments, the investment decisions of firms

and net exports. The theoretical foundation for such models is provided by the work of Godley and Lavoie (2012), who place a particular emphasis on a full and consistent account of the relationships between monetary stocks and flows within and between different financial sectors: so-called 'stock-flow consistent' (SFC) macroeconomic modelling.

The overall rationale of SFC macroeconomic modelling can be captured in three broad axioms: first that each expenditure from a given sector is also the income to another sector; second, that each sector's financial asset corresponds to some financial liability for at least one other sector, with the sum of all assets and liabilities across all sectors equalling zero; and finally, that changes in stocks of financial assets are consistently related to flows within and between economic sectors. These simple understandings lead to a set of accounting principles with implications for actors across the economy which can be used to test the consistency of any scenario simulation (Godley and Lavoie, 2012).

LowGrow SFC is not simply a macroeconomic model in the post-Keynesian tradition, however. It is explicitly an ecological economics model in the sense of attempting to capture key environmental concerns and simulate policies that aim to achieve specific environmental targets. It takes some of its inspiration from an earlier model of the Canadian economy developed by Victor (2008) and by Victor and Rosenbluth (2007). But the model described here has a substantively different underlying structure from that earlier work. It draws in particular on a suite of SFC models developed more recently by Jackson and Victor (2015, 2016, 2017, 2019a) and collaborators. A key characteristic of LowGrow SFC is that the rate of economic growth is endogenous as are the increases in labour productivity on which this growth depends.

Fig. 1 illustrates the broad structure of the model articulated in terms of six inter-related financial sectors: households, firms, banks, government, a central bank and a 'rest of the world' or foreign sector. The accounts of firms and banks are further subdivided into current and capital accounts in line with national accounting practices. The so-called 'circular flow' between households and firms is clearly visible towards the bottom of the diagram in Fig. 1. Firms employ labour and capital to produce goods which are purchased by households using the returns to their own labour (wages) and capital (profits) paid to them by firms.

The rather more complex structure that surrounds this circular flow represents the financial flows to and from the banking, government and foreign sectors. The role of the financial sector in LowGrow SFC is threefold. First, banks create loans and receive deposits for households and firms. Next, the profit generated from an interest rate spread on these loans and deposits is returned directly to households as dividends. Finally, the banks sector holds relatively small quantities of central bank reserves and government bonds in proportions that provide to ensure financial stability. The central bank operates to regulate the interest rate, counteract unemployment and protect financial prudence. The foreign sector represents the trade relationships between Canada and the rest of the world. It is notable that these relationships all include both the flow of incomes and expenditures and also the changes in holdings of financial assets and liabilities (deposits, pensions, loans, mortgages, equities and bonds for instance).

If the model is stock-flow consistent, the flows into and out of each financial sector should sum consistently to zero throughout the model run. So, for instance, the incomes of households (consisting of wages, dividends and interest receipts) must be exactly equal to the outgoings of households (including consumption, taxes, interest payments and the net acquisitions of new financial assets). Likewise, for each financial sector in the model. These balances – which must hold for every financial sector – provide a ready test of consistency in the model.

LowGrow SFC is built using the STELLA Architect platform. This kind of system dynamics software provides a useful platform for exploring economic systems for several reasons, not the least of which is

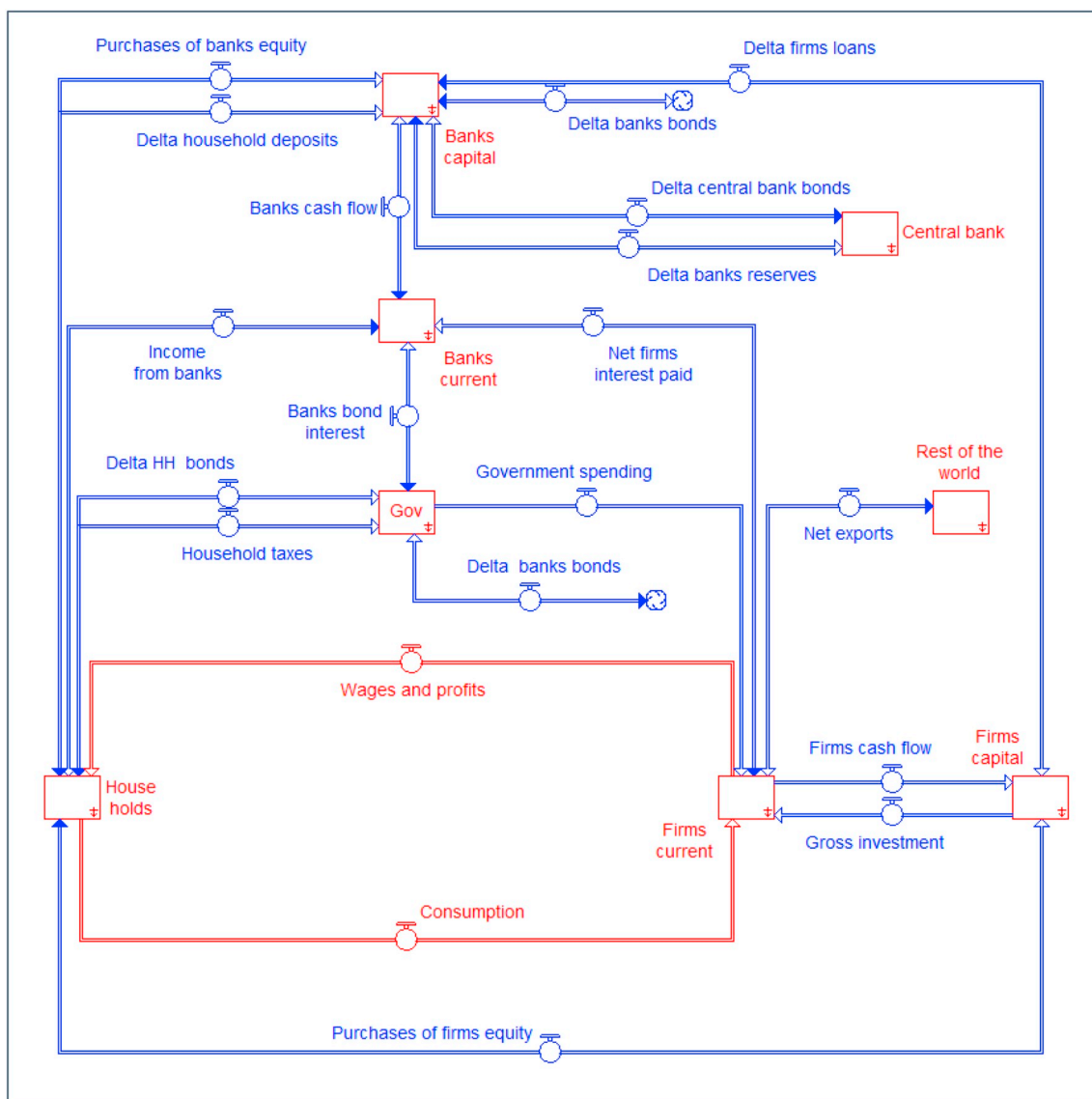


Fig. 1. Overview of the sector structure of LowGrow SFC.

the ease of undertaking collaborative, interactive work in a visual (iconographic) environment. A further advantage is the transparency with which it is possible to model fully dynamic relationships and mirror the stock-flow consistency that underlies our approach to macroeconomic modelling. STELLA Architect also allows for an online user-interface through which the interested reader can follow the scenarios presented in this paper and explore their own.

Our approach embodies a good deal of macroeconomic theory but LowGrow SFC is not a purely theoretical model. Its initial values and behavioural parameters have both been calibrated empirically using national accounts data from Statistics Canada (2017). Some of the behavioural relationships in the model are based on econometric estimations using data from previous years. Others reflect plausible assumptions informed by the relevant literature. Simulation results are reported for a fifty-year period from 2017 to 2067. When using a model to describe alternative economic futures over half a century, statistical relationships estimated from data for the past two or three decades are not always a very reliable guide to future behaviour (Jackson, 2019c). It is best therefore to think of the model as employing a set of ‘stylized facts’ (Godley and Lavoie, 2012) that are grounded in empirical data but allowed to vary in order to explore future possibilities.

A full technical description of the model is available in Jackson and Victor, 2019b and an online version of the model allows the user to explore their own scenarios.<sup>1</sup> For the sake of saving space, we do not elaborate in detail on the model structure here. However, before describing the scenarios for the evolution of the Canadian economy, it will be useful to offer more detail on two specific aspects of the model which are of direct relevance to understanding the transition to a sustainable prosperity: firstly, the handling of investment – and in particular green investment in LowGrow SFC; and secondly, the construction of the two performance indicators used to assess the outcomes. We address each of these issues in turn in the following sections.

### 3. Modelling Investment

Several kinds of investment are incorporated into the model. These include normal non-residential (business) investment in the firms’ sector; residential investment in the domestic housing stock; and green investment undertaken with the specific intention of reducing

<sup>1</sup> <https://www.cusp.ac.uk/themes/s2/lowgrow-sfc/>.

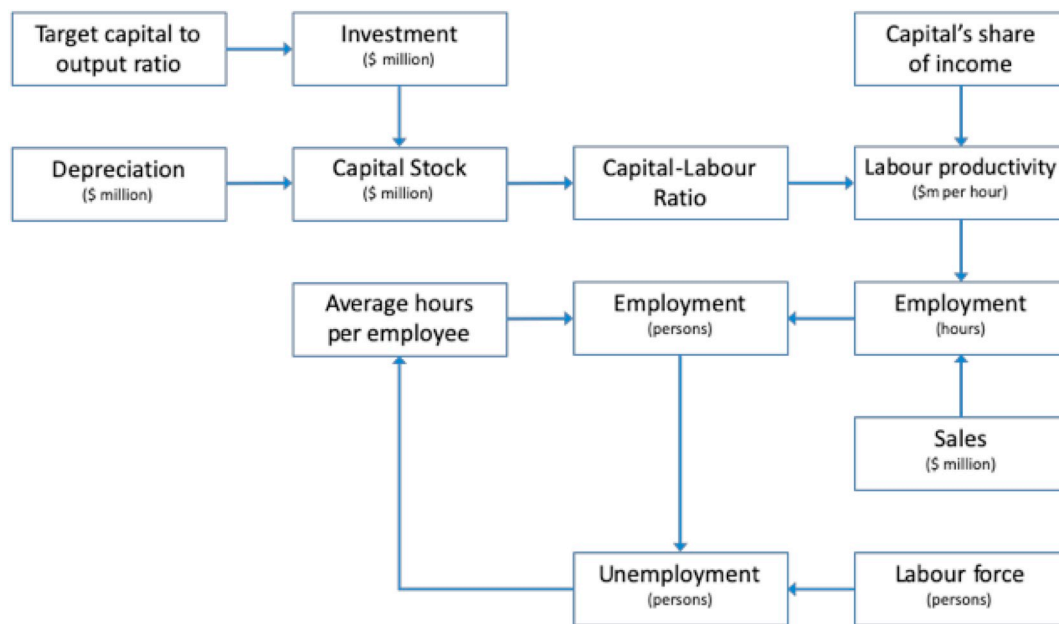


Fig. 2. Overview of supply-side structure in LowGrow SFC.  
Source: Fig. 3 in Jackson and Victor, 2019b

environmental burdens.

Most non-residential investment decisions are modelled through a capital-stock adjustment process using a partial adjustment function in accordance with the post-Keynesian literature (Godley and Lavoie, 2012, p226). In this kind of model, firms are deemed to have a target capital-to-output ratio that they deem sufficient to meet an expected level of output. If at any time the expected capital-output ratio falls short of the target ratio then investment is undertaken to close the gap. The rate at which the gap is closed by new investment is determined by a partial adjustment coefficient.

The exception to this is investment in the electricity sector which is based on the difference between endogenous forecasts of the demand for electricity and generation capacity over an assumed planning horizon. A market share equation then allocates investment in the sector between renewable and non-renewable generating technologies.

The level of capital stock has a number of important implications for the supply side structure of the model. The overall supply structure of the business sector in the LowGrow SFC economy is shown in Fig. 2, with the labour relationships mainly shown on the right-hand side of the figure and the investment relationships on the left. These two sets of relationships are linked through the endogenous calculation of labour productivity which depends on the stock of non-residential business capital in two distinct ways, firstly through the capital-to-labour ratio and secondly through capital's share of income. In particular, it should be noted that a higher capital-to-labour ratio increases labour productivity through labour enhancing investments. Higher labour productivity increases wages which then increases aggregate consumption, leading to a growth imperative in the model – under conventional assumptions. As we shall see, this imperative can also be diluted or even entirely neutralised when investment is diverted away from labour enhancing technological change.

Also visible in Fig. 2 (in the middle of the diagram) is the dependency of business sector employment on the average hours worked by each employee in the economy. In line with discussions in the literature (Victor, 2008; Jackson, 2009; Cooate and Franklin, 2013), reducing the average hours worked in the economy is one of the ways in which employment can be maintained even as the growth rate declines. In fact, a secular decline in the hours worked is one of the factors that has contributed to high levels of employment over recent decades.

In addition to business investment, LowGrow SFC includes an

account of investment in residential fixed capital assets (ie housing). Investment in housing depends on both population and an endogenous 'house price index' which reflects the potential for speculative demand in housing. By convention, the System of National Accounts deems residential investment to be part of business investment, with the costs of servicing this investment (through mortgage payments) allocated to household consumption spending through a component known as the 'imputed rent' of the owner-occupied sector. For the sake of consistency with the data, we follow this same accounting convention in LowGrow SFC.

There is one final component of firms' investment which is absolutely critical to our exploration of the transition to a sustainable prosperity, namely: investment that is specifically undertaken in order to protect the environment, by reducing environmental impact, meeting environmental targets or reducing the resource intensity of the economy. For the purposes of this exercise we term this set of activities *green investment* and for the sake of clarity, we aim to distinguish this class of investment, which is undertaken with the specific goal of reducing the environmental impact of the economy, and *conventional investment*, characterised as investment that reproduces or expands the productive capital stock through a partial adjustment process.

It is important to note that some portion of conventional investment will also have a tendency to reduce the environmental impact per unit of economic output. Even without a determined effort to increase green investment, we can expect economic progress to result in technological efficiency measures which reduce the rate of throughput of materials and pollutants. For example, investment in energy efficiency can have this effect, provided that the 'rebound effect' is not too great. For this reason, we incorporate a 'business-as-usual' improvement in the environmental performance of the economy in the model, which we assume to be a result of conventional investment, driven by the stock adjustment behaviour described above.

The level of green investment in the scenarios described in this paper is determined by the need to achieve environmental targets which are determined in the user-defined scenarios. Broadly speaking, LowGrow SFC simulates four kinds of changes in response to such targets:

- 1) the electrification of the economy;
- 2) the decarbonisation of the electricity sector;



- 3) the decarbonisation of the non-electricity sector; and
- 4) non-carbon related environmental improvement.

The first three changes are associated with the need to tackle climate change by reducing carbon emissions from economic activity. The last is captured by some simplistic assumptions about additional investment needed to protect biodiversity (for instance) or to reduce other environmental impacts. The first two dimensions above are modelled in a more detailed way than the last two, but in combination these aspects of the model allow us to parametrise various environmental and resource implications of the economy and to explore the transition to a sustainable economy.

In order to understand the macroeconomic implications of green investment, we make a fundamental distinction between *productive* and *non-productive* green investment. Recognising that some kinds of green investment will not only reduce environmental impact but also contribute to the productive capacity of the economy, just as conventional investment does, we call this component *productive green investment*. Specifically, it contributes to the ability of firms to meet their target capital-to-output ratios needed in the production of market goods and services.

On the other hand, it is likely that some kinds of green investment can only be undertaken at a net cost or with a rate of return too low to be competitive with other investments. We refer to this latter type of investment as *non-productive green investment*, so termed here because it does not in itself contribute to the productive capital stock of the economy. This kind of investment might include damage prevention investments such as storm water management and engineered carbon sequestration as well as investment in natural assets such as grassland management or forestry. Because non-productive green investment relies on the ability of the economy to fund the investment flow, without at the same time delivering an increase in the productive capacity of the economy, it can have a significant impact on the ability of the model to generate long-term economic growth.<sup>2</sup>

We draw a further distinction that is vital for assessing the macroeconomic impact of green investment. It concerns what we call *additionality*. We call green investment which is over and above the investment needed for stock adjustment, *additional* green investment. In this case, the total investment expenditure would exceed the investment determined by the stock-adjustment calculation alone. In other circumstances, it is possible that firms will have insufficient funds to meet the requirement for additional green investment. In this case, some or all of the green investment undertaken by firms may have to displace some of the investment that would be desirable from a stock-adjustment point of view. We call this *non-additional* green investment. The impact of non-additional green investment on the productive capital stock depends on whether or not this non-additional green investment is productive or non-productive, in the sense outlined above. If it is productive then the rate of economic growth will be unaffected. If it is non-productive then the rate of economic growth will be reduced.

It is worth reiterating that there are broadly two kinds of macroeconomic effects that green investment might have in the economy, summarised in Table 1. One of these is an immediate impact on aggregate demand, during the period of investment, because investment spending contributes to nominal aggregate demand. Additional green investment will increase real (ie price-adjusted) aggregate demand so

<sup>2</sup> It is important to note that 'productive' is being used here in a conventional economic sense to relate to the capacity of the economy to produce economic goods and services as conventionally captured in the GDP. In a wider sense, needless to say, green investment is playing a quite fundamental role in protecting the ability of our economies to produce anything at all. But the distinction between productive and non-productive investment (in the conventional sense) is an essential one for us in being able to understand the impact that green investment has on the macroeconomy.

long as the economy is not already operating at full capacity. Non-additional green investment simply displaces conventional investment by firms and there is no increase in nominal aggregate demand. If the economy is already operating at full capacity, then neither additional nor nonadditional green investment increases real aggregate demand.<sup>3</sup>

The second effect relates to the impact green investment has on the productive capacity of the economy. If all green investment is productive then it will tend to increase the productive capital stock beyond what would happen in the absence of green investment – but only to the extent that the green investment is additional to conventional investment. If all green investment is unproductive and is also non-additional, then it reduces the productive capacity of the economy because it displaces productive investment. If green investment is additional but non-productive or non-additional but productive it will have no effect on the productive capital stock.

Determining how much green investment is productive and how much is non-productive is, at this point in time, something of a judgement call. Clearly, the early 'low-hanging fruit' of efficiency improvements will tend to be rather productive, with longer-term efficiencies in the capital stock and strong positive rates of return. On the other hand, once these are exhausted, the same kinds of financial rewards may be more elusive and it seems likely that as the situation becomes more urgent with the passing of time, an increasing proportion of green investment will be non-productive, since it will consist of measures designed to lessen adverse impacts on the environment but not increase the economy's productive capacity.<sup>4</sup>

#### 4. Measuring Progress Towards Sustainable Prosperity

Our broad understanding of sustainable prosperity (Jackson, 2017) is that it consists in our ability to flourish as human beings within the ecological limits of a finite planet. It remains an open question how progress towards this goal should be measured. Several indices such as the Canadian Index of Well Being and the Genuine Progress Indicator have been developed to address shortcomings of GDP as a measure of social progress, by taking into account a wider range of factors that contribute to well-being (Corlet-Walker and Jackson, 2019; Kubiszewski et al., 2013; WEF, 2018).

All these measures have something to offer in the effort to improve how we track the performance of the economic, social and environmental systems within which we live. Yet they lack an important dimension: they do not emerge from an articulated model of the system whose performance we are interested in. This stands in marked contrast to the GDP, which is constructed on the basis of a consistent macroeconomic model of the economy.

The fact that GDP emerges from a model of the economy is both a blessing and a curse. It is a blessing because it means that GDP is not just a passive metric that can be measured and monitored. It is a curse because it only captures a part of what matters in society and, by promoting its growth with such enthusiastic single-mindedness, we can miss opportunities that have a more beneficial effect on human well-being (Corlet-Walker and Jackson, 2019; Stiglitz, 2019; Stiglitz et al., 2009). To offset this danger, we have developed two additional composite indicators that are used to describe the scenarios developed in

<sup>3</sup> In the simulations described in this paper all green investment is regarded as non-additional, that is, it displaces other intended investments. This is to avoid attributing expansionary effects to green investment that arise simply because an economy is not at full capacity. In the event that the envisaged level of green investment is higher than the estimated level of conventional investment, then the excess is deemed to be additional green investment

<sup>4</sup> Our default assumption in the scenarios set out in this paper is that 50% of total green investment will be productive. If it turns out to be more than this, then the implications of green investment for economic growth will be less than indicated in the scenarios. If it turns out to be greater, then the opposite will be true.

**Table 1**  
Productivity and additionality in green investment.

	Productive	Non-productive
Additional	Increases productive capital stock. Adds to aggregate demand.	No effect on productive capital stock. Adds to aggregate demand.
Non-additional	No effect on productive capital stock. No effect on aggregate demand.	Reduces productive capital stock. No effect on aggregate demand.

this paper: the Environmental Burden Index (EBI) and the Sustainable Prosperity Index (SPI). A detailed description of the underlying methodology for constructing the two measures are given in Jackson and Victor, 2019b.<sup>5</sup> Our broad aim in this paper is to use the two measures as a diagnostic tool to explore the evolution of several different scenarios emerging from LowGrow SFC, which we describe in the next section of the paper.

Broadly speaking the EBI is designed to capture the environmental impacts of economic activity notably absent from GDP. More specifically, the EBI aims to reflect the four distinct kinds of environmental changes detailed in the previous section, namely: the decarbonisation of the electricity sector, the decarbonisation of the non-electricity sectors, the co-benefits arising from decarbonisation, and the non-carbon benefits from other green investments.

Carbon emissions contribute 25% of the value of the EBI. This is the weight given to ‘climate and energy’ in the Environmental Performance Index produced by Yale University (Hsu et al., 2016). Co-benefits are health and environmental benefits that come from reductions in contaminants such as particulates which occur as a result of the reduction in carbon emissions. There is a considerable body of literature on these co-benefits, pointing out that their size relative to the climate change benefits from reduced carbon emissions depends very much on time, place and circumstances. In the simulations described in this paper, our default assumption is that co-benefits are equivalent to 20% of the benefits of reductions in carbon emissions (Hamilton et al. 2017).

The SPI consists of a weighted sum of GDP per capita, the Gini coefficient on household incomes, average hours worked in the economy, the household loan-to-value ratio,<sup>6</sup> the government debt-to-GDP ratio, the unemployment rate and the EBI (Fig. 3). The signs shown in Fig. 3 indicate whether SPI increases or decreases as the respective components increase. A ‘+’ indicates that the SPI moves in the same direction as changes in the component measure, and a ‘-’ indicates that the direction of change of the SPI is in the opposite direction to the component measure. For example, as the GDP per capita increases, so does the SPI (albeit in a non-linear way). On the other hand, as the loan to value ratio of household rises, so the SPI falls.

Composite indicators such as the SPI do not substitute for disaggregated measures of individual components, which – in accordance with the principles of ‘strong sustainability’ (Ayres et al., 1998) – should be used to ensure that key system conditions are not compromised through economic activity. However, they can be useful for signaling the overall performance of a complex system by providing a more comprehensive indicator of prosperity than GDP alone.

In any metric that combines more than one variable, weights must be used to add the variables together. GDP uses market prices for this purpose. For the purposes of this paper, weights used in the SPI were selected for each variable based on the empirical estimate of the contribution of GDP/capita to happiness (Helliwell et al. (2017), Table 2.1) and using the judgement of the authors (Jackson and Victor, 2019b). There are many ways in which these preliminary measures could be improved, particularly as more and better data become available and

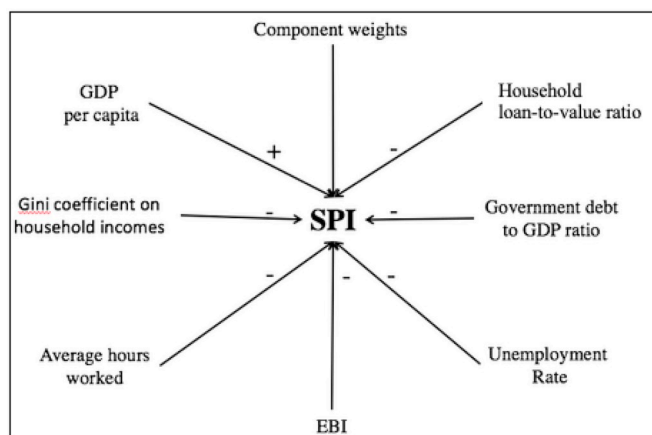


Fig. 3. Overview of the sustainable prosperity index.  
Source: Fig. 6 in Jackson and Victor, 2019b

weights are selected through a deliberative process involving many people representing different interests and values (see Mavrommati et al., 2017).

However, the EBI and SPI both share with GDP the feature that their values emerge endogenously from a model of the system in whose performance we are interested. They can therefore be used to model the effect of measures designed to make the system work better. Since GDP is also generated by LowGrow SFC, it is possible to compare GDP at an aggregate and per capita level with the SPI in any scenario generated by the model. This allows us to distinguish between the ‘intermediate ends’ to which economic activity is dedicated and the means through which this is achieved. However, it would be a mistake to rely too heavily on any single aggregated indicator because it can hide tradeoffs and can be sensitive to the weights used in calculating it. For this reason, in what follows we consider carefully how each key variable behaves in the different scenarios.

### 5. Three Futures for the Canadian Economy

In this section, we describe the results provided by the model under three scenarios for the future evolution of the Canadian economy. Here we provide a brief summary of their construction and rationale before describing the output from the model.

The *Base Case Scenario* is a description of what would happen, broadly speaking, at the national level, if current trends continue through and beyond mid-century. It assumes that the Canadian economy will perform on average over the next fifty years in much the same way as it did in the preceding 25 years or so. The *Base Case Scenario* is therefore a benchmark against which other scenarios can be compared. It is not in itself a prediction of what will happen in the absence of policy interventions. It says nothing, for instance, about the marked regional differences that would accompany such trends.

The *Carbon Reduction Scenario* simulates a comprehensive program of carbon emission reductions aimed at achieving a target reduction of 80% over 1990 levels by 2050.<sup>7</sup> Emission reductions come from the increased use of renewable sources of electricity and from the electrification of road and rail transport. These changes are induced in the

<sup>5</sup> The weights of individual components may be found in Table 11.2 in Jackson and Victor, 2019c, p282.

<sup>6</sup> Measured as the ratio of all household secured (mortgage) and unsecured loans to the total household net worth (including housing).

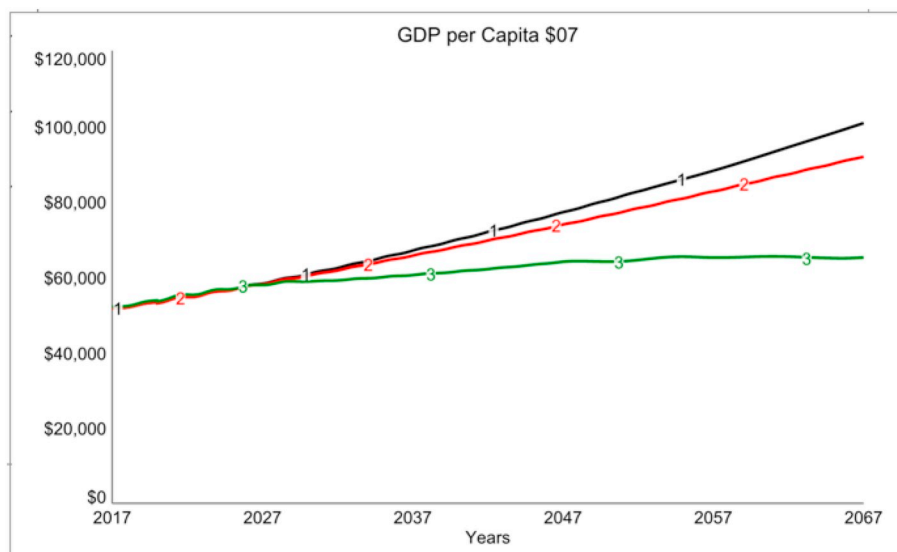


Fig. 4. Gross Domestic Product (GDP) per capita: 2017–2067.  
1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

model by increasing price on carbon emissions from the electricity sector which in turn affects the market share of renewables in the selection of new generating capacity and the price of electricity. This in turn influences electricity sales and generation.

Finally, the *Sustainable Prosperity Scenario* includes all of the innovations included in the *Carbon Reduction Scenario* and, in addition, it introduces further measures aimed at reducing a wider set of environmental impacts. In particular, it imposes a faster transition towards a net zero carbon economy, aiming to meet a net zero target by 2040. In addition, this scenario includes policies aimed at achieving beneficial social outcomes. Specifically, it introduces a substantial increase in annual transfer payments from government to reduce the inequality of incomes. Two further assumptions are changed in the *Sustainable Prosperity* scenario. First, it assumes a slower rate of population growth (the low projection in *Statistics Canada, 2017* stabilizing after 2063). Second, it introduces a decline in the average hours worked.

None of these scenarios is a prediction of the future. Rather they are intended to illustrate some of the possibilities facing Canada, to inform discussion and debate, and to suggest the kinds of choices available, not just to Canada but to similar economies, as we move further into the 21st century. The three scenarios presented here run over a period of 50 years from the beginning of 2017 until the beginning of 2067, the year in which Canada will mark the 200th anniversary of the establishment of the Canadian Federation.

It is instructive to start our comparison of the results from the model by looking at the estimated GDP per capita over the period. Fig. 4 shows this comparison for the three scenarios. Under the *Base Case Scenario*, per capita GDP about doubles from \$52,000 in 2017 to just over \$100,000 in 2067, with an average growth rate of 1.3%.<sup>8</sup> This is essentially a conventional, growth-based view of the future, in which the economy as a whole (taking into account population growth of around 44%) increases its magnitude 2.8 times by the year 2067.

The *Carbon Reduction Scenario* has a somewhat lower average growth rate in GDP per capita of 1.1%, with incomes in 2067 reaching a level of nearly \$92,000 per annum. It is worth remarking that the reduced rate of economic growth in this scenario is at the high end of the range of estimates of the impact on GDP from achieving significant

reductions in greenhouse gas emissions, as cited in the literature (*Ekins, 2017*).

The *Sustainable Prosperity Scenario* shows much more clearly marked differences from the base case, revealing a stabilization of per capita income at a level slightly above current income levels by the end of the run. Specifically, the GDP per capita in 2067 is \$65,000 – an average annual increase of only 0.4% over the period. More significantly, both GDP and GDP per capita are essentially stable over the final twenty years of the scenario. This scenario therefore illustrates a transition from a growth-based economy to a quasi-stationary-state economy (*Jackson and Victor, 2015*). The declining rate of economic growth and ultimately its cessation altogether result from the reduced investment in productive capital, the increased costs associated with deep carbon abatement and other green investments, and the reduction in average work hours.

Conventional wisdom would suggest that such a transition is impossible without causing irreparable damage to prosperity and well-being in society. But Fig. 5 suggests that this undesirable outcome is avoided. In fact, the composite SPI described in the previous section rises significantly in the *Sustainable Prosperity Scenario* despite falling in both the other two scenarios. Starting from a base of 100 in 2017, the SPI falls by more than 50% in the *Base Case*. Even in the *Carbon Reduction Scenario*, the SPI declines 11%. In the *Sustainable Prosperity Scenario*, by contrast, the SPI increases 35% between 2017 and 2067.

To understand the reason for these differences, we must examine the component parts of the SPI (Fig. 3) in more detail. One of those components is the GDP per capita itself, which tends to push the SPI upwards, the higher the level of GDP. This ought to help maintain a high level of SPI. So clearly there are other factors which offset this apparent advantage for the *Base Case*. Alongside the GDP per capita, lie a variety of other indicators, some environmental, some social, some financial in nature, each of which has some effect on the overall measure of the SPI. These components are clearly sufficient to allow the *Sustainable Prosperity Scenario* to perform much better over the long run. It is worth looking at each of them in turn.

### 5.1. Environmental Influences on the SPI

Principal amongst the factors which favour the *Sustainable Prosperity Scenario* over the *Base Case Scenario* is the Environmental Burden Index (EBI), designed to include, amongst other things, the negative impact of carbon emissions. Fig. 6 illustrates the changes in the indexed value of

<sup>7</sup> This was until recently the official reduction target of the Canadian government (*Munson, 2016*).

<sup>8</sup> Unless otherwise stated, values are in 2007 Canadian dollars.

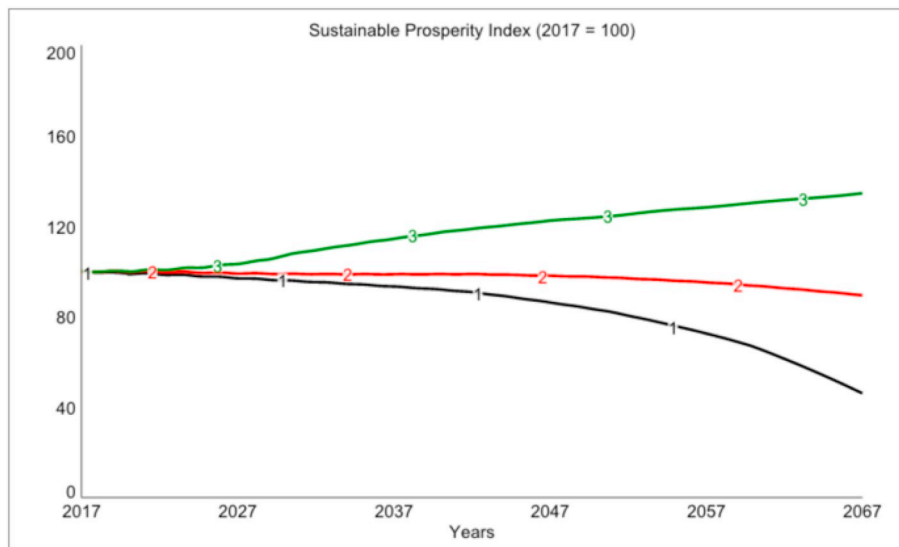


Fig. 5. Sustainable Prosperity Index (SPI): 2017–2067. 1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

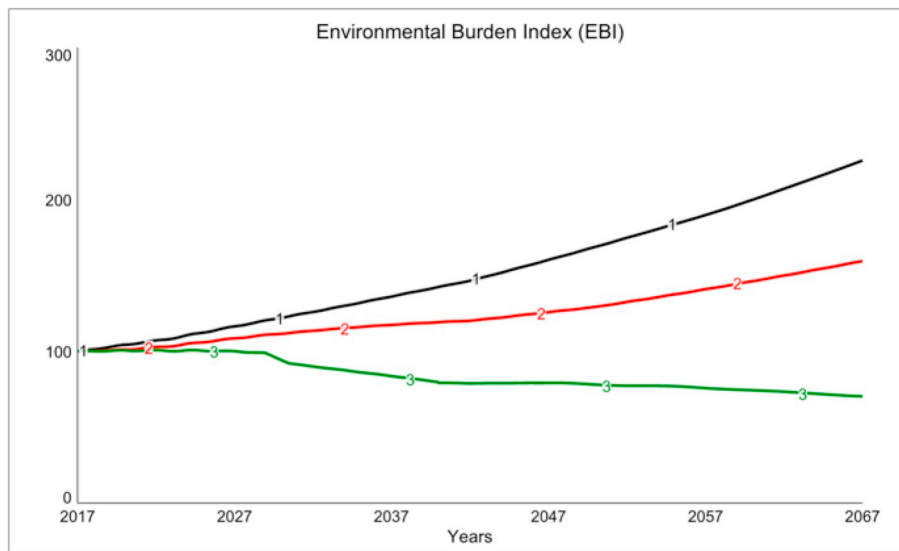


Fig. 6. Environmental Burden Index (EBI): 2017–2067. 1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

the EBI over time. Clearly, here is a partial explanation for the reversal of fortunes witnessed as we move from an indicator based on GDP towards a broader measure of sustainable prosperity such as the SPI. The EBI for the *Base Case* more than triples over the period of the scenario, as greenhouse gases continue to rise, and little is done to offset other environmental impacts from the economy. Since a rising EBI depresses the SPI, it contributes to the poor performance of the *Base Case Scenario* in Fig. 5.

The EBI for the *Carbon Reduction Scenario* performs significantly better. The main reason for this is a marked decline in carbon emissions to around 27% of their level in 2017 (Fig. 7). Disappointingly, this reduction still falls short of the 80% reduction target with a projected decline of just over 60% from 2017 to 2050 as shown in Fig. 6. Nonetheless, the reduction is sufficient to suppress the rise in the EBI and in doing so has a notably positive effect on the SPI shown in Fig. 5. Certainly, the steep decline in SPI visible for the *Base Case Scenario* has been avoided. With a determined effort to reduce carbon emissions, the

SPI declines much less than in the *Base Case Scenario*, most of the decline coming after 2050.

Put another way, even though the GDP per capita is projected to grow at an average 1.1% per year in the *Carbon Reduction Scenario*, well-being as measured by the SPI declines slowly but steadily. By comparison, the *Sustainable Prosperity Scenario* achieves net zero emissions by 2040 as shown in Fig. 7. The high level of carbon reduction combined with considerable green investment to address other environmental problems facilitates a decline in the EBI (Fig. 6) for the *Sustainable Prosperity Scenario* of 30% by the end of the period, contributing significantly to the improved SPI score (Fig. 5) for this scenario.

### 5.2. Social Influences on the SPI

Two specific social measures adopted in the *Sustainable Prosperity Scenario* also contribute to the improved performance of this scenario



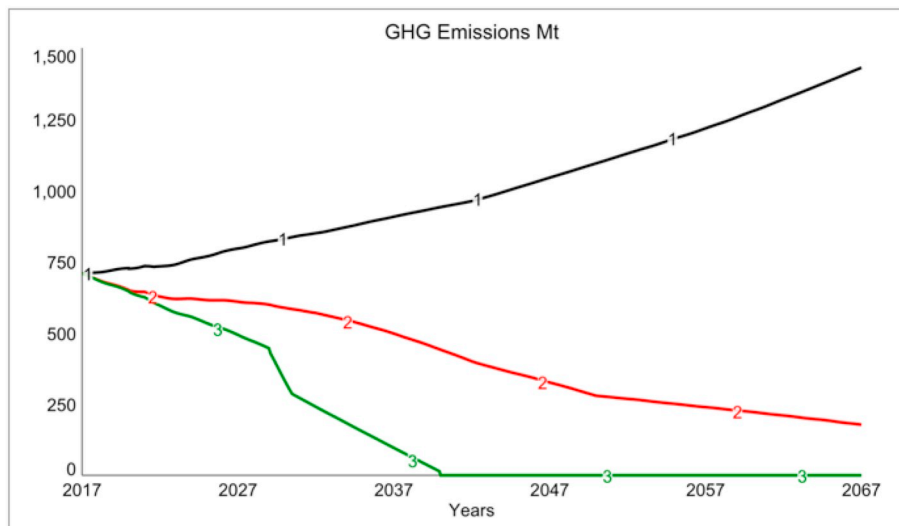


Fig. 7. Carbon Emissions (MtCO<sub>2</sub> equivalent): 2017–2067. 1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

over the other two cases. The first of these is the redistributive fiscal policy described in the previous section, in which transfer payments are progressively increased from 2020 and distributed preferentially to the lower income categories. These enhanced transfers have the effect (Fig. 8) of achieving a significant reduction in the Gini coefficient in the Canadian economy on pre-tax incomes, which declines from 0.47 in 2017 to 0.19 in 2067. A lower Gini coefficient improves the performance of the SPI (Fig. 6) and this accounts for some of the advantage of the Sustainable Prosperity Scenario over both the Base Case and the Carbon Reduction Scenarios.

A further social policy adopted in the Sustainable Prosperity Scenario is the reduction in the annual average hours worked across the workforce. The average paid employee in Canada worked a little over 1750 h in 2017. In the Base Case and the Carbon Reduction Scenario, this does not change significantly (Fig. 9). Increases in labour productivity (the output per hour) are more or less offset by increases in output in these two cases and the small fluctuations in the rate of unemployment in these scenarios have a minimal impact on average work hours. In the

Sustainable Prosperity Scenario, however, the average hours worked in the economy falls to 1450 h per year by 2067, an average annual rate of decline of less than 0.4%. This innovation offers more opportunities for people to enjoy time with their families and friends, perhaps volunteering in the community or taking advantage of increased leisure, much as Keynes predicted in his famous (1930) essay on ‘Economic possibilities for our grandchildren’ and as recently proposed by the Prime Minister of Finland (Kelly, 2020). It is therefore deemed to be a positive contribution to people’s well-being and quality of life and contributes positively to the SPI, explaining some of its improved performance in the Sustainable Prosperity Scenario.

Reduced working hours also play a significant role in preventing unemployment rising as output stabilizes. As discussed previously, a stabilization of output in the context of increasing labour productivity would tend to exacerbate unemployment, leading to perverse social outcomes. Fig. 10 reveals that despite some variability across the period, the average level of unemployment is very similar in all three scenarios with somewhat greater fluctuations in the Sustainable

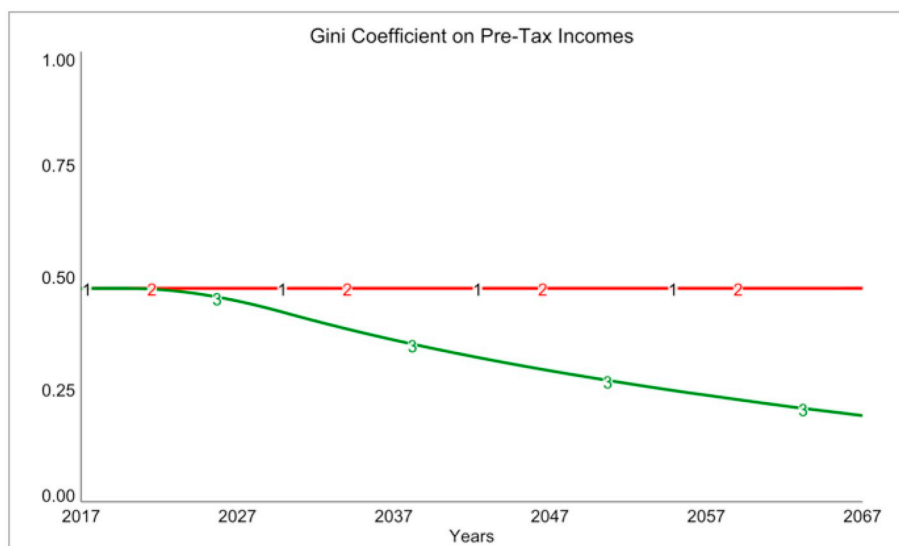


Fig. 8. Gini Coefficient on per capita Income: 2017–2067. 1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

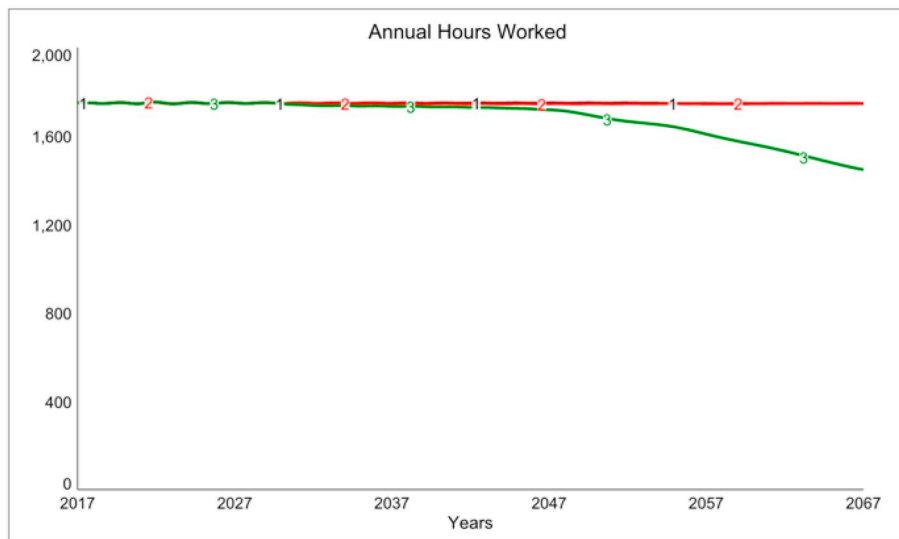


Fig. 9. Average hours worked per year: 2017–2067.  
1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

Prosperity Scenario.

5.3. Financial Influences on the SPI

The advantage of a stock-flow consistent model such as LowGrow SFC is its ability to articulate the financial positions of different sectors in a meaningful and consistent way. So, for example, the net lending positions of each sector can be determined under any scenario, as can the long-term impact of these positions on the financial worth of different sectors of the economy. The basic mechanism of stock-flow consistency ensures that the sum of all net lending across the economy (including the foreign sector) is equal to zero.

For as long as banks, firms and the foreign sector maintain net lending positions close to zero, this means that any positive net lending position for government is offset by a corresponding negative net lending position for households (and vice versa). As a consequence, the state always has the ability to balance the net lending position of households: by increasing its deficit when household saving drops too far or reducing it when household net worth rises excessively. In the

long term, the health of the economy depends on having both public sector debt and household debt lie within reasonable bounds. Two specific components of the SPI aim to reflect this requirement.

Fig. 11 shows the ratio of combined government debt to GDP across the three LowGrow SFC scenarios. In 2017, the public debt in Canada was around 55% of GDP, somewhat lower than in other rich economies, partly because of the country's relative financial prudence in the run up to the 2008 crisis. In the *Base Case* and *Carbon Reduction Scenarios*, this value rises slightly to a peak of around 66%, before declining to about 60% by the end of the run, indicating a relatively stable position in relation to Canada's public debt.

In the Sustainable Prosperity Scenario, the debt to GDP ratio rises slowly but steadily, reaching more than 80% of the GDP by the end of the run. This is because the GDP itself has stabilized at that point in time while the Government continues to borrow and revenues from the carbon tax have fallen to zero because of the elimination of net carbon emissions. The rise in this indicator suppresses the SPI and raises a potential concern over the long-term sustainability of the Canadian economy. Nonetheless, it is worth pointing out that even at the end of

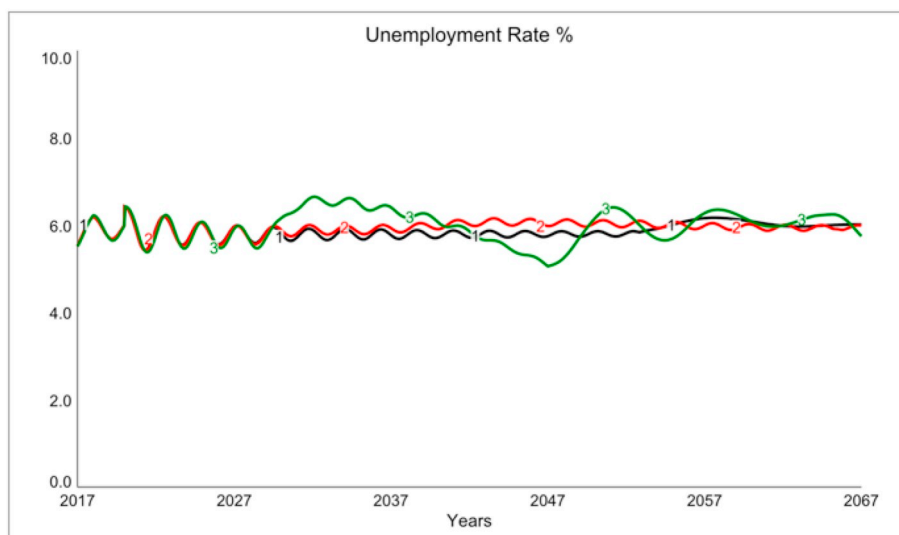


Fig. 10. Unemployment rate: 2017–2067.  
1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

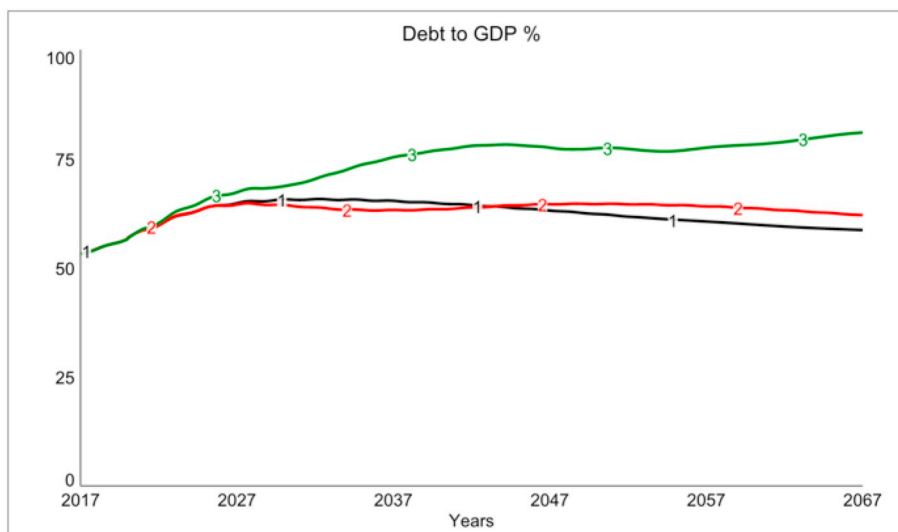


Fig. 11. Government debt to GDP Ratio: 2017–2067. 1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

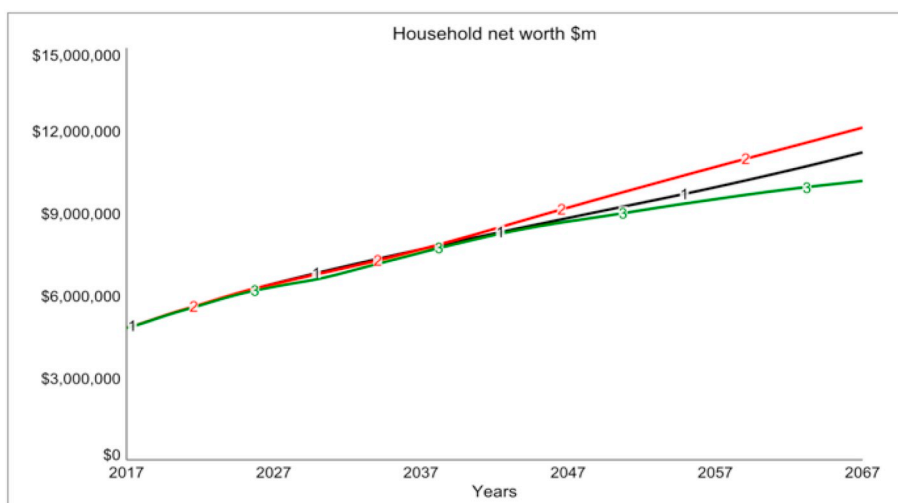


Fig. 12. Household net worth (\$07 m) 2017–2067. 1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

the run, the debt-to-GDP ratio remains at a level that has been far surpassed by many countries without the collapse of their economies. As an example, Japan's debt to GDP ratio has exceeded 200% since 2009, reaching 250% in 2016 (Trading Economics, 2018).

With government running a deficit, it follows from the stock-flow consistency of the model (and the financial behaviours of the other sectors) that the overall net lending position of the private sector is positive in all three scenarios, leading to a healthy (if stabilizing) position in terms of household net worth. This expectation is confirmed in the findings from LowGrow SFC. Fig. 12 shows the household net worth rising consistently in the model over the three scenarios.

Despite this steady increase in net worth across all three scenarios, it remains possible that households' consumption decisions and portfolio preferences can lead them towards financial instability. For instance, it is still possible, even with positive net lending, for the ratio of households' loans to incomes to rise to a level where banks' confidence in their ability to repay those loans could fall. If the banks were then to impose a constraint on lending (as is possible in the model), it could have a destabilizing effect on household spending and potentially send the economy into a spiral of recession. This is why we have included households' loan-to-value ratio as a component of the SPI to measure

the overall performance of the economy. As Fig. 13 reveals, there are minor increases in the ratio of household loans to incomes in the Base Case and the Carbon Reduction Scenarios. Interestingly the Sustainable Prosperity Scenario reveals the best position in relation to household indebtedness, with a slight rise over the period, but a broadly declining ratio over the second half of the period. This improved position follows from the higher spending rate of government and the lower profit rate of firms (Fig. 14 below) in the Sustainable Prosperity Scenario. These in their turn lead to greater protection of workers' wages and allow households to improve their effective savings ratio and reduce the debt burden by comparison with the Base Case.

Needless to say, an exercise of this kind has numerous limitations. Some of these limitations relate to the availability of data, for instance in calibrating the degree of additionality or productivity of green investments. To some extent these are empirical questions that can only be tested in a world that does not yet exist. Nonetheless, the value of a model such as we have presented here is to allow users to make and test a range of assumptions about such factors.

Other potential limitations arise from the international repercussions associated with taking a unilateral approach to sustainable prosperity such as the one modelled here. Would a unilateral pursuit of

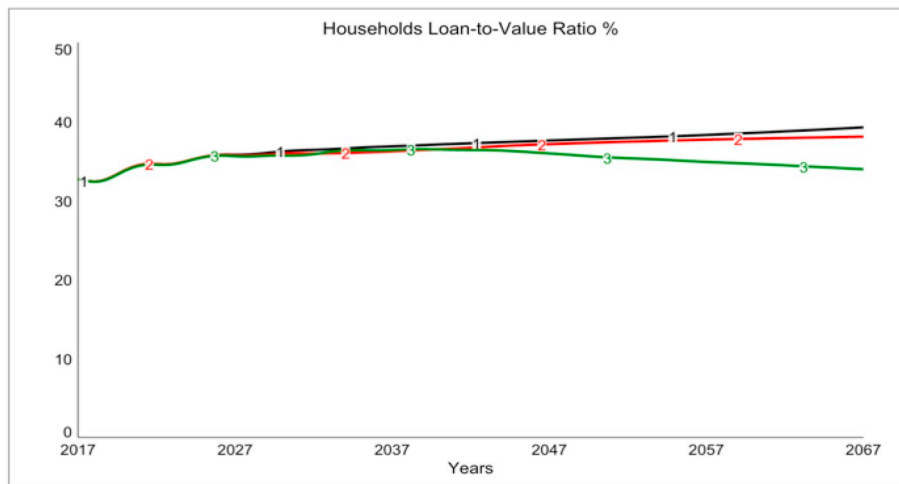


Fig. 13. Household loan to value ratio: 2017–2067. 1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

sustainable prosperity place Canada at a disadvantage in relation to capital flight or international currency exchange, for instance? The Sustainable Prosperity Scenario incorporates some potential implications of such a move in terms of lower investment rates. But to answer these questions more fully would require a fully articulated foreign sector with more insight into foreign direct investment behaviour and exchange rate effects.

Finally, of course, we cannot decide issues of public or political acceptability on the basis of a simulation model of this kind. There are good indications that public awareness of climate change, for instance, is higher than it has ever been and the demand for ‘system change’ has been heard more clearly than ever over the last year (Thunberg 2019). It would be foolish though to ignore the potential for adverse public reactions to policies such as those modelled here. Perhaps the most that we can say here is that policy attempts to meet stringent environmental targets are likely to be most feasible when they are aligned with policies to improve social outcomes – as we have suggested in our *Sustainable Prosperity Scenario*.

## 6. Discussion

This paper has presented a simulation model of a national economy,

broadly calibrated using Canadian data. We used the model to generate three very different stories about the future, covering the half century from 2017 to 2067: a *Base Case Scenario* in which current trends and relationships are projected into the future, a *Carbon Reduction Scenario* in which several measures are introduced specifically designed to reduce carbon emissions, and a *Sustainable Prosperity Scenario* which incorporates additional measures to further achieve net zero carbon by 2040 and to improve environmental, social and financial conditions across the scenario.

On current trends (the *Base Case*) it may be possible to continue to pursue economic growth for the next half a century, but if this is typical of other advanced economies, it happens at the expense of a deepening environmental crisis leading to a high probability of runaway climate change. The Sustainable Prosperity Index (SPI) for the Base Case declines dramatically over the course of the scenario.

On the other hand, we have shown that substantial reductions in carbon emissions can be achieved with appropriate changes to the structure of the economy. The impact of these reductions on the macroeconomy depends on numerous factors, including: the speed of the transition and the productivity (and additionality) of green investments.

For a relatively slow and shallow transition (the *Carbon Reduction*

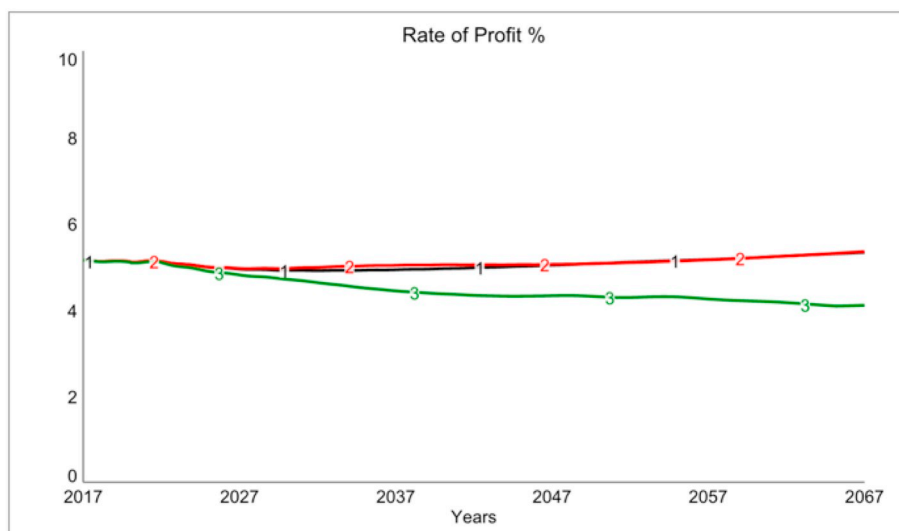


Fig. 14. Endogenous rate of profit in LowGrow SFC: 2017–2067. 1 = Base Case; 2 = Carbon Reduction; 3 = Sustainable Prosperity.

Scenario), the impact on the GDP is still larger than others have suggested and at odds with those who see a 'green' economy as growing faster than a 'brown' one. Furthermore, this 'green growth' scenario falls well short of the greenhouse gas target reduction of 80% by 2050.

Deeper and faster transitions are also possible (the *Sustainable Prosperity Scenario*). These changes impact the endogenous growth rate in the model and lead to what is essentially a quasi-stationary economy by 2050. Nonetheless, the simulations in this paper suggest that with appropriate policy interventions, this scenario could also deliver a better quality of life with greater social equality and lower environmental impact. In fact, it is only in this third scenario that we see any overall improvement in performance as indicated by the SPI.

It is of particular interest to find that even the financial indicators of a low growth economy can, under the right conditions, remain relatively stable under the *Sustainable Prosperity Scenario*. Investment portfolios have changed, productivity growth has declined, consumption demand has stabilized, but the economy is nonetheless still financially resilient, its social outcomes are improved and its environmental burden on the planet is dramatically reduced.

Recent years have seen a burgeoning interest in ecological macroeconomic models (Hardt and O'Neill, 2017). One recent model that is comparable to LowGrow SFC is the EUROGREEN model (D'Alessandro et al., 2020). EUROGREEN has been calibrated for France and used to simulate various scenarios from 2014 to 2050. Both models use system dynamics and are stock-flow consistent. They are both demand-driven and include environmental variables and income distribution as well as conventional economic variables such as GDP and its components. Unemployment is mitigated in both models by a reduction in the average hours worked.

One difference between the models is how production in the economy is represented. EUROGREEN uses an input-output structure driven by endogenous changes in the technical coefficients associated with the energy sector. In LowGrow SFC, production is calculated from labour productivity and hours worked. Labour productivity is determined as a function of the capital:labour ratio. In LowGrow, this allows us to endogenise the growth rate via the productivity of the capital stock (taking green investment into account). EUROGREEN incorporates greater detail in the examination of income distribution and social programs. LowGrow SFC includes more detail in relation to environmental scope going beyond carbon emissions, a detailed electric power sector module. It also proposes two new composite performance indicators (EBI and SPI).<sup>9</sup>

D'Alessandro et al. (2020) report four scenarios: baseline, green growth (GG), policies for social equity (PSE), and degrowth. These scenarios are not directly comparable with the four scenarios described in this paper, but they do give a picture of possibilities for France that are largely consistent with those generated for Canada with LowGrow SFC. The rate of economic growth in the GG scenario is somewhat below the baseline scenario. When the social equity policies are added in the PSE scenario the rate of economic growth rises above the baseline rate. Eventually the growth rates in all three scenarios converge to 0.7% by 2050. Only in the degrowth scenario where domestic consumption is reduced does the growth rate decline to below zero. Carbon emissions decline in all four scenarios but only by 80% even in the degrowth scenario. This contrasts with the sustainable prosperity scenario described in this paper where carbon emissions are eliminated by 2040.

A part of our aim in LowGrow SFC has been to address the nature of the transition to a sustainable prosperity. A particular question arises at this point. Does the *Sustainable Prosperity Scenario* still describe a viable form of capitalism? Or do the various policies and measures introduced

to improve social and environmental outcomes and to maintain financial stability essentially mean that LowGrow SFC no longer describes a capitalist economy? It is beyond the scope of this paper to address this question in detail.<sup>10</sup> But it is perhaps worth remarking here that the rate of profit is expected to fall slightly in the Sustainable Development Scenario (Fig. 14), suggesting some move away from a capitalistic economy with greater protections on wages and the distribution of income and wealth.

In summary, we have attempted in this paper to refute the 'impossibility theorem' espoused by most politicians, many economists and much of the mainstream media that neither societal progress nor environmental protection can be achieved without economic growth. On the contrary, the results reported here suggest that the pursuit of economic growth at the expense of a deepening environmental crisis has a very high probability of catastrophe. On the other hand, there clearly are alternatives to this paradigm. For instance, substantial reductions in GHG emissions can be achieved without massive changes to the structure of society. The impact on the rate of growth, while modest, is larger than others have suggested and at odds with those who see a 'green' economy as growing faster than a 'brown' one (UNEP, 2011).

Broader and deeper changes are also possible. Achieving a sustainable prosperity will require a major reorientation of society's priorities towards improvements in social equity, economic security and environmental quality. These changes may well lead to a quasi-stationary state economy, but they will also deliver a better quality of life. The result may not be entirely incompatible with capitalism; but it will look very different from the over-financialized consumer capitalism of the early 21st century and may well be worthy of a different name altogether.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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<sup>9</sup> Another ecological macro simulation model similar to LowGrow SFC is described in Dafermos et al. (2017). It is applied at the global rather than national level so a comparison with LowGrow SFC is less meaningful than with EUROGREEN.

<sup>10</sup> For a fuller discussion see Jackson and Victor, 2019c – which also includes scenarios which are similar – although not exactly identical – to the scenarios described here.



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