Journal of Environmental Management 351 (2024) 119717

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

The macroeconomics of near zero growth of GDP in a world of geopolitical risks and conflicts

Giuseppe Fontana, Malcolm Sawyer *

University of Leeds, UK

ARTICLE INFO

Journal of Economic Literature codes:
E12
Q57
044

Keywords:
Ecological macroeconomics
Geopolitical risk
Zero growth
Unemployment
Investment

ABSTRACT

This paper offers an analysis of the macroeconomic conditions for near zero economic growth based on a demand-led growth model, and their implications in terms of paid employment, government finances, and the rate of profit. The main finding of the paper is that a level of net investment compatible with near zero growth would lead to a lower level of paid employment in terms of total hours worked. The effects on the distribution of work and the unemployment level would depend on changes to working time, whether in terms of average hours worked per annum, ages of entry into, and exit from, the work force. Furthermore, changes in working time would be achieved through social actions and legislation, rather than market mechanisms. A government budget deficit may well be required to underpin full employment and capacity utilisation, though there may be long-term limits on the use of budget deficits in a near zero growth context. Finally, a near zero growth rate would also mean a substantial lower rate of profit than hitherto.

The implementation of these theoretical conditions require a level of cooperation between and within countries, which is much more difficult to reach in the presence of geopolitical risks and conflicts. Yet, there is no country secure from geopolitical risks and conflicts without an ecologically sustainable use of the natural resources. The theoretical conditions discussed in this paper could serve as "condiciones sine quibus non" to ecological sustainability, while navigating the complexities and uncertainties caused by the on-going conflicts and heightened geopolitical risks.

1. Introduction

1.1. Background

The main goal of this paper is to explore the macroeconomics of low rates of economic growth, with a particular focus on near zero growth, in a world characterised by geopolitical risks and conflicts (Caldara and Iacoviello, 2022). Economic growth is evaluated in terms of Gross Domestic Product (GDP) as a measure of marketed output and of economic activity, which is closely associated with climate change, and other ecological and environmental problems (Antal, 2014).

There are at least two main reasons for undertaking a macroeconomic analysis of near zero growth of GDP. One reason is motivated by the recent experiences of economic growth in industrialised economies over the past two decades, which has been much slower than had been recorded in the first half century of the post-Second World War period. This recent experience is reinforced by projections of continuing slow growth into the future (Copley, 2023; IMF, 2018). The hypothesis of a secular stagnation has been raised, which has been explained in terms of different supply-side causal factors, including a slowdown of technological change and productivity growth, and a tendency for investment falling short of savings (Gordon, 2012; Summers, 2014). Secular stagnation is essentially a supply-side phenomenon though demand factors (e.g. austerity policies) can reinforce the slowdown of growth in the short run (e.g. lower investment and capital formation, discouraged workers effects). Climate change itself has significant effects on productivity. Authors including Chang et al. (2019), Colscito et al. (2019), de Oliveira and Lima (2022), and Graff Zivin and Neidell (2012) have reported a range of ways in which climate change and pollution contribute to a slowing down of productivity growth. Kahn et al. (2021) use a panel data set of 174 countries over period 1960–2014 and "find that per-capita real output growth is adversely affected by persistent changes in the temperature above or below is historical norm".

From this perspective, one of the major issues is how the future growth of the demand for goods and services would adjust to the prospects of a low supply of commodities, i.e. how the aggregate demand

* Corresponding author.
E-mail address: m.c.sawyer@lubs.leeds.ac.uk (M. Sawyer).

https://doi.org/10.1016/j.jenvman.2023.119717
Received 17 July 2023; Received in revised form 3 November 2023; Accepted 23 November 2023
Available online 1 December 2023

adapts to an aggregate supply-led slow rate of economic growth.

The second, and possibly more important, reason for undertaking a macroeconomic analysis of near zero growth comes from ecological and environmental concerns. These concerns question the sustainability of the pace and continuity of economic growth vis-à-vis the finite capacity for our planet of absorbing emissions and regenerating natural resources.[1] The issue of sustainability places the spotlight on role of aggregate demand as a main cause for, and a potential solution to, the tension between economic growth and the use of natural resources. A low or zero rate of growth of demand is viewed as a necessary, but not sufficient, condition for the achievement of a sustainable economy and society. The achievement of ecologically sustainable economic and social activity also requires many changes on the supply-side of the economy, including the restructuring of production towards renewable activities and low carbon use. In the absence of sufficient restructuring, environmental degradation and ecological damage would itself tend to slow down growth of potential supply and the level of output, by making among other things production more difficult[2]

The achievement of ecological sustainability would require a much slower rate of growth of aggregate demand than hitherto, possibly zero or negative growth. The focus of this paper is (i) on the conditions under which the rate of growth of demand could be near zero; and (ii) to explore the consequences of this for GDP, government finances, employment, and profits. It should be emphasised that a near zero growth rate of GDP does not rule out a positive rate of growth of what may be viewed as economic activities, if economic activities shift away from the market, and into the household and local or community groups (Jackson, 2009). Also, a near zero rate of growth of aggregate demand and of GDP clearly does not mean that economic and social well-being cannot continue to develop.

The many on-going conflicts[3] together with heightened geopolitical risks add a further dimension to the analysis. The implementation of the theoretical conditions for the achievement and preservation of ecological sustainability requires cooperation between and within countries, which is much more difficult to reach in presence of wars, and regional or global geopolitical risks disrupting peaceful relationships between countries, populations and territories (Alqahtani and Klein, 2021; Ha, 2023). There is increasing evidence that threats of adverse geopolitical events lead to similar, even if not bigger, declines in real activity, low stock returns, and disruptive movements in capital flows, than actual conflicts (Caldara and Iacoviello, 2022).

There are various reasons for the linkages between geopolitical risks and conflicts, cooperation, and ecological sustainability. First, the implementation of the theoretical conditions for the achievement and preservation of ecological sustainability is going to heighten threats of adverse geopolitical events between nations and within nations over access to, and distribution of, the currently available natural resources, including water, food, critical raw materials. Secondly, on-going conflicts lead to resources being diverted from other sectors and activities to the carbon-intensive defence sector, and rebuilding programmes in response to destructions caused by geopolitical conflicts. This means that resources that could secure the transition to a low carbon economy are redirected into other uses. Furthermore, the increasing resources devoted to the defence sector, which is highly carbon-intensive in both production and consumption (Akkerman et al., 2022; Rogaly, 2023), will make *ceteris paribus* the application of the theoretical conditions for the achievement and preservation of ecological sustainability more challenging.

The next two subsections discuss the main divide between supply-led growth models and demand-led growth models, and assess the use of GDP as a measure of economic growth.

1.2. Modelling issues

The analysis of economic growth can be approached from the perspective of the aggregate supply or the aggregate demand. Neoclassical growth models (Solow, 1956) and the endogenous growth theory (Barro and Sala-i-Martin, 2004) are supply side models constructed under the crucial assumption that the demand will adjust to the supply side, and it will underpin full employment. There is a range of secular stagnation approaches to low rates of growth of GDP and unemployment, which largely draw on a supply-side approach. The original paper by Hansen (1939) invoked slower population growth and slower pace of technical change. Steindl (1952) in the monopoly capitalism tradition postulated that lower rates of invention and innovation along with a shift in the distribution of income from wages to profits would generate secular stagnation. Gordon (2015) is also focused on lower rates of invention and innovation, whereas Summers (2016) draws on perceived changes in the so-called 'natural rate of interest' at which savings and investment are theorised to be in balance, where in turn investment is related with the supply-side rate of growth. These approaches have elements of demand-side influences, though in the main it is demand responding to supply-side changes.

The analysis of this paper is based on a non-neoclassical, demand-led growth model, where economic growth in both the short and long run is driven by the interaction between the demand for and the supply of goods and services. This is consistent with the view that in modern industrialised economies sharp decreases in economic activity and rising unemployment are generally associated with falls in aggregate demand, due to a variety of reasons including banking and financial crises like in 2007–2009. The focus of the paper is then on the macroeconomic conditions which would be consistent with near zero economic growth.

There is a range of demand-led growth models, though as explained by Setterfield (2010) and Tavani and Zamparelli (2017), for all their differences demand-led growth models share five features, namely (1) a short and long-run role for aggregate demand, (2) a surplus approach to value and distribution, (3) a fixed coefficient approach to production, (4) the endogeneity of technical change, and (5) the possibility of an unbalanced approach to growth.

According to the first feature, the aggregate demand for goods and services plays a determinant role, together with the aggregate supply of commodities, in determining both the short and long-run rate of economic growth (Arestis and Sawyer, 2009; Dutt, 2012). In the context of climate change and other ecological constraints, this means that aggregate demand has to be brought down to a sustainable rate of growth, which includes the possibility of zero growth (a form of stationary state), and negative growth (a form of degrowth).

The adoption of a surplus approach to value and distribution means that prominence is given to the issues of power and inequalities in the functioning of modern economies, and that the neoclassical marginal productivity theory is rejected. It also draws attention to the notion that, in general, modern economies produce a surplus of output over what is socially necessary for consumption, and that surplus can be used for a range of purposes including investment (Baran and Sweezy, 1966).

The third feature is related to the assumption of a fixed proportions production function, which implies that there is not a continuous substitution between labour, capital and other inputs including non-renewable and renewable natural resources (Fontana and Sawyer,

[1] The focus in this paper on a zero economic growth economy is intended to serve as a proxy for a sustainable economy. Supporters of the de-growth school (Kallis, 2018) would question whether zero growth would be consistent with life within planetary boundaries, while other scholars would envisage that profound and suitable re-structuring of production and consumption will make positive growth rate of GDP compatible with a sustainable use of natural resources (Pollin, 2018).

[2] Aggregate demand would here also have to be adjusted in line with lower supply growth.

[3] According to the "Rule of Law in Armed Conflicts" (RULAC; https://www.rulac.org/) project, based on international humanitarian law, there are currently 110 armed conflicts in the world.

2016). This is significant in that changes in relative prices, which include putting a price on the use of natural resources, do not lead in a mechanic and automatic way to substitution between the factors of production.

Fourth, the endogeneity of technical change indicates that technology is sensitive to investment decisions, economic growth and distribution (Tavani and Zamparelli, 2017). This raises the question of technical change in the context of near zero economic growth.

Finally, the fifth feature means that demand-led growth models characterise the economic growth as fundamentally an unbalanced process, though it is not excluded *a priori* that growth could be stable and balanced for a period.

This paper maintains that these features make demand-led growth models well suited for a macroeconomic analysis of near zero growth driven by ecological and environmental concerns.

1.3. On the use of Gross Domestic Product (GDP)

The measure GDP largely relates to market activities, and as such output is valued in terms of the market price of the output. As a result, it omits a range of economic activities, notably those within and between households. This omission leads to the undervaluing in a social sense of those who undertake those economic activities within the household, mainly women in traditional households. The measure of GDP also includes some activities which do not involve market transactions. For example, this is the case of the valuations of government services based on the wages of government employees, and imputed rents from owner occupation.

This paper does not use GDP as a measure of economic welfare or well-being, but rather it uses it as an incomplete measure of economic output and economic activity that involve market transactions. This use of GDP is consistent with national accounts statistics, and enables some analysis of the distribution of income between wages and profits, and of paid employment. It is also consistent with several works exploring the relationship between GDP and environmental damage, the literature on the existence of the so-called environmental Kuznets curves, and more recent empirical evidence showing a strong correlation, if not statistical causality, between GDP and ecological footprint and environmental degradation (Hickel, 2020), including loss of biodiversity (Otero et al., 2020).

In national accounts, GDP is approached in three ways, namely as the expenditure, income, and production of the economy, with each of the three measures being in principle equal. Expenditure may be linked with consumption, investment and other components of the aggregate demand for goods and services. It is mostly from the link with consumer expenditure that has come the view of relating GDP with economic welfare, in so far as consumer expenditure provides economic well-being, which as indicated above may not. As a measure of income, GDP provides links with wages and profits, enabling some exploration of income distribution issues. As a measure of production, GDP also provides links with paid employment, enabling analysis of unemployment in terms of absence of paid employment. Furthermore, the scale of production (and its growth) would have relationships with environmental damage and climate change. These links of employment and environmental damage are to be viewed neither as fixed nor easily identifiable. In this paper, the macroeconomic analysis of near zero growth draws on all three measures of GDP.

The paper is organized as follows. Section 2 is devoted to the development and analysis of a demand-led growth approach within the Post Keynesian tradition. It is divided into two parts. Section 2.1 outlines the main features of the Post Keynesian analysis of growth, while Section 2.2 develops an original demand-led growth model, with the goal of analysing the conditions under which near zero growth would be attainable. Section 3 discusses the implications of the demand-led growth model in terms of paid employment, working time, and unemployment level. Section 4 considers the rate of profit in a near zero growth economy. Section 5 concludes.

2. The macroeconomic model

2.1. Main features

The macroeconomic model of this paper is a Post Keynesian demand-led growth model. The labelling summarises some notable features of the model. First, the model analyses a monetary production economy, namely an economy where money plays an essential role (Graziani, 2003, Ch. 3). The essential role of money has a dual meaning here. Firms as a whole cannot start the production of commodities and the financing of investment for short, without using first money (i.e. bank loans) to purchase the inputs for the production process. It also means that the production and the exchange of commodities are carried out in order to achieve monetary returns, not real returns. The provision of loans is essentially demand driven (that is arising from financing needs of firms) to which banks respond by providing loans to credit-worthy customers.

Second, the distinct nature and role of investment (capital formation) is a crucial feature of the model. Investment is an important and volatile component of aggregate demand (AD), and is financed by bank loans. Consumption is treated as a more passive component of AD, responding to the level of household income. As a creator of productive capacity, investment affects the aggregate supply of goods and services. By contributing to the growth of fixed capital stock, investment is then closely linked with economic growth. It is investment which pushes the economy towards expansion. The approach in this paper is to consider the driving forces behind investment, and then to investigate the available routes to influence those driving forces in order to achieve lower rates of investment consistent with near zero economic growth.

In the Post Keynesian approach, three driving forces behind investment are identified, namely the pursuit of profits, capacity utilisation, and 'animal spirits' (Baddeley, 2003). Profits and profitability influence investment in various ways. Past profits provide the internal funding ('retained earnings') for investment, while the prospects of future profits are a stimulus for current investment. The degree of capacity utilisation also influences investment. Firms with substantial spare capacity will be deterred from increasing further their capital stock. The third driving force, which may be termed 'animal spirits' (Baddeley, 2017), conveys the idea that expectations on the future, particularly with regard to economic growth, play a significant role for investment, and that those expectations are formed in a world of fundamental uncertainty.

A zero growth economy would in general involve close to zero net capital formation. There may be some net investment, which gradually raises the capital-output ratio, coming from example through increased automation, but there are limits to how far the capital-output ratio can be raised, or it is profitable to do so. This implies that in a zero growth economy gross investment would typically cover depreciation, i.e. net investment would be near zero and the scale of the capital stock constant (though with changes in its structure during transition to zero growth and during zero growth). With investment much lower than in a growth regime, consumer expenditure would therefore be a much higher proportion of output.

With investment being at the centre of the macroeconomic model of this paper, the question of how investment is financed and funded becomes fundamental. In this regard, the paper follows the approach of Fontana and Sawyer (2016), where planned or desired investment are first modelled as determined by profits, capacity utilisation and animal spirits. It is then postulated that the realised or effective level of investment is a proportion of desired investment, which depends on the willingness of commercial banks to finance investment. For reasons of simplicity, in this paper it is assumed that banks provide loans as required to enable planned investment to proceed, i.e. planned and realised investment are equal. It is also implicitly assumed that the rate of profit on new investment is higher than the interest rate on loans.

2.2. A demand-led growth model

The macroeconomic model of this paper examines a monetary theory of production where investment in capital goods is driven by three factors, namely profits, capacity utilisation, and 'animal spirits'. Savings are dependent on profits and wages, with the savings rate out of profits much higher than the savings rate out of wages. For simplicity, a couple of assumptions are also made. First, there is no foreign sector. Since for the world considered as a whole exports and imports are equal, this amounts to saying that the model describes the whole world or its 'average' country. Second, the government activity is included simply through the budget deficit parameter *d*, namely the primary balance (i.e. government net borrowing or net lending) plus the interest payments on accumulated government debt over GDP. For convenience, investment, savings and the budget deficit are all scaled by the capital stock in the equations.

The demand for investment is modelled as follows:

$$\frac{NI}{K} = \alpha_0 + \alpha_1(u - u^*) + \alpha_2 rn \tag{1}$$

where *NI* is net investment, *K* a measure of the capital stock, *u* capacity utilisation, u^* desired capacity utilisation, *rn* is net rate of profit. The net rate of profit is $rn = \frac{mu}{v} - \delta$ where m is the gross profit share linked with the mark-up of prices over wages, and *v* the capital-output ratio, which in general is treated as exogenously determined and δ is the rate of depreciation. The parameter α_0 is treated as including effects of 'animal spirits' and expectations on future growth. This means that if the prospects of climate change leads to the belief that future growth rates will be lower, then the investment function shifts down. It is the level of gross investment which is relevant for the level of aggregate demand. In order for investment to proceed, finance and funding has to be available, and the approach here is that banks to provide any required finance.[4]

Saving behaviour is modelled as follow:

$$\frac{NS}{K} = \beta_0 + \beta_1\left(\frac{mu}{v} - \delta\right) + \beta_2\frac{(1-m)u}{v} \tag{2}$$

where N*S* is net saving, and the second and third terms on the right-hand side of the equation reflect total saving out of net profits and total saving out of wages, respectively. The parameter β_0 reflects the autonomous, negative component of saving, namely the obverse of the autonomous component of consumption. The parameters β_1 and β_2 are the marginal propensity to save out of net profits and out of wages, respectively.

The basic sectoral balance relationship (for a closed economy) is savings minus investment equals government expenditure minus tax revenues (i.e. budget deficit *d*). In terms of outcomes, this is a national income accounting identity. In terms of intentions this provides an equilibrium condition, alongside which the processes of adjustment to bring intentions consistent with the condition. The macroeconomic equilibrium condition of investment plus government expenditure are equal to saving plus tax revenues provides:

$$\alpha_0 + \alpha_1(u - u^*) + \alpha_2\left(\frac{mu}{v} - \delta\right) + d = \beta_0 + \beta_1\left(\frac{mu}{v} - \delta\right) + \beta_2\frac{(1-m)u}{v} \tag{3}$$

This can be solved to give the equation for the capacity utilisation (*u*):

$$u\left[\frac{m}{v}(\beta_1 - \beta_2 - \alpha_2) + \frac{1}{v}(\beta_2) - \alpha_1\right] = \alpha_0 + d - \alpha_1 u^* - \beta_0 + (\beta_1 - \alpha_2)\delta \tag{4}$$

Placing this equation for *u* into the investment equation gives the following for the rate of growth:

$$g = \frac{\left[\frac{m}{v}(\beta_1 - \beta_2) + \frac{1}{v}\beta_2\right](\alpha_0 - \alpha_1 u^*) + (d - \beta_0)\left(\frac{m}{v}\alpha_2 + \alpha_1\right)}{\frac{m}{v}(\beta_1 - \beta_2) + \frac{\beta_2}{v} - \alpha_1 - \alpha_2\frac{m}{v}} \tag{5}$$

This formulation assumes the Keynesian stability condition that the slope of the capacity utilisation *u* in the investment function is smaller than the slope of *u* in the savings function holds. Equation (5) indicates the different variables that determine the rate of growth *g*, including the role of animal spirits. For instance, reduced animal spirits coming from the realisation that economic growth cannot be sustained for ecological reasons at high rates would influence *g*. Furthermore, equation (5) indicates that *ceteris paribus* a higher budget deficit *d* is associated with a higher rate of growth, which arises from the effect of the budget deficit on capacity utilisation *u*, and thereby on investment.

In equation (5) capacity utilisation *u* is not in general at its desired level u^*. From Equation (4), the following budget deficit would be required to secure full capacity utilisation, i.e. $u = u^*$.

$$d^* = \beta_0 + u^*\left[(\beta_1 + (1 - \beta_2))\frac{m}{v} + \alpha_2\frac{m}{v}\right] - \alpha_0 - (\beta_1 - \alpha_2)\delta \tag{6}$$

A shift in the distribution of income between wages and profits would lead to different values of d*. Equation (7) shows that the following profit share *m* would secure that $u = u^*$ with a balanced budget, i.e. $d^* = 0$.

$$m^* = \frac{\alpha_0 - \beta_0 - \beta_2\frac{u^*}{v}}{(\beta_1 - \beta_2 - \alpha_2)\frac{u^*}{v}} \tag{7}$$

Equations (6) and (7) show, respectively, the budget deficit and the profit share (with balanced budget) that secures full capacity utilisation (which may not correspond to full employment of labour). Section 3 below explores the correspondence between full capacity utilisation and the full employment of labour.

Finally, from equation (5) the condition for zero economic growth (i.e. $g = 0$) is as follows:

$$\left[\frac{m}{v}(\beta_1 - \beta_2) + \frac{1}{v}\beta_2\right](\alpha_0 - \alpha_1 u^*) + (d - \beta_0)\left(\frac{m}{v}\alpha_2 + \alpha_1\right) = \delta\left[\alpha_2\beta_2\frac{(1-m)}{v} + \alpha_1(\alpha_1 - \alpha_2 - \beta_1)\right] \tag{8}$$

In equation (8) capacity utilisation *u* is again not necessarily at its desired level u^*. As before a particular level of the budget deficit *d* or of the profit share *m* could secure $u = u^*$, though again it would not necessarily bring full employment. With a zero growth rate, net investment is zero, and hence the budget deficit is equal to net savings. Equation (9) shows that the following budget deficit of d** would then be consistent with zero growth and full capacity utilisation:

$$d^{**} = \beta_0 + \beta_1\frac{mu^*}{v} + \beta_2\frac{(1-m)u^*}{v} - \beta_1\delta \tag{9}$$

[4] Fontana and Sawyer (2022) discuss among other things the link between money creation and economic growth (see also Binswanger M., 2009, 2015; Binswanger H.C., 2013; Douthwaite, 2000; Farley et al., 2013; Lietaer et al., 2012). The authors reject the so-called monetary growth imperative (MGI), namely the view that the creation of money by commercial banks is incompatible with a near zero growth economy. They argue that, in addition to the dynamics of the saving rate of households, the crucial conditions for the MGI is the necessity for commercial banks as a whole to increase their equity capital (assets) when making loans, and hence creating deposits (liabilities), such that to keep a constant ratio between assets and liabilities (e.g. Binswanger, 2009, p. 713). However, in a stationary state of zero growth, loans are made and fully paid back, hence deposits destroyed, such that the assets and liabilities of commercial banks remain constant.

3. Unemployment, (paid) employment and full employment

Many ecological economists have appealed to the so-called Okun's relationship (e.g. Antal, 2014; Malmaeus and Alfredsson, 2017) to argue that economic growth is required in order to avoid unemployment.[5] Okun's relationship, named after Okun (1962), refers to the empirically observed relationship that, according to the first-difference model specification of the relationship, a 1 percentage point change in unemployment is associated with 2–3 percentage changes in GDP. According to the "gap model" specification, for a given time period the Okun's relationship is given by the following expression:

$$U - U^* = b_0 + b_1 \ (y - y^*) \tag{10}$$

where U is (the log of) unemployment rate, U* the 'equilibrium rate of unemployment', b_0 the intercept, b_1 the Okun's coefficient, y (log of) current output, and y^* (the log of) trend output. Thus, the Okun's coefficient measures how the cyclical rate of unemployment (U–U^*) is affected by the output gap (y - y^*), with the view that b_1 is substantially greater than 1, though smaller values in the range 0.6–1 percent were found in the meta-regression analysis of Perman et al. (2015).

From equation (10), assuming that the 'equilibrium rate of unemployment' is constant, it then follows:

$$\frac{\Delta U}{\Delta t} = -\frac{1}{b_1}\left(\frac{\Delta y}{\Delta t} - \frac{\Delta y^*}{\Delta t}\right) \tag{11}$$

where $\frac{\Delta U}{\Delta t}$ represents the cyclical movements in unemployment, and $\frac{\Delta y}{\Delta t}$ and $\frac{\Delta y^*}{\Delta t}$ are the proportionate rate of growth of current output and trend output, respectively. Therefore, in growth terms, the rate of unemployment is constant when the actual growth in a period is equal to the trend rate of growth.

This paper maintains that for several reasons the Okun's relationship is not a suitable place to start from in discussing the relationship between changes in unemployment and output growth. First, unemployment is generally measured in terms of number of people seeking work, and as such it takes no account of those who are working less hours than they would wish. Second, unemployment is the difference between employment and the workforce, and the Okun's relationship does not explicitly take into account movements into and out of the workforce. Furthermore, the Okun's relationship is between changes in unemployment and the output gap, namely deviations of current output from trend output. On that basis, policies designed to speed up growth on a trend basis would not in itself reduce unemployment as the actual period to period growth would fluctuate around the trend rate as before. In a near zero growth environment, the trend rate of growth would be near zero, and hence an actual rate of growth of output near zero would involve constant unemployment, and fluctuations of the actual rate of growth would lead to some ups and downs of unemployment averaging out around zero. Finally, the standard interpretation of the output gap is that trend output is supply determined, while current output is demand determined. In accordance with the demand-led growth model adopted in this paper, this interpretation is rejected, and with it the "gap model" specification of the Okun's relationship. Trend output could be, and often is, influenced by aggregate demand.

A link between the rate of growth and unemployment can be derived from the investment function. In this regard, Smith and Zoega (2009) maintain that macroeconomic data consistently shows a medium to long-term relationship between investment and unemployment over the last five to six decades. This stylised pattern applies to OECD countries, and it remains valid even after the 2007–2009 financial crisis (Katsimi and Zoega, 2018). Blanchard (2000, n.22) labelled the medium to long-term relationship between investment and unemployment the 'Modigliani Puzzle' (Modigliani, 2000). It is a puzzle since in the dominant mainstream literature, investment is a component of aggregate demand, and as such it cannot affect output and unemployment beyond the short term. By contrast, the long-term empirical relationship between investment and unemployment is theoretically consistent with the demand-led growth approach, where components of the aggregate demand like investment do affect economic growth and unemployment in the long term.

Smith and Zoega (2009) also show that long-term movements in investment and unemployment are empirically driven by a common factor, namely changes in the global expected rate of return on productive activities, which they consider a social product of animal spirits. This interpretation offers empirical support to the presence of the coefficient α_0 in equations (1) and (5) above. The coefficient α_0 represent animal spirits and the drive for growth based on expectations about the future state of the economy: lower animal spirits lead to lower capacity utilisation, hence lower investment and higher unemployment for a given capital stock, and consequently a lower rate of growth. A slower (higher) rate of growth would be associated with a slower (higher) rate of investment, which in turn would be associated with a slower (higher) level of aggregate demand, thereby lower (higher) capacity utilisation, and for given capacity higher (lower) unemployment.

Paid employment (measured in person hours) E is treated as directly related with the level of output Y. This translates into employment $E = \frac{uK}{v}\frac{1}{P_E}$,. This expression shows that the level of paid employment (employment for short thereafter) depends on the size of the capital stock K, capacity utilisation u, and labour productivity P_E.

Employment can also be expressed as $E = hfF$, where h is the average number of hours of paid work (on a period basis, say annual), and fF the workforce, namely f (say those over 16 years of age) is the proportion of the relevant population F. For simplicity, this formulation treats each hour of work as equivalent to all others, and hence no allowance is made for some hours being more productive than others (e.g. declining productive as more hours are worked in a day). The employment ratio is $\frac{E}{E^*}$, where E^* is full employment, which can be viewed in terms of h^*f^*F, where h^* represents full employment in terms of average hours worked, and f^*F is full employment in terms of people employed. The condition for full employment to be achieved and consistent with full capacity utilisation u^* is then:

$$h^*f^*F\,P_E = \frac{u^*K}{v} \tag{12}$$

Equation (12) indicates that as labour productivity P_E increases *ceteris paribus* the level of output would need to increase in order to maintain full employment. In a near zero growth scenario, this option is automatically ruled out. Therefore, this shifts the focus of the analysis on the reductions of the other components of the left side of equation (11). In terms of the full employed workforce f^*F, that is all people who are of working age, and able and willing to work, a neoclassical approach would think in terms of individual decisions on being employed dependent on the incentives for work, including the real wage, income if unemployed etc. A more socially oriented approach would acknowledge that there are social norms and expectations on which groups are regarded as being in the workforce, which may be reinforced by the law, e.g. at what age can a person take paid employment, to what age does full-time compulsory education extend, and who would receive income support in the event of unemployment. Similarly, the age at which people are supported to leave the workforce is governed by pension arrangements.

As for the average full employment hours for each worker h^*, in many industrialised countries, over the past couple of centuries increases in P_E have been translated in reductions in the average hours of employment for each worker (Golden and Figart, 2000), often as a result

[5] This paper prefers to use 'Okun's relationship' to the oft-used label of 'Okun's law', since what is involved is at most an empirical generalisation, and then one in which the key empirical coefficients are observed to vary considerably over time and between countries.

of union activism, new legislation or forms of collective pressure (Alesina et al., 2005; Skidelsky, 2019).

Work time reductions are also a familiar topic in the analyses of a near zero growth scenario, the so-called "sharing the work and sparing the planet" option (Hayden, 1999; Schor, 2010; Stagl, 2014). In a near zero growth scenario, lower levels of h^* mean that the total full employment hours of work are spread through the whole workforce, rather than being focused on the employed, while others remaining unemployed. Lower levels of h^* could take different forms, including changes in the average hours worked per week/month, weeks worked per annum, career breaks, sabbatical and parental leaves.

It is also relevant to consider the possible evolution of the labour productivity P_E. Insofar as research and development (R&D) continues, and there are 'learning by doing' effects, there would be new products and processes, and a consequent rise in P_E. The pace of the rise may well be much slower than hitherto. For instance, some R&D can lead to medical advances, which add to human welfare, but do not affect GDP. Nevertheless, P_E is likely to increase in future. Therefore, as long as there is a commitment to near zero economic growth, a continuing growth of labour productivity would require a decline in the other components of the left side of equation (12), namely the employed workforce and/or the average employment hours for each worker.

Two fundamental questions and a policy implication arise from the full employment condition represented in equation (12). These questions are increasingly touched upon in the ecological literature on post-growth visions of work (Mair et al., 2020). First, what are the processes by which the legal and social norms appropriate for full employment in a near zero economic growth scenario could be established? Secondly, what is the coercive force of those legal and social norms?

The first question touch on the issue of the transition to, rather than the consequences of, full employment in a near zero economic growth scenario. As such the issue is outside the main purpose of this paper. However, there are not what may be termed automatic, self-stabilising market forces which would bring full employment in a near zero economic growth scenario. A wide range of political and social actions are necessary to establish legal and social norms appropriate for such economic scenario. The difficulties of reaching any form of social consensus on what is to be regarded as full employment in a near zero growth scenario should also not be underestimated. In the other direction, in so far as there is some social consensus on the sustainable level of output, then there is a presumption that in general individuals over the course of their lifetime have to undertake the amount of employment implied by h^* and f^*F. The legal and social norms act to set the parameters on who is expected to work, in that society would not otherwise provide income to them.

The second question relates to the coercive force of legal and social norms. It is usual to treat these norms as being widely accepted, such that employees and employers fully adhere to them. However, the social and legal norms could in effect limit the number of paid hours of work an individual may wish to undertake or offer. For instance, employees may well seek to work longer hours than the established norms allow for, in order to generate a larger income and expand their consumer expenditure. In the model above, the overall level of employment hours are set by the level of aggregate demand, with the government budget deficit potentially playing the role of ensuring sufficient aggregate demand. However, individuals seeking to work more than the norms allow for may deny employment to others, and/or through expanded consumer expenditure, they could generate higher levels of aggregate demand and output. The same would also apply to employers seeking to increase hours of work in order to generate larger profits. This line of thought suggests that there would be economic pressures for higher output coming from some employees and employers, and further legal and social constraints may have to be placed on their behaviour in order to maintain full employment in a near zero economic growth scenario.

4. The rate of profit

The rate of profit is an important influence on the rate of investment as reflected in equation (1). At the macroeconomic level, Post Keynesian economists have found a positive relationship between the rate of profit and the rate of growth, a simple version being expressed in the 'Cambridge equation' (Pasinetti, 1962; see also Bortis, 1993) that the propensity to save out of profits times the rate of profit is equal to the rate of growth of the capital stock.

From the model above, the following relationship linking the rate of profit and rate of growth can be obtained for a closed economy without a government (or with balanced budget):

$$rn = \frac{g + \beta_2\delta - \beta_0 - \frac{\beta_2}{v}u}{(\beta_1 - \beta_2)} \tag{13}$$

Placing β_0 and β_2 equal to zero, this would give the 'Cambridge equation'. When g is zero or very small, then the rate of profit could be expected to be very small, and depending on the relative sizes of the parameters involved, and whether β_0 is positive or negative, the rate of profit could even be negative. The rate of profit is then positively related with the rate of growth, negatively related with propensity to save out of profits, and positively related with propensity to save out of wages. In the range where the solution of equation. (13) involves a non-negative value for capacity utilisation, then the rate of profit is positive related with the rate of growth.

This simple expression raises a particularly important issue, namely the implications of a near zero growth rate on the overall rate of profit. A rate of profit above zero would seem to be a fundamental condition for the continuation of capitalism. Yet, a near zero growth could involve that. The implication of equation (13) is that a lower growth rate would involve a lower rate of profit, unless that is offset by some other changes, such as a rise in the propensity to save out of wages.

An alternative scenario would be the use of budget deficit to maintain aggregate demand, and thereby the rate of profit. Equation (14) shows the rate of profit under the conditions of zero growth, with a budget deficit set to ensure full capacity utilisation:

$$rn = \frac{d** + \beta_2\delta - \beta_0 - \frac{\beta_2}{v}u*}{(\beta_1 - \beta_2)} \tag{14}$$

The rate of profit would then be raised through the scale of the budget deficit, where the size of the budget deficit would be also dependent on the relative propensities to save.

A budget deficit required to sustain full employment and to absorb net savings, then the continual total budget deficit (relative to GDP) d run by government would lead to the debt ratio converging on $\frac{d}{g}$ where g is the nominal growth rate. A zero growth rate would involve an ever rising debt ratio, which leads to rising household wealth, and may eventually impacts on savings decisions (e.g. Cahen-Fourot and Lavoie, 2016). Insofar as rising household wealth diminishes the effective propensity to save out of income, then the savings rate would tend to fall, and the need for a budget deficit to sustain full employment diminish.

Under zero growth, the nominal growth rate equals the rate of inflation, and as such a positive rate of inflation would enable the debt ratio converging on the deficit divided by the rate of inflation. Under the view that the nominal rate of interest would be at least at the level of the rate of inflation, then the total budget deficit would become composed of interest payments and a primary budget surplus.

There would be effect on the distribution of income as the interest payments on government debt rise, and would tend to favour the recipients of profits rather than the recipients of wages to the extent to which the propensity to save out of profits is greater than the propensity to save out of wages.

5. Conclusions

The main goal of this paper has been the analysis of the macroeconomic conditions for near zero economic growth, with a particular focus on the role of investment, savings and the government budget deficits, in a world characterised by geopolitical risks and conflicts. The analysis is based on a demand-led growth model, which has several attractive features that make the model well suited for a macroeconomic analysis of economic growth driven by ecological and environmental concerns. The paper explores the effects of near zero growth on paid employment, government finances, and the rate of profit. The main results of the analysis are as follows.

A level of net investment compatible with zero growth would lead to a lower level of paid employment in terms of total hours worked. The effects on the distribution of work and the level of unemployment of people would depend on changes to working time, whether in terms of average hours worked per annum, or ages of entry into, and exit from, the work force. Changes in working time enabling full paid employment of people would not be achieved through market mechanisms, and would have to come through social actions and legislation.

Insofar as the zero level of net investment is not matched by saving, then a government budget deficit would be required to underpin capacity utilisation, and full paid employment. However, in a near zero growth economy there may be long-term limits on the use of budget deficits in that public debt to GDP ratio would rise continuously, since the debt is increasing while GDP is not. If the private sector wishes to continue to save and to accumulate government bonds, the budget deficit can, and indeed be required to continue. However, if consumption rises relative to income due to the stock of government bonds rising, which could be regarded as consumption out of wealth, then the need for a government budget deficit would decline, and a balanced budget consistent with full employment could be achieved.

There is a close relationship between the rate of profit and the rate of growth, which in its strongest form has been summarised in the so-called "Cambridge equation". From that perspective, near zero growth would mean a substantial lower rate of profit than hitherto. The drive for growth comes from the drive for accumulation and profits. Therefore, the achievement of a near zero growth of GDP economy would require the dampening of the drive for profits and for accumulation.

The application of these theoretical conditions requires a level of cooperation between and within countries, which is much more difficult to reach in presence of the many on-going conflicts and heightened geopolitical risks. Interestingly, there is increasing evidence that threats of adverse geopolitical events lead to at least as much decline in real activity, low stock returns, and disruptive movements in capital flows as actual conflicts (Caldara and Iacoviello, 2022).

Conflicts involve destruction of capital, and investment has to be devoted to its replacement. In the model of this paper, zero net investment (i.e. gross investment minus depreciation) was viewed as necessary for zero growth. In the presence of conflicts, destruction of capital stock adds to the depreciation of capital stock, and a higher level of gross investment would be required to offset that destruction. The higher requirements for gross investment alongside resources diverted to the highly carbon-intensive defence sector make the achievement of zero and sustainable growth more difficult. Yet, there is no country secure from conflicts and geopolitical risks without an ecologically sustainable use of the natural resources. The theoretical conditions discussed in this paper could serve as "condiciones sine quibus non" to ecological sustainability, while navigating the complexities and uncertainties caused by the many on-going conflicts and heightened geopolitical risks.

Finally, there are two main policy implications that can be drawn from the analysis presented in the paper. First, legal and social norms will play a significant role in the transition to, and maintenance of, a near zero economic growth. Policy makers will have therefore a considerable role to play in establishing, and give coercive force to, legal and social norms that will aim to guarantee, among other things, full paid employment and sustainable consumer expenditure in a near zero growth economy. Second, industrial policy needs to go far beyond the current approach of solving market failures, controlling monopoly, and promoting competition (Sawyer, 2021). Policy makers will have to redefine industrial policy (with supporting fiscal and monetary policies) through a combination of investments in line with zero growth, and of investments that are environmentally friendly (e.g. focused on improving energy efficiency and the development of renewable energy sources).

Authos

The two authors were equally involved at all stages of the conceptualisation of the paper and its writing.

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.

Data availability

No data was used for the research described in the article.

References

Akkerman, M., Burton, D., Buxton, N., Lin, H.-C., Al-Kashef, M., de Vries, W., 2022. Climate Collateral: How Military Spending Accelerates Climate Breakdown. Transnational Institute. https://www.tni.org/en/publication/climate-collateral.
Alesina, A., Glaeser, E., Sacerdote, B., 2005. Work and Leisure in the U.S. And Europe: Why So Different. NBER Working Paper Series No. 11278 (Cambridge, MA, USA).
Alqahtani, A., Klein, T., 2021. Oil price changes, uncertainty, and geopolitical risks: on the resilience of GCC countries to global tensions. Energy 236, 121541.
Antal, M., 2014. Green goals and full employment: are they compatible? Ecol. Econ. 107, 276–286.
Arestis, P., Sawyer, M., 2009. Path Dependency and Macroeconomics. Palgrave Macmillan, Basingstoke.
Baddeley, M.C., 2003. Investment Theory and Analysis. Palgrave Macmillan, New York.
Baddeley, M.C., 2017. Keynes' psychology and behavioural macroeconomics: theory and policy. Econ. Lab. Relat. Rev. 28, 177–196.
Baran, P., Sweezy, P., 1966. Monopoly Capital. Penguin Books, Harmondsworth.
Barro, R.J., Sala-i-Martin, X., 2004. Economic Growth, second ed. MIT, Cambridge, MA.
Binswanger, H.C., 2013. The Growth Spiral: Money, Energy, and Imagination in the Dynamics of the Market Process. Springer, Berlin.
Binswanger, M., 2009. Is there a growth imperative in capitalist economies? A circular flow perspective. J. Post Keynes. Econ. 31 (4), 707–727.
Binswanger, M., 2015. The growth imperative revisited: a rejoinder to Gilányi and Johnson. J. Post Keynes. Econ. 37, 648–660.
Blanchard, O., 2000. The Economics of Unemployment: Shocks, Institutions, and Interactions. Lionel Robbins Lectures. MIT Press, Cambridge, MA. October 2000.
Bortis, H., 1993. Notes on the Cambridge equation. J. Post Keynes. Econ. 16, 105–126.
Cahen-Fourot, L., Lavoie, M., 2016. Ecological monetary economics: a post-Keynesian critique. Ecol. Econ. 126, 163–168.
Caldara, D., Iacoviello, M., 2022. Measuring geopolitical risk. Am. Econ. Rev. 112 (4), 1194–1225.
Chang, T., Graff Zivin, J., Gross, T., Neidell, M., 2019. The effect of pollution on worker productivity: evidence from call center workers in China. Am. Econ. J. Appl. Econ. 11 (1), 151–172.
Colscito, R., Hoffman, B., Phan, T., 2019. Temperature and growth: a panel analysis of the United States. J. Money Credit Bank. 51 (2–3).
Copley, J., 2023. Decarbonizing the downturn: addressing climate change in an age of stagnation. Compet. Change 27, 429–448.
de Oliveira, G., Lima, G.T., 2022. Economic growth as a double-edged sword: the pollution-adjusted Kaldor-Verdoorn effect. Ecol. Econ. 199, 107449.
Douthwaite, R., 2000. The Ecology of Money. Green Books, Devon.
Dutt, A.K., 2012. Kaleckian growth theory: an introduction. Metroeconomica 63, 1–6.
Farley, J.C., Burke, M., et al., 2013. Monetary and fiscal policies for a finite planet. Sustainability 5, 2802–2826.
Fontana, G., Sawyer, M., 2016. Towards Post Keynesian ecological macroeconomics. Ecol. Econ. 121, 186–195.
Fontana, G., Sawyer, M., 2022. Would a zero-growth economy be achievable and be sustainable? Eur. J. Econ. Econ. Pol.: Intervention 19, 89–102.
Golden, L., Figart, D.M., 2000. Working Time: International Trends, Theory and Policy Perspectives. Routledge, London.
Gordon, R.J., 2015. Secular stagnation: a supply-side view. Am. Econ. Rev. 105 (6), 54–59.

Gordon, R.J., 2012. Is US economic growth over? Faltering innovation confronts the six headwinds. NBER Work. Pap. No. 18315. Available online at: http://www.nber.org/papers/w18315.pdf.
Graff Zivin, J., Neidell, M., 2012. The impact of pollution on worker productivity. Am. Econ. Rev. 102 (7), 3652–3673.
Graziani, A., 2003. The Monetary Theory of Production. Cambridge University Press, Cambridge.
Ha, L.T., 2023. A wavelet analysis of dynamic connectedness between geopolitical risk and renewable energy volatility during the COVID-19 pandemic and Ukraine-Russia conflicts. Environ. Sci. Pollut. Control Ser. 1–16.
Hansen, A.H., 1939. Economic progress and declining population growth. Am. Econ. Rev. 29 (1), 1–15.
Hayden, A., 1999. Sharing the Work, Sparing the Planet: Work Time, Consumption, and Ecology. Zed Books, London.
Hickel, J., 2020. The sustainable development index: measuring the ecological efficiency of human development in the Anthropocene. Ecol. Econ. 167, 106331.
IMF, 2018. IMF World Economic Outlook. The Global Recovery 10 Years after the 2008 Financial Meltdown, (Chapter 2).
Jackson, T., 2009. Prosperity without Growth: Economics for a Finite Planet. Earthscan, London.
Kahn, M., Mohaddes, K., Ng, R.N.C., Pesaran, M.H., Taissi, M., Yang, J.-C., 2021. Long-term macroeconomic effects of climate change: a cross-country analysis. Energy Econ. 104, 105624.
Kallis, G., 2018. Degrowth. Agenda Publishing, Newcastle upon Tyne.
Katsimi, M., Zoega, G., 2018. The Modigliani Puzzle Revisited: a Note. CESifo Working Paper Series No. 6833, Available at: SSRN: https://ssrn.com/abstract=3129986.
Lietaer, B., Arnsperger, C., Goerner, S., Brunnhuber, S., 2012. Money and Sustainability: the Missing Link. Triarchy Press, Axminster.
Mair, S., Druckman, A., Jackson, T., 2020. A tale of two utopias. Ecol. Econ. 173, 106653.
Malmaeus, M.J., Alfredsson, E.C., 2017. Potential consequences on the economy of low or no growth – short and long term perspectives. Ecol. Econ. 135, 57–64.
Modigliani, F., 2000. Europe's Economic Problems. Prepared for testimony before the Monetary Committee of the European Central Bank.
Okun, A., 1962. Potential GNP: its Measurement and Significance. Proceedings of the Business and Economic Statistics Section of the American Statistical Association, pp. 98–104.
Otero, I., Farrell, K., Pueyo, S., Kallis, G., et al., 2020. Biodiversity policy beyond economic growth. Conserv. Lett. 13 (4), e12713.
Pasinetti, L., 1962. Rate of profit and income distribution in relation to the rate of economic growth. Rev. Econ. Stud. 29, 267–279.
Perman, R., Stephen, G., Tavéra, C., 2015. Okun's Law: a Meta-Analysis, vol. 83. Manchester School, pp. 101–126.
Pollin, R., 2018. De-growth vs a green new deal. N. Left Rev. 112, 5–25.
Rogaly, K., 2023. The Asset Manager Arsenal: Who Owns the UK Arms Industry? Report. Common Wealth, UK.
Sawyer, M., 2021. Financialisation, industrial strategy and the challenges of climate change and environmental degradation. Int. Rev. Appl. Econ. 35 (3–4), 338–354.
Schor, J.B., 2010. Plenitude: the New Economics of True Wealth. The Penguin Press, New York.
Setterfield, M., 2010. Handbook of Alternative Theories of Growth. Edward Elgar, Cheltenham.
Skidelsky, R., 2019. How to Achieve Shorter Working Hours (Progressive Economy Forum Report).
Smith, R.P., Zoega, G., 2009. Keynes, investment, unemployment and expectations. Int. Rev. Appl. Econ. 23, 427–444.
Solow, R.M., 1956. A contribution to the theory of economic growth. Q. J. Econ. 70, 65–94.
Stagl, S., 2014. Ecological macroeconomics: reflections on labour markets. Eur. J. Econ. Econ. Pol.: Intervention 10, 171–181.
Steindl, J., 1952. Maturity and Stagnation in American Capitalism. Basil Blackwell, Oxford.
Summers, L., 2014. U.S. economic prospects: secular stagnation, hysteresis, and the zero lower bound. Bus. Econ. 49, 66–73.
Summers, L., 2016. The age of secular stagnation. Foreign Aff. 15 (February).
Tavani, D., Zamparelli, L., 2017. Endogenous technical change in alternative theories of growth and distribution. J. Econ. Surv. 31, 1272–1303.