Joined up Economics:

The Political Economy of Sustainability, Financial Crises, Wages, Equality and Welfare

Brian Heatley

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We will publish a series of reports and briefings on different subjects. We do not intend to have a party line, but rather to stimulate debate and discussion.

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Lorton Barn, Lorton Lane, Weymouth, Dorset DT3 5QH, United Kingdom.
+44 (0)1305 816514
info@greenhousethinktank.org
http://www.greenhousethinktank.org

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Green House Post-growth Project

Everyone agrees that we are in the midst of a massive financial and economic crisis. We have suffered the biggest crash since the 30s, and it may get far bigger yet. How ought this ongoing crisis to be understood, and resolved?

There is the mainstream view: we have vast government deficits, and stagnant economies. We have a dire need for economic growth – and a deep-set need for austerity, bringing with it massive cuts in public services.

But what if that diagnosis, which reflects mainstream wisdom, is all wrong? What if the crisis that we are currently experiencing is one which casts into doubt the entire edifice of capitalist economics, which sets growth as the primary objective of all policy? What if the fight between those who say that without austerity first there can be no growth and those who say that we must invest and borrow more now in order to resume growth is a false dichotomy – because both sides are assuming 'growthism' as an unquestioned dogma?

The aim of the Green House Post-growth project is to challenge the common sense that assumes that it is 'bad news' when the economy doesn't grow and to analyse what it is about the structure of our economic system that means growth must always be prioritised. We need to set out an attractive, attainable vision of what one country would look like, once we deliberately gave up growth-mania – and of how to get there. And we need to find ways of communicating this to people that make sense, and that motivate change.

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Contents

The author

Brian Heatley is a retired senior civil servant, former Policy Coordinator of the England and Wales Green Party and Secretary of Green House. His academic background is in mathematics and history. He has worked alongside economists for much of his life, but is not one himself, so is delightfully unencumbered by the constraints of too much conventional economic knowledge.

Acknowledgements

I am grateful in particular to Victor Anderson and Molly Scott Cato for extensive comments throughout. And I am grateful to my other Green House colleagues for their comments, to Andy Dobson for his encouragement and also to my good neighbour David Smith. But I have ignored some of the no doubt wise things all these people have said, and in the end the responsibility is mine.

Summary

The conventional view is that the UK economy is in a crisis of stagnation, unemployment, debt (especially government debt) and austerity. Growth in GDP is seen as the only answer. I argue that growth is not the answer: it is neither possible, necessary nor desirable.

I start by reviewing the last sixty years of punctuated growth in the UK economy.

The resource and environmental limits to growth mean that growth in material throughput in the world economy will end in the next 10-15 years. While increased productivity will mitigate this, such improvements will not be sufficient to prevent the end to growth in real GDP. The UK economy will not be able to resist this overall trend.

With the end of growth, the share of wages in GDP versus profits will matter more than ever. The share depends on politics not just economics. A smaller share for wages increases inequality. A low share for wages also makes the economy more financially unstable. Welfare is more damaged by inequality than lower GDP per head.

The present UK recession is mainly a financial crisis, prompted by high oil prices in 2007/8, and after 2010 deepened by cuts to government spending. It can be analysed by a catastrophe theory of credit creation allied to Werner's theory of the consequences of credit creation. Substantial growth will not return in the next few years anyway, quite apart from the material limits to growth, due to the debt overhang.

If there is no change in policy my simulations suggest that the UK economy will stagnate for the next few years, inequality will continue to increase and welfare to decline. In the medium term we will become increasingly dependent on expensive fossil fuel imports and our economy will decline further, with adverse consequences for welfare in a world suffering from severe climate change and other environmental degradation.

The alternative is to invest heavily for the next few years in non-fossil fuel energy resources, introduce controls on credit, gradually shorten the working week initially without wage reductions to both prevent unemployment and raise the share of wages and reduce inequality, and limit the use of materials. In the medium term this may lead to stabilisation of the level of GDP and end unemployment, but in the longer term to gradually reducing GDP. Welfare however will be increased.

I conclude that long term sustained real growth in GDP is over forever, *whatever* purely economic policies we adopt. With the end of growth, the major way to improve our society is not growth but to reduce inequality, and the simple way to do that is to increase the share of wages. Finally, there is no real conflict between the various proposals for a green new deal and the end of growth, provided those proposals are aimed at preparing for the post growth future. But the idea that Green Keynesianism will lead to an era of sustained real green growth in GDP is an illusion.

1. Introduction

1.1 Prologue

Britain's Royal Society is not known for its pronouncements on economics; it largely sticks to science. But its recent report, People and the Planet,[1] is pretty blunt about what we need to do with developed economies like our own:

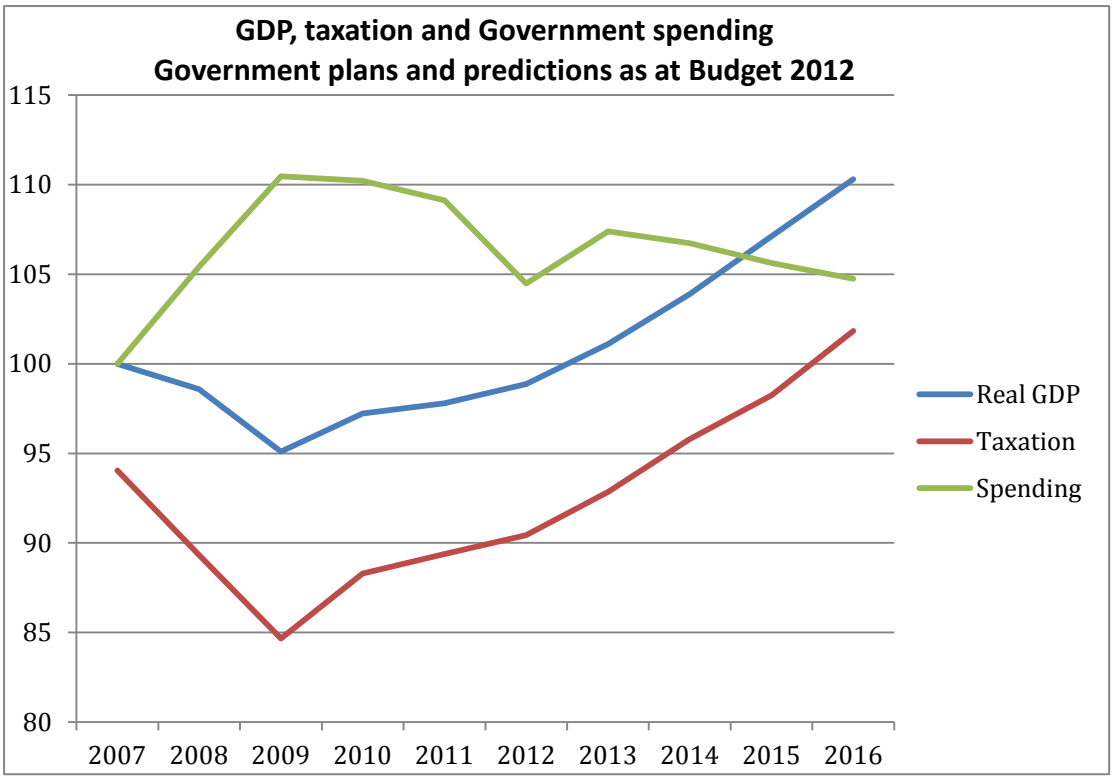
'*in the most developed and the emerging economies unsustainable consumption must be urgently reduced. This will entail scaling back or radical transformation of damaging material consumption and emissions and the adoption of sustainable technologies, and is critical to ensuring a sustainable future for all. At present, consumption is closely linked to economic models based on growth. Improving the wellbeing of individuals so that humanity flourishes rather than survives requires moving from current economic measures to fully valuing natural capital. Decoupling economic activity from material and environmental throughputs is needed urgently…'*

The same message, with an additional warning about population, was then endorsed in June 2012 by the global network of national science academies.[2] The aim of this present report is to draw out the economic implications of this scientific consensus.

1.2 The short term figures and the alleged need for growth

The UK economy is in crisis. Growth in Gross Domestic Product (GDP)[3] has stalled, with the economy contracting almost 6% during 2008 and 2009. Despite the 1.0% growth in the third (Olympics) quarter,[4] the Bank of England expects zero growth overall in 2012.[5] Unemployment (in terms of those on Jobseeker's Allowance) has risen to over 2.5 million, over 8% of the labour force, including over one million 18-24 year olds out of work.[6] The parallel fall in tax yield has led to a huge gap in the government's budget, to be met in the short run by borrowing, but also by cutting public services. The basic prescription for getting out of this mess is shared across the political spectrum: growth needs urgently to be restored, unemployment will fall, tax revenues will rise and the government's deficit will be met by rising tax revenues. But this will take time and in the meantime we need austerity, which means cutting public services. If there is a mainstream debate, it is about the merits of the government taking greater risks to promote growth through increased spending and borrowing, and simultaneously reducing the need for austerity.[7] Three other debates are marginalised: how to react to the emerging environmental crisis, how to stabilise our crisis prone financial system and how to stem the rising tide of inequality.

The figures underlying the crisis are illustrated in the following graph of real GDP, taxation and public spending since the crisis began in 2007. Up to 2010 this graph reflects actual history, while from 2011 it is Government prediction as set out in Spring 2012 in the Budget.



Source: author's calculations based on 2012 Budget Report.

The blue line is real GDP, indexed to 100 for 2007. Real GDP had grown by an average of 2.8% per annum in the ten years up to 2007. GDP fell by 1.1% in 2008, and more substantially, by 4.4% in 2009. There was 1.8% growth in 2010, but the government assumption for 2011 reflected in this graph was in fact a bit high. With a 0.3% fall in the first quarter of 2012, the assumption of 0.8% growth in that year now also looks much too high. Subsequent years in this graph assume growth will then recover at 2.0 to 3.0%. Later I will argue that this is both unrealistic and unwise.

The green line is real public spending, also indexed to 100 in 2007. In 2008 and 2009 under Labour government plans it was growing at around 5% per year. In 2010 it began to decline, with a sharp cut in 2012,[8] and overall with spending falling from 48% of GDP in 2009 to a projected 39% in 2016. It remains to be seen if this can be achieved.[9]

The red line is real taxation, on a scale comparable with the spending. Taxation fell about twice as sharply as GDP in 2008 and 2009. The rise after 2010 depends upon the increased GDP, and includes a little in tax increases (mainly VAT).

The gap between the spending (green) and taxation (red) lines is the deficit to be met by government borrowing. Taxation was already below spending in 2007, though no one seemed too worried about the gap.[10] It widened to £166Bn in 2009, and is now planned slowly to narrow.[11]

The purpose of this paper is to argue that growth is not the answer, in that it

is neither possible because of the financial and environmental crises, and neither necessary nor desirable in terms of improving welfare.[12] But before I start, there are a couple of methodological notes.

1.3 Data rather than theories

Much of orthodox economics is a largely deductive activity based on assumptions that are manifestly wrong, such as the notion that economic actors have perfect information,[13] or that they will always act rationally. On these bases, policy conclusions are usually (but not always) correctly deduced as a matter of logic, but of course that does not mean that the conclusions themselves are either correct or wise.

I do not share this approach, and instead I will try where possible to use real data to suggest that certain fairly simple propositions (essentially listed in the Summary above) are at least plausible.[14] Only then are the propositions combined deductively to simulate the economy as a whole and to suggest policy conclusions. But the bane of economics is avoided – making an assumption principally to make the mathematics easier, even if the economics or social reality of the assumption is daft.

1.4 The UK, not the world

Secondly, this is a paper mainly about the UK economy, not about the world.

The UK economy is extremely open, with high levels of imports (including imports of food and natural resources) and exports, and a globally significant finance sector. But, with the exception of the issue of the availability of natural resources to the UK, where I start below from an analysis of world supply and demand, I have ignored this, and treated the UK as if it were in isolation. This is a serious deficiency, particularly given my concern not to make unrealistic assumptions, but one has to start somewhere.

Moreover, three particular points that are not mentioned again are set out below but are nevertheless extremely important:

- the overwhelming need for economies in the poorer parts of the world to grow in material terms and meet the basic needs of all their citizens. In particular the 1.3 billion people living on less than US$1.25 a day need to be lifted out of the direst absolute poverty.[15] This means for the UK that we will need to meet even more stringent targets on material use and pollution to make room for this growth;

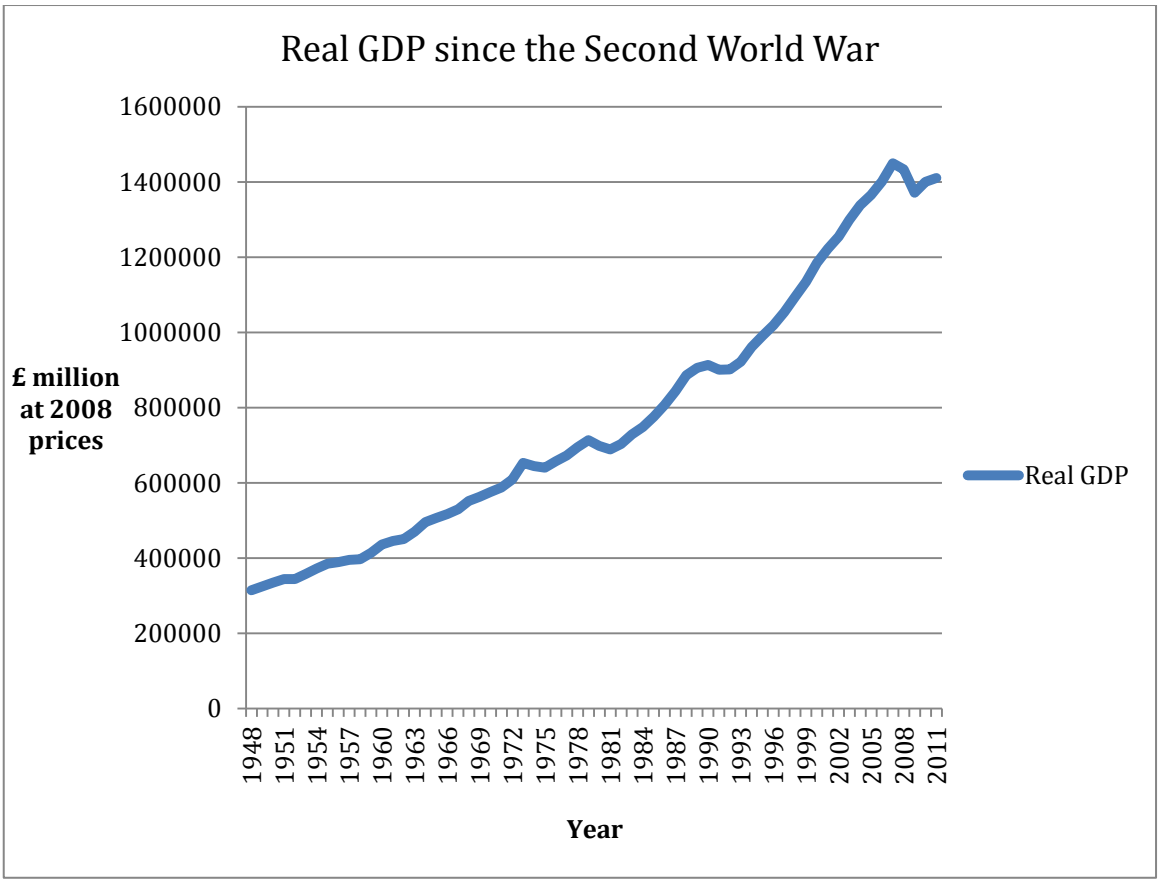
- the fact that many of the policies suggested at the end of the paper could be de-stabilising if implemented unilaterally, and that the political challenge of securing international agreement is immense. Our fear is that in practice we will only see the construction of the necessary new international economic order after a devastating world resource war; and

- the need to localise the UK economy and restore its manufacturing and agricultural base to make it more resilient and less dependent on what is going on elsewhere.

2. The UK economy in the last 60 years

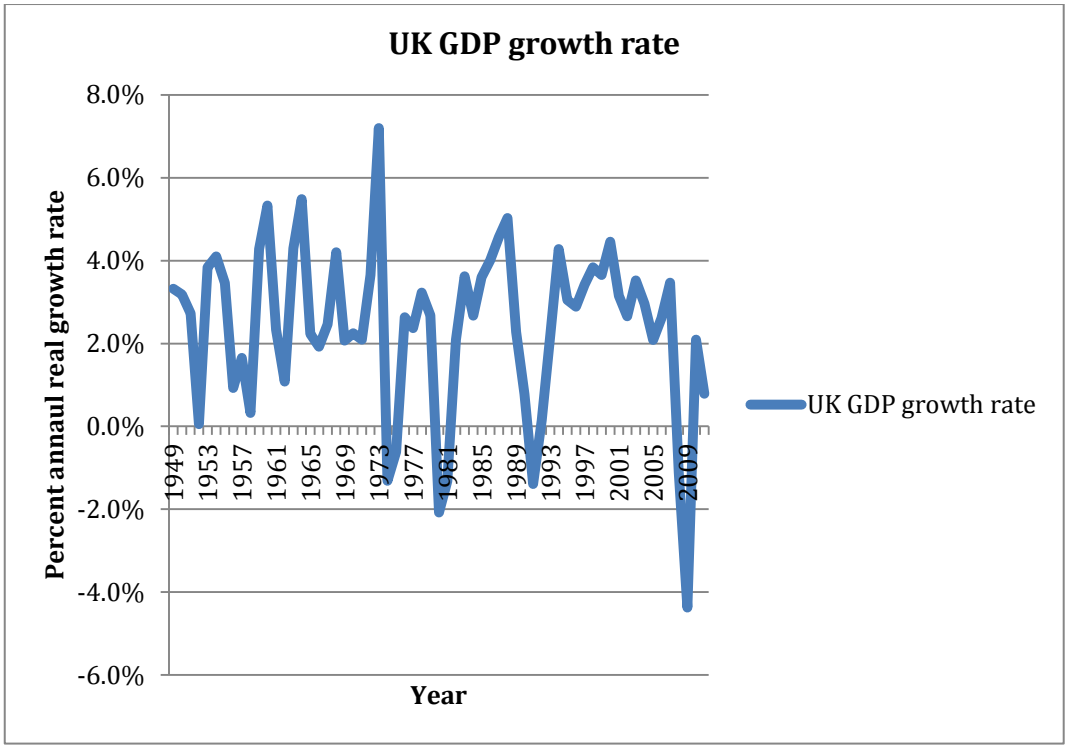
2.1 Overview

Our most basic experience of the economy is that it grows.[16] Successive generations are richer than their parents, and this GDP growth underlies our very idea of progress. And in particular, the growth since the Second World War has been substantial, though far less in the UK than in some other countries. The graph below shows this basic experience:



Source: author's calculations and ONS 2011b.

If the first major feature of the history of GDP is its growth, then the second feature is its instability. Economics has many unsolved problems, but one of the most contentious areas is why there are fluctuations in output, generally around a trend growth rate, that affect most sectors of the economy simultaneously. This is usually called the trade or business cycle. There is no serious argument that such fluctuations actually occur; the issue is what causes them. The graph of the GDP growth rate since the Second World War looks like this:



Source: author's calculations and ONS 2011b.

In particular there were major checks to growth in the early 1970s, around 1980, in the early 1990s and most recently from 2007 onwards.

I will in sections 3 and 4 below look at two other longer term features of the economy, how it uses material resources, especially energy, and how the share of wages and profits changes, and with it the level of economic inequality. But I first turn to the causes of growth and instability.

2.2 Why does the economy grow?

Economists have spent some time asking why the economy grows. The focus of those enquiries is nearly always on the process of production. In that area three main components of growth are recognised

- population growth, very important in the early industrial revolution, and still not unimportant. The UK population was 50 million in 1950, 59 million 2000 and is projected to be 78 million by 2050, an average annual rate of growth of almost 0.5%; [17]

- growth in the use of machinery, employing increasing amounts of energy and materials, raising labour productivity; and

- innovation, including not just better ways of doing things, but finding new things to do, like telephony.

Early theories of growth tended to concentrate on plant and machinery; Marx called his magnum opus Capital, not Innovation, while the first mathematical growth model, the 1939 Harrod-Domar model,[18] has its emphasis on saving to invest in more machinery. More modern accounts tend to stress the importance of innovation, competition, or the role of institutions.[19]

A further reason a capitalist economy's GDP grows is its tendency to bring into the market activities that previously were not within the market. The classic example is that of enclosures that transformed land held in common mainly for subsistence farming into privately owned land producing produce for the market. More modern examples mainly involve commodifying work formerly done mainly by women, such as the commodification of cooking through manufactured foods and ready meals, or the creation of a whole market in social care that was largely carried out before in the family. These enclosures do not create any additional value, but they do increase GDP through commodifying the activities involved.[20]

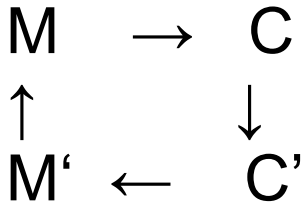
However, although the capacity for greater production is *necessary* for an economy to grow, it is not *sufficient*, and a range of other stages in the economic cycle must also operate smoothly if growth is to take place. I will examine them below in the next sub-section (2.3) in our discussion of the stability of the economy, since it is failures in these factors that lead to interruptions to growth.[21]

2.3 Why is the economy unstable?

While our focus is on the longer term prospects for the economy, the business cycle is still important. First, the current concerns over growth, debt and austerity have arisen precisely because the economy has recently suffered a slowdown. Second, any recession, or even worse depression, causes major human misery in terms of unemployment and anxiety (see the welfare section 6.2 below). Third there must be concern whether an economy that did not prioritise growth can be stable, coupled with an interest in the conditions that might make it so.

Theories of the business cycle tend to pick up on some part of the cycle of production and consumption, and then imply that *all* interruptions to growth come from that part. Thus some economists point to aggregate demand, and suggest that a slump is due to a failure of some part of aggregate demand, such as the government failing to spend enough. Others focus on the supply of credit, and suggest we get a slump when that fails. Those more politically minded of both right and left look for disruptions in the relative sizes of wages and profits. This is complicated by the fact that a failure in one of these parts may well provoke a failure in another part; lack of credit creates insufficient aggregate demand for example.

The view I take here is that any or all of these explanations may be true at some particular time. To justify that I consider David Harvey's account (ultimately derived from Marx) of how the process of accumulation can go wrong at various points in the cycle of production; or to put it another way every part of the cycle of production has to work properly for growth to take place.[22] Broadly following Marx and Harvey we can think of the activities of a capitalist firm as going through the following cycle: [23]



where each arrow represents a part of the process:

M → C is turning money into raw materials, a provision for wages, and machinery, that is the process of deciding what and how much to make and investing to do so;

C → C' is the production process (and raw materials, labour and machinery C are combined to produce different commodities C'), and in particular determines wages;

C' → M' is selling the product, that is changing the commodities C' into money, and determines prices; and

M' → M is the process of financial intermediation, that is profits are retained or invested elsewhere, money is paid back to or borrowed from the bank.[24]

Shocks to the system can arise at any stage around this cycle, and the shocks at each stage give rise to different theories of the business cycle. In contrast, each point in the cycle has to work for growth, and accumulation, to take place.

Thus, M → C can give rise to three considerations:

- those in control of businesses will normally want to expand their operations. For a modern shareholder owned capitalist firm this is normally the prime reason for their existence. Thus the default assumption is that businesses will invest and expand;

- however, businesses may not be able to buy the inputs they need, due to outright shortages or price hikes. The 1973 oil crisis was such a problem. Our analysis of raw material availability and prices suggests that this will increasingly be a problem in the cycle; and

- despite the default assumption of expansion, businesses may be unwilling to invest in either new equipment or in production itself because they foresee problems further along around the cycle.

C → C' is the actual production process. One main thing and various miscellaneous ones can go wrong here:

- the workers may refuse to work for the wages offered, resulting in strikes or lock outs, which disrupt production, or higher wages and lower profits. The latter result in less willingness for capitalists to invest in production, but maybe higher aggregate demand; and

- there may be some other physical or economic disruption to the production process, such as accidents, environmental damage or natural disasters (eg BP's Gulf disaster, climate change disrupting food production or Japan's tsunami), changes in regulations (a minimum wage), or war or civil disturbance.

The production process also generates an important political cause for growth. Modern democratic governments in capitalist economies assume that full time full employment of the entire labour force is a good thing, largely because the catastrophe of less employment tends otherwise to fall on the relatively small group who are full time unemployed.

C' → M' is selling the product. The crucial ingredient here is the level of aggregate demand, which itself

depends on consumer incomes, ability to borrow, saving and confidence, Government spending, the level of investment in plant and materials in M → C above and the balance of exports and imports. There must be sufficient expansion of aggregate demand to buy the increased output, whether domestically or as exports. Or to put it another way, consumers must be rich enough to continue to expand their purchases. And individual producers may simply get it wrong, producing something few consumers want.

Finally, there is M' → M which I have labeled financial intermediation. This is extremely complex, with a profound interaction in particular with aggregate demand. There needs to be a system to extend credit to fund existing production, expansions of production or new types of production. Financial instability can interfere with growth.

Given this overall analysis, it is surely entirely possible that there are many ways the economy can receive negative shocks, and different ones may be important at different times and in different places. This makes modeling and prediction extremely difficult. If the very simple model I will be proposing later seems to have picked on some particular theories it is because they seem important *here and now*, not because they are universally valid. And the things that seem most important here and now are three:

- the effects of increasing resource scarcity and the effects of having to avoid and adapt to climate change;

- the declining share of wages and the effects of that on inequality, aggregate demand and stability; and

- the over-expansion of the financial system and the huge levels of indebtedness.

I turn to each of these successively in sections 3, 4 and 5 that follow.

3. Limits to Growth

3.1 Output and resources

A major problem of most existing theories of macroeconomics is that they take no account of the finite nature of the planet's resources.[25] This is encapsulated in how these theories specify the production function; that is to say the function that predicts the overall capacity of the economy to produce GDP from knowledge of the level of various resources.

In the short run, say over around one year, it suffices generally to assume that actual GDP is simply proportional to the number of people employed, and that productive capacity is the GDP that will be achieved at full employment. This is the basic assumption that was made by Keynes in developing his theory of the short run equilibrium of the economy.[26] As an equation, we might write

$$Y = f(L)$$

where Y is real GDP and L is employment, and Y is normally assumed to be simply proportional to L.[27] In practice this assumes that in the short run there will be no significant change in plant and machinery or technology, and that production will not be altered by changes in the supply of materials or energy. However, the strength and ubiquity of the basic relationship is quite clear to every person unfortunate enough to become unemployed at a time of recession, even if there is normally a bit of a lag between the decline in GDP and the onset of unemployment.

In order to consider economic growth, which necessarily involves a longer time period, economists have normally supplemented the production function to make it a function of both employment L and physical capital stock, K giving

$$Y = f(L, K)$$

The physical capital stock K stands for the actual physical amount of plant and machinery.[28] However, because there are many different kinds of physical plant it is *measured* in money in real terms; this is different from the idea of capital as a sum of money that might or might not be invested.[29] Various functional forms are assumed for how production depends on K and L, usually to make the mathematics easier rather than because of any very close correlation with reality.

However, for our purpose I want to emphasise the importance of two other factors. The first is material natural resources, M. The second is one particular natural resource, energy, E, since it is particularly important and pervasive as an input and because its supply is constrained, both by finite physical resources and the costs, through climate change if it is derived from fossil fuels, of its use. Thus, I will consider the production function as taking the general form

$$Y = f(K, L, M, E)$$

where K is physical capital, L is labour, M is materials used apart from energy resources and E is energy.[30]

So what is an appropriate functional form for this relationship? [31] Rather than impose some ideal functional form, I start by looking at the actual UK economy in the last 15 years, and the amounts of GDP (measured in 2008 terms) produced by fixed

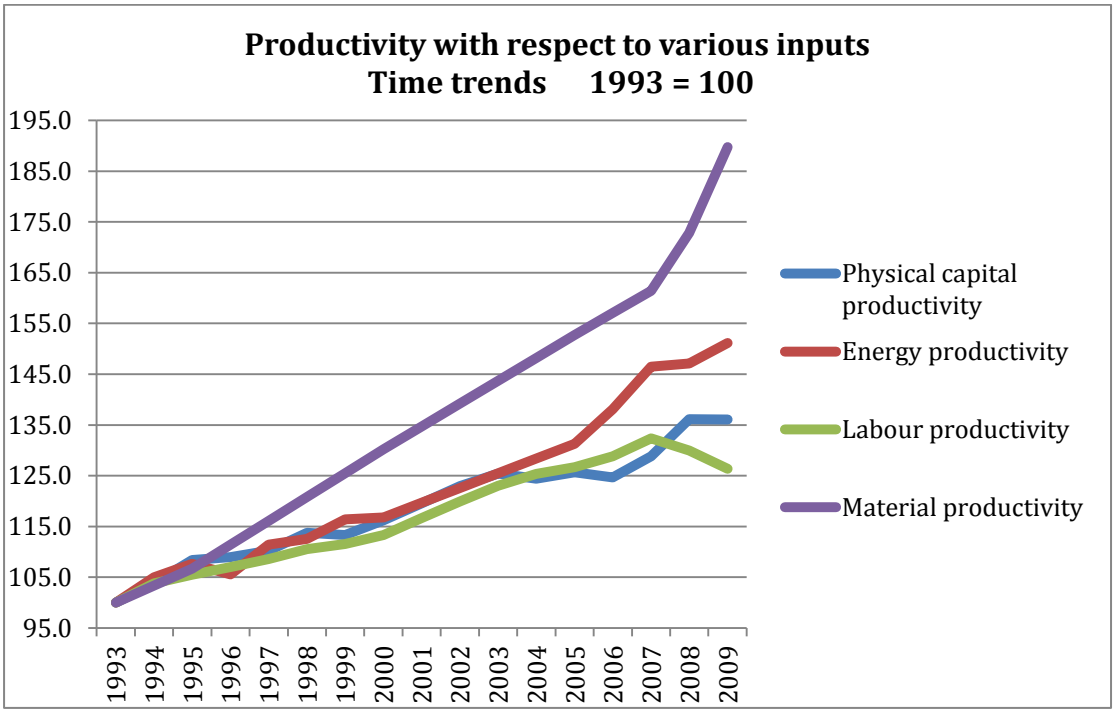
amounts of each of the four inputs. In 1993, as the economy was beginning to recover from the last recession,

> £1m of fixed physical capital used for one year was required to produce on average £450,000 of GDP;
>
> 1 worker produced in a year £37,000 of GDP;
>
> 1 tonne of oil equivalent produced £4300 of GDP; and
>
> 1 tonne of other materials produced £2000 of GDP.

By 2007, just before the current recession, more GDP was being produced for each of these inputs:

> £1m of fixed physical capital used for one year produced £600,000 of GDP;
>
> 1 worker produced in a year £50,000 of GDP;
>
> 1 tonne of oil equivalent produced £6300 of GDP; and
>
> 1 tonne of other materials produced £3300 of GDP.[32]

This change, which underlay the growth in GDP,[33] was slow and steady over the period as can be seen from the graph below.



Source ONS 2011b (National Accounts) and 2011c (Environmental Accounts) and author's calculations.

The graph shows an index of the productivity (with the 1993 level normalised to100) of each resource. 'Productivity' for each input means the GDP produced in a year by a unit of the input, that is per £1 of physical capital, worker, tonne of oil or tonne of other material; it is just a ratio of what is produced under hypothetical (and in practice non-existent) average

conditions. A number of points can be deduced from this data.

- The input productivities have grown at much the same rate, the main exception being materials whose productivity has grown faster than the others (but see below as to why). This suggests that in the short run substitution at the national level between these inputs is very limited, reflecting for example the long time it takes to bring new mines or energy resources on line, to invest in substantive new plant and machinery, or to increase the size of the workforce. Thus in the short term an appropriate production function might take the form of a simple linear input function without substitution, and with production limited by whichever input was in shortest supply:

$$Y = Min(kK, lL, mM, eE)$$

where *k, l, e,* and *m* are the productivities for each of the inputs at the time in question.[34]

- Nevertheless, in the long run we need to recognise that the growth in labour productivity is essentially driven by increased use of energy and physical capital. If these, energy in particular, were to become restricted, then we might expect labour productivity not to grow so fast or even to fall.

- Over this period the average annual growth in productivities for physical capital, labour, energy and materials have been respectively 1.8%, 2.0%, 2.8% and 3.5%.

- The greater part of this growth in efficiency (say the 2% growth in physical capital and labour productivity) is probably down to improved technology and innovation, including the development of human capital. It is this that has driven the overall 2.6% growth rate in the entire economy over recent years; the rest is not growth in productivity but growth in the labour force, made up of about 0.5% pa growth in population and 0.1% pa growth in participation.

- However there has been an additional 1% or so improvement each year in the apparent efficiency with which energy and materials have been used.

- But as the UK Environmental Accounts put it, *'levels of imports have generally risen over the same period suggesting that some of the environmental impacts associated with consumption are being transferred abroad.'*[35] In fact there is more to it than that; the decline in manufacturing and the rise in imports of manufactures means that some part of the improved

material and energy productivity simply reflects the fact that energy and materials intensive processes have moved abroad. Calculations by the Stockholm Environment Institute suggest for example that UK green house gas emissions are in fact now at a higher level than in 1990 if this effect is taken into account.[36]

- When we come to consider scenarios for the future we will need to consider whether it is either possible or desirable for this extra annual 1% improvement in efficiency in energy and material use to go on forever.

However, the evolution of productivities is not the only consideration for the determination of GDP. We need too to consider the absolute availability of resources. The caveat is of course crucial; and I turn to that in the next sub-section.

3.2 The supply of energy and materials: is it gonna be alright?

In the long run it is clearly impossible to continue expanding indefinitely the use of energy and materials on a finite planet. Environmentalists have made that case for years. But what of course is critical is coming to an understanding of how quickly we will meet those limits. If they are still thousands of years away, only the most farsighted readers of this paper will be too concerned. But, if as I argue here, those limits are a matter of a decade or so away, they are clearly of critical importance to us here and now.

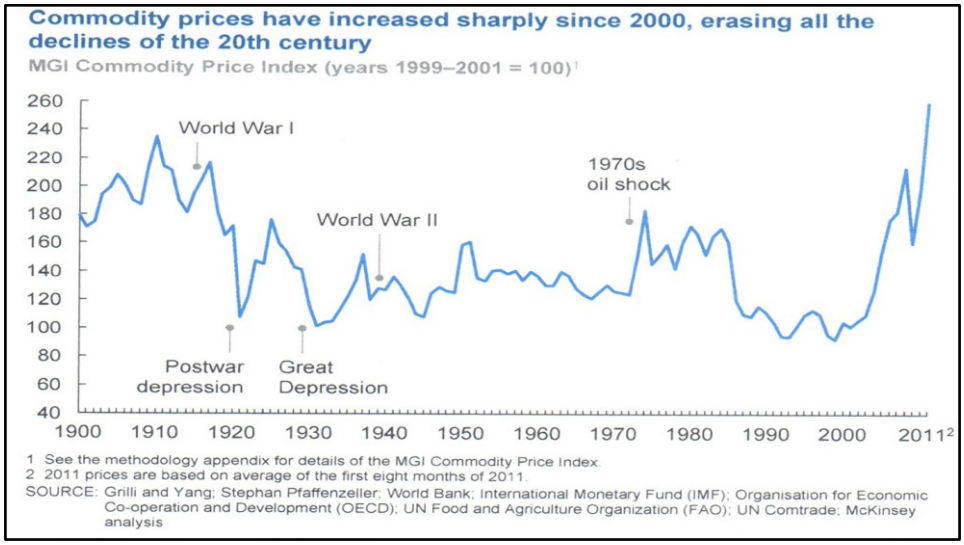
The proximity of the limits is a very detailed matter requiring comprehensive investigation; different resources have very different availabilities and uses.[37] Fortunately there a comprehensive recent report, by the McKinsey Global Institute, published in 2011.[38] While McKinsey may not seem like a natural ally of the environmental movement, and as we will see their report is full of technological and political wishful thinking, it nevertheless contains a wealth of useful factual material. There is perhaps some advantage in working from a report that comes from a perspective that is not obviously sympathetic to the Limits to Growth thesis, and using so-called factual data (which might of course be contested) that is widely accepted by conventional economists.

There is general agreement that the years of plentiful, cheap natural resources are past. As McKinsey themselves put it

"During most of the 20th century, the prices of natural resources such as energy, food, water, and materials such as steel all fell, supporting economic growth in the process. But that benign era appears to have come to an end. The past ten years have wiped out all of the price declines that occurred in the previous century. As the resource landscape shifts, many are asking whether an era of sustained high resource prices and increased economic, social, and environmental risk is likely to emerge." [39]

McKinsey's report includes a striking graph of their index of real commodity prices over the past 110 years.[40] The index includes 28 commodities broken into four subgroups: energy, food,

agricultural raw materials, and metals. Broadly speaking commodity prices having just about halved over the 20th century, then doubled again during the first ten years of the 21st, with just a brief dip for the current recession:



To put this rise in context, the historian, Niall Ferguson has said of this graph '

The only previous periods I'm aware of when there have been correlated spikes in the prices of nearly all commodities are World War I and World War II. If you were on another planet observing Earth (and all you had was this graph)... you would conclude that World War III was in progress right now.' [41]

However, McKinsey are not alarmed. Their broad conclusion, rather surprisingly in view of what the detail of their report has to say, is that

'This research has established that both an increase in the supply of resources and a step change in the productivity of how resources are extracted, converted, and used would be required to head off potential resource constraints over the next 20 years. The good news is that this research has identified sufficient opportunities to expand supply and improve productivity to address the resource challenge.' [42]

or as one reviewer put it, *'It's Gonna be Alright!'* [43]

So are McKinsey right, or is the basic idea that continual material expansion on a finite planet is impossible now beginning to come home to roost? In fact, as I have suggested above, the detail of their report does not support their conclusions.

McKinsey's basic methodology is this. For their base case McKinsey's suppose that real world GDP continues to expand at 3.4% pa, with most of this growth (4.7% pa) concentrated in China and India in particular.[44] They then work out the increase in demand for four key commodities, energy, land, water and steel, bearing in mind in particular that that the increasing GDP will be accompanied by 3 billion new 'middle class' consumers (there

are 1.85 billion now), who will tend to start doing resource intensive things, like running cars and heating (or air-conditioning) their houses.[45] Their assumptions about demand incorporate assumptions that de-materialisation will continue at trend rates, so for example they expect energy productivity to grow at about 2% pa in OECD countries.[46] They then wind up with levels of potential demand for each of the commodities by 2030. They make no attempt to factor in the effects of rising prices, though rehearse cases where substitutes have been found in the past when resources have run short (eg kerosene for whale oil, coal for charcoal, artificial fertilisers for guano, synthetic rubber for rubber, though it is interesting that in all these cases the substitute came from fossil fuels, and that we were already running out of renewable natural resources.[47])

They then consider whether supply can be expanded to meet this level of demand. For energy in the timescale they are concerned about (20 years) they anticipate little problem with overall reserves (they claim 45 years of proven oil reserves, with another 55 years in tar sands, 50 years for natural gas with maybe another 180 years in shale gas, and 110 years of coal.[48]) However extraction costs are rising, there are environmental problems with tar sands and shale gas, and they do not mention the possibility of the politics of the Middle East and Central Asia disrupting oil supplies. They accept that there will be serious and connected shortages of both land and water, mainly because the available sources are in the wrong places, and also because of associated threats like de-forestation.[49] On minerals they point out that mining capacity, which takes a long time to expand, is short for the crucial ingredients of steel, that is iron ore and coking coal, and that exploration expenditures are going up but discoveries are tailing off.[50] While reserves are available for most minerals, and availability of metals in particular can be increased (at a cost) by recycling, they also point out the political problems associated with minerals concentrated in particular countries. Thus China produces 97% of the world supply of rare earth elements, important amongst other things for the permanent magnets in lightweight electric motors (eg electric cars), generators (eg wind turbines) or miniature speakers (phones and computers). In 2010 it cut its export quota in half, prompting a search for supplies elsewhere, including in Australia where so far there has been little production.[51] Morocco controls 80% of the reserves (albeit plentiful) of phosphates, a crucial input for fertilisers in intensive agriculture. Thus they come to an overall conclusion that there will be a problem of supply, despite investment of US$3trillion over the period:

'If investment in supply remained at historical levels and productivity growth improved only in line with our base case, there would be a notional gap between supply and demand in 2030 of 15 to 80 percent across the four key resources we discuss. We estimate that the annual pace for supply additions over the next 20 years would have to be almost triple the rate at which it expanded over the past two decades.' [52]

But for McKinsey technology, in the form of 'the productivity challenge' will come riding to the rescue. They

identify a series of 'productivity opportunities' that could, if implemented, address 30% of the total of 2030 demand,[53] that is achieve a *further* 2% pa productivity improvement overall. These opportunities include things with which most environmentalists will be familiar, such as in rough order of cost efficiency:

switching commercial lighting to LEDs,
improving electric arc furnaces,
preventing land degradation,
improving consumer and commercial electronics and appliances,
improving commercial building insulation efficiency,
enhanced oil recovery,
improved irrigation,
ending municipal water wastage,
shifting road freight to rail and canals,
improving agricultural yields,
higher strength steels

and so on through to new higher standard residential buildings. This list is painless; the opportunities don't include things involving behavioural change, such as reducing consumer food waste, driving and air travel, or lower indoor temperatures or switching from meat to fish and vegetables.[54] The list involves an additional US $3 trillion of investment, and three quarters of the opportunities arise in developing countries.

But even this is not enough to achieve another target, which is green house gas emissions which are on a pathway to achieve the Cancun target, that is emissions that give a 50:50 chance of avoiding a global average temperature rise of 2 deg C. This needs a further massive investment of US $3 trillion in renewables and reforestation.

Despite the upbeat language in the conclusion, when McKinsey analyse the barriers to achieving this programme – that is expanding supply and ordinary 'historical' productivity improvements, investing in the extra productivity opportunities and meeting the 2 deg C emissions path – they conclude that none of them are easy and the climate response case is 'almost impossible.'[55] Their ultimate modified optimism is based on not dealing with climate change!

So what are we to make of all this? Is there a crisis looming in the supply of resources or not? Of course the answer is not that it will all turn difficult for everything at some particular point. Any crisis will occur in fits and starts, and will have political manifestations – which will bring their own problems – as well as economic ones. But there is quite a lot wrong with the McKinsey analysis:

- it only covers the next twenty years. 45 years of oil reserves looks not too threatening over 20 years, but over 50 it is clearly a problem (even if climate policy allowed us to burn it). At best McKinsey make a case for saying we can muddle through for twenty years, but says nothing beyond that. Surely a report of this kind has to adopt a longer perspective;
- McKinsey are double counting input productivity improvements. The historical rate of improvement is not some disembodied process. It depends on actual technological changes, like the essentially

completed change to fluorescent lighting in commercial premises, more fuel efficient vehicles, apparently improved agricultural productivity and so on. Their list is no more than a list of how to achieve the continuation of historical improvement levels, not an extra level of improvement;
- their report does not cover reduction in bio-diversity or degradation of eco-system services, which will begin to create ever larger costs;
- apart from climate change, which it anyway discounts, it has nothing to say about pollution and the extent to which either the costs of avoiding pollution or the costs of combatting its consequences in for example poor health will depress GDP levels;
- it doesn't take proper account of rebound effects from resource or energy efficiency gains, such as for example when improved building insulation simply encourages people to turn up the temperature of the central heating system;
- the majority of the supply, productivity and climate change improvements are available only in the developing world. There must be concerns that infrastructure and politics will not allow them to take place.

Given these caveats 'it's not gonna be alright', and we can expect significant problems with the supply of energy and materials to the world economy within the next ten to fifteen years; they have been foreshadowed by the recent increases in commodity prices.[56]

3.3 Material inputs to the UK economy

We now need to bring together the previous two sub-sections to consider the likely prospects for the supply of materials, energy and labour to the UK economy in particular in the light of the likely world situation over the next forty years. I will cover each item in turn. But before I do so I need to make some overall assumptions about the world and the UK's place in it.

We have to develop a base case, which is essentially a 'business as usual' case. This is an assessment of what I think is likely to happen, not what I think should happen. I will also develop an alternative policy approach below. And there is an important proviso even for the base case. I cannot possibly predict major wars or disruptions of trade, in the sense of saying for example, that there will be an armed conflict in the Middle East involving all the major powers and massively disrupting oil supplies in, for example, 2018, or for example that the US will ban the sale of US grain on world markets to protect home consumption from 2025. Yet one of the conclusions of any study of the problems of economies securing supplies of essential material inputs over the next few decades must be that conflicts over resources, or restrictions on trade, are extremely likely. In the business as usual case, with states continuing to pursue their own interests and being unwilling to submit to international authority, major conflicts are surely more likely to occur than not.

Moreover climate change may have surprising, devastating and unpredictable impacts. But we cannot model these disturbances explicitly, so we will have the paradoxical position of a base case which broadly assumes that things go along much as before in international relations, while not really believing that this is likely. Moreover we need to take account of the fact that the UK will continue its relative international decline in terms of political influence and military power, and its ability to secure for itself a disproportionate share of the world's resources will decline over the period. That is not to say that I think the UK should use political and military power to secure a disproportionate share for itself, simply to say that in the business as usual case that that is what I would expect the UK to want to try to continue to do.

That said our major broad assumptions about material supply to the UK economy are as follows:

- that there will be no major outbreak of protectionism in world trade;
- the terms of trade for the UK will worsen gradually over the period as manufactured imports get more expensive and the UK's relative overall economic strength declines;
- the UK will continue to be able to buy energy and other material supplies on world markets, but at rising prices, and as the period progresses in quantities that decline faster than present trends;
- the world as a whole will make only minor progress towards climate change targets, and renewables will constitute only about 20% of world energy supplies by 2050, with nuclear maybe constituting a further 20%;[57]
- the UK will have a similar energy mix by 2050 (I will address below a variant where the UK does what it *should* do on climate change);
- the UK will therefore become increasingly dependent on imported fossil fuels. With worldwide development of tar sands and shale gas these fuels will be available, but at increasing financial and environmental cost;
- I will use the UK government's projections of population (which project a rise from the current 62 million to 78 million in 2050[58]) as underlying figures for the supply of labour;[59]
- investment will respond to demand seeking to be at a level where total capacity based on physical capital neither constrains nor inhibits capacity from the other factors; and
- the climate change implicit in these assumptions will have only minor effect on the UK economy as measured by GDP and that there will be no catastrophic climate change in the period – there will be adjustments to be made, but also benefits (though may be catastrophic elsewhere, and there will be widespread damage to eco-systems).

In the section on Business as Usual below I will translate these, as well as productivity changes and other variables, into precise numerical assumptions.

4. Wages, profits and equality

4.1 The relative shares of wages and profits are determined both by politics and economics

Concern for the relative shares of wages and profits seems an old fashioned, almost nineteenth century idea, or at least a throw back to the 1970s. The prevailing neo-classical doctrine is essentially that the 'factors of production' – labour and capital – will, if the system is working properly, each get what they economically deserve. More precisely, it is alleged that each will be rewarded by their marginal financial productivity, that is to say that the additional worker taken on by a firm will be rewarded by the extra revenue her contribution produces. Similarly for an additional machine; profits will go up by the amount that that machine adds to production. Thus there are 'natural' shares for wages and profits determined by the conditions of production. It is bad economics and sentimental nonsense to allege that profits are too high or that the salary and bonuses of a particular banker too outrageous; they are what the market demands.

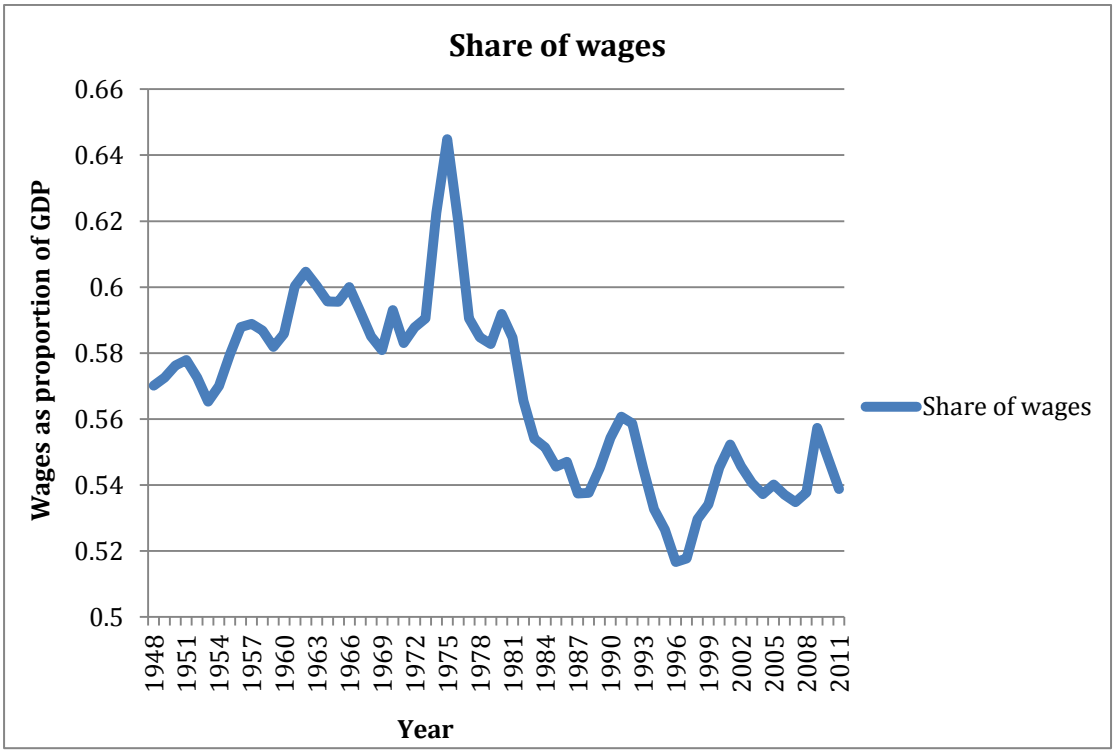
Of course, the story goes on, there are times when the system does not work properly because there are constraints on free competition in the market. Such conditions obtained we are told in the 1970s, when trade union monopoly power bid up wages to too high a level compared to their natural level, causing inflation and depriving firms of the profits needed for further prudent investment, which would provide economic growth. The 1976 IMF conditions and the Thatcher government restored the proper competitive relationship, and the wage and profit shares are now at their appropriate economic levels.

All of this theory is wrong. There is no necessary relationship between the rewards of factors of production and their marginal productivities; rather there is a range of possibilities for the relative shares of wages and profits and the actual distribution is co-determined by economics and politics. The history of the share of wages since 1976 bears this out (see below); the share of wages was reduced as a result of political action, such as restrictions upon trades unions, rising levels of unemployment and exposure of western workers to the competitive pressures brought about by globalisation. Of course, the relative shares have economic consequences as I will go on to argue below, but the basic causation is from the politically determined shares to the economic consequences. The economic reasons why the marginal productivity theory is wrong are set out in Keen's book, *Debunking Economics*[60]: they are very briefly the lack of competitive labour markets; the peculiar nature of labour as a commodity; the complications caused by those who extract rents; and the conceptual difficulty of defining a rate of return on capital when the price of that capital itself depends upon the rate of return. But there is also a compelling, rounded and historically grounded case for seeing the rate of wages as socially and politically determined in Polyani's *The Great Transformation.*[61]

4.2 The history of the share of wages

If the battle between capital and labour has been less fraught over the later part of the twentieth century, it is because it has shifted to a battle as to how growth resulting from productivity gains should be shared out. Unlike the concern of the classical economists as to what determined the proper absolute shares of wages, rents and profits[62], the modern debate, based on a presumption of growth, tends to be about how the additional *gains* are to be shared, with neither side suffering an absolute reduction.

The graph below shows the history of the share of wages in the UK since the Second World War. Not all of the income that is *not* wages (and salaries) is 'profits.' Quite a large chunk, 12%, is made up of net taxes on production.[63] A fairly stable 6% or so of GDP is what the National Accounts call 'mixed income,' '*the operating surplus of unincorporated enterprises owned by households,*'[64] which is largely incomes from self-employment, and which it would be wrong conceptually to separate into wages and profits. Amongst other incomes that are not 'profits' in the usual sense are rents and interest on loans and bank deposits. And profits themselves occur in many forms, including retained profits, dividends or incomes to pensioners for example. Finally, the whole picture is complicated by the parts that government takes from both wages and 'not wages' in taxation. Here is the post war history of the share of wages. The horizontal axis shows the year, the vertical axis the proportion of GDP taken by wages and salaries:



Source Author's calculation from Office for National Statistics, 2011b, line NQAU divided by line YBHA .

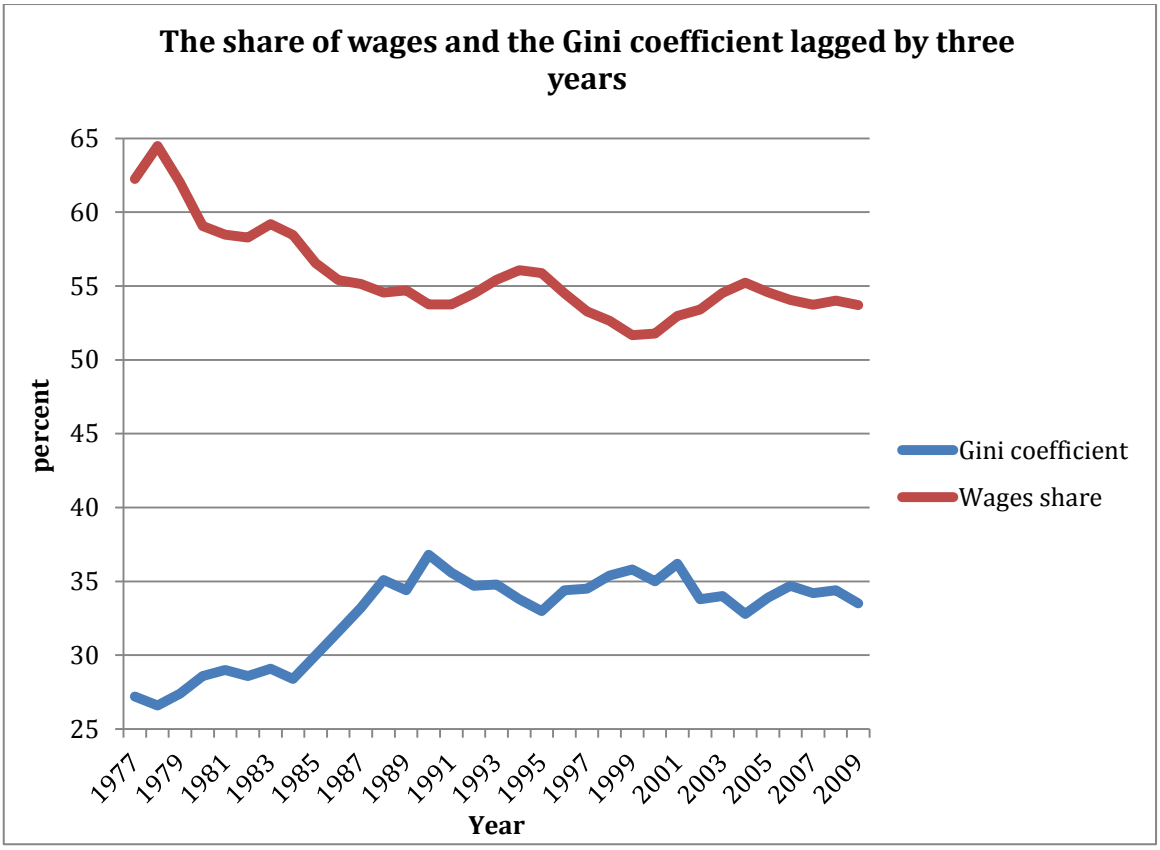
That said, the contention that the share of wages is as much a political matter as an economic one is borne out by how strongly the graph reflects the political history of the UK since the Second World War:

- there is usually a peak in the share of wages (whose immediate cause is economic) around the start of each recession, for example in 1962, 1975, 1980, 1991 and 2009 as a fall in profits is the immediate consequence of a fall in demand and sales, and it is only as employers shed workers and the labour market weakens that the share of wages falls back;
- there is a fairly consistent rise in the share of wages in the period from the end of the Second World War, the era of the formation of the welfare state, growth in the parts of the economy where profits were not possible and Butskellism;[65]
- there is then a continuous fall from 1976,[66] the imposition of the IMF conditions and subsequently by the onset of Thatcherism, with its attack on Trade Union power, rise in unemployment and increase in the size of the sectors of the economy where profits are possible through privatisation; with
- a modest but short lived recovery in the share of wages under New Labour from 1997 until 2000.[67]

4.3 The share of wages and inequality

On the face of it if the share of earned income, or wages and salaries, falls, you would expect the distribution of income to get worse. However, distributional measures such as the Gini coefficient are usually computed after taxes and benefits, and on the basis of household income, while the share of wages and salaries is individual and before tax and benefits. Does the data show equality following the share of wages after these have been taken into account?

The data from the mid 1970s onwards does suggest that inequality has increased closely following the pattern of the share of wages. A graph of the share of wages against the Gini coefficient after tax and benefits, the usual measure of income equality, but lagged by three years, shows two time series that are almost mirror images of each other:



Source: Author's calculations using ONS 2011b

A Gini coefficient of 0% represents perfect equality, that is everyone getting exactly the same income. A coefficient of 100% represents one person getting all the income and everyone else getting nothing. This graph shows the lagged Gini coefficient rising as the share of wages falls to the early 1990s, falling a little as wages recovered their share in the 1990s recession, and then broadly mirroring the wage share thereafter.[68] Why is there a three year lag? It may be because the Gini coefficient is a measure of inequality between households; while one member of a household may fall behind, another member might keep up for a while, delaying the relative fall in household income.

And even within wages, much of the share of the real increase in absolute wages and salaries has gone to those on higher incomes. Changes in the structure of the economy, such as globalisation, a wider skill mix, and the introduction of IT removing many semi-skilled clerical jobs has stretched differentials.[69] And the very highest salaries have increased considerably compared to median salaries and wages.[70]

4.4 The share of wages, aggregate demand, and borrowing

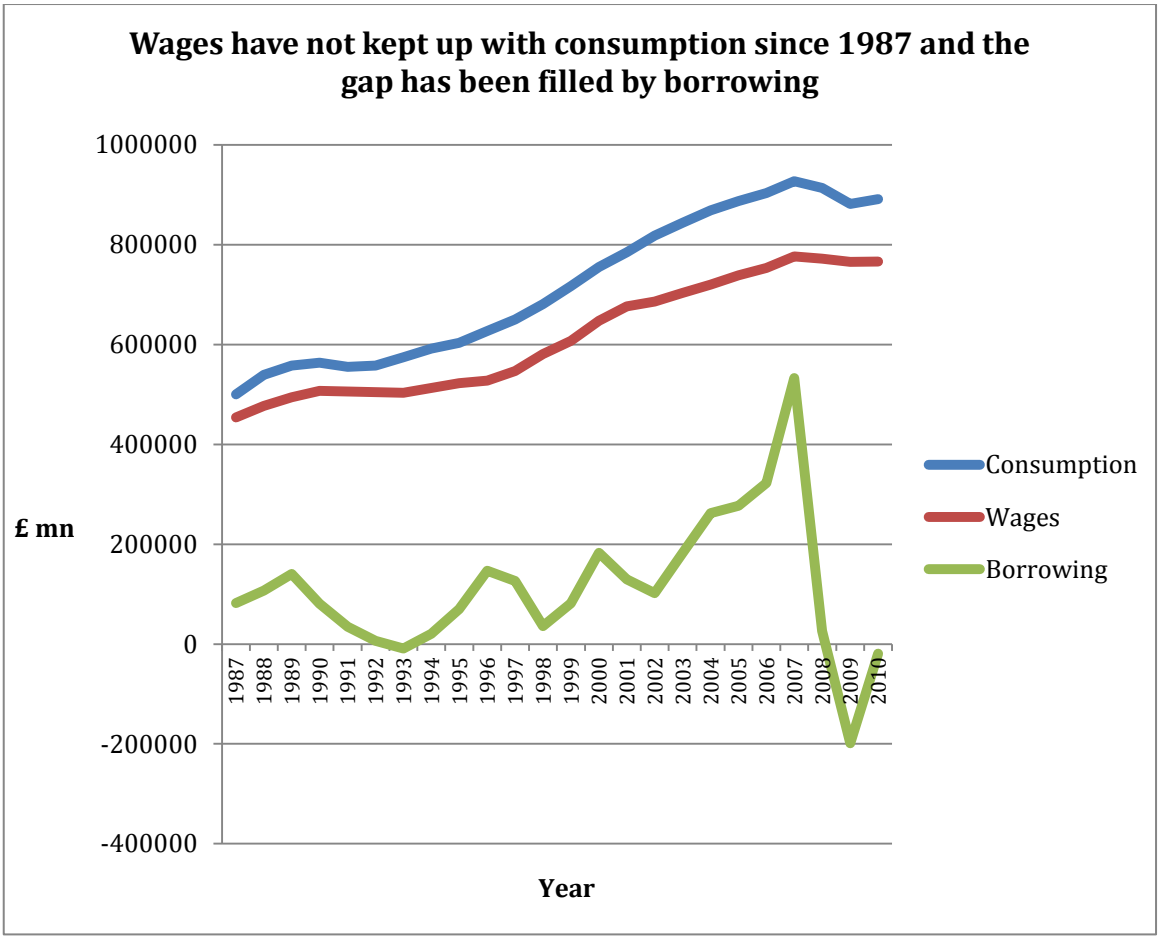
A recent TUC pamphlet said 'The falling wage share has itself led to widening inequality while driving higher levels of personal debt.'[71]
We've seen above how the first part of

this statement is true; I now turn to the second part, that is the idea, mainly put forward by David Harvey,[72] that a lower share for wages has driven higher levels of personal debt, which itself has led to greater financial instability.

As we have seen, wages have on the whole diminished as a share of national income since the mid-1970s. Correspondingly, other types of income, such as profits retained by companies, dividends, interest and rents and incomes paid from these components like pensions, have risen as a share of GDP. Classical economists used to argue that wages were entirely spent by their recipients (indeed Marx would argue that since they were no more than was enough for subsistence they *had* to be spent) while profits would be partly spent on consumption, even luxury consumption, but would of course provide that prudent and socially necessary fund from which savings and investment and future prosperity would be produced. Marx pointed out that if the workers got too little there could be a problem of insufficient aggregate demand, anticipating Keynes. But another problem also could arise; if profits were too high there may not be enough profitable investment opportunities in the real economy to go round. In that case profits could be used to bid up asset bubbles, ultimately creating a crash.

Now in the twentieth century, the idea of treating wages and profits separately as components of aggregate demand fell out of fashion, as workers began to save money to provide funds for investment, and more of profits were distributed more widely, often to people who didn't look like capitalists, like pensioners. These smoothing effects meant that it became customary to regard consumption as a simple fraction of the whole of income.

However, since the 1970s a new way of solving both the problem of weakening aggregate demand from wage earners as their share of national income fell and finding a profitable outlet for excessive profits has come to prominence. The expansion of consumer credit – particularly with the invention of the credit card – has become massive, sped on its way by de-regulation of the financial sector. Unfortunately credit figures before 1987 don't seem to be available in the National Accounts, but it is well worth looking at the history of credit, wages and consumption since then:



Source: figures from 2011 Blue book, with some calculations by the author.

Real consumption and wages have both risen over the period, with a slight downturn in the early 1990s recession and of course in 2008 and 2009. But the two lines have diverged from each other as the share of wages has declined, though this effect is less marked in the early years of the Blair government when the share of wages rose and the two lines rose briefly almost in parallel, only to diverge again after 2000. The gap has been filled by borrowing, shown by the green line. Of course not all of this borrowing has gone into consumption, much has gone into houses and asset speculation (of which more below). But the steep decline in borrowing in the early 1990s is reflected by a slightly steeper decline in consumption than wages. This is repeated more sharply in 2007 and 2008. Average household debt was 45 per cent of income in 1980 but rose to 157 per cent in 2005.[73] While the rich have been lured into Ponzi schemes, wage earners have been lured into improving their living standards and owner occupation only at the cost of incurring ever greater debt. But eventually, if the aggregate debt level climbs too high, some workers cannot pay it back and the house of cards collapses. This brings us to the current financial crisis, and in the next section we take a closer look at money and debt.

5. The Financial Crisis

5.1 Determining GDP, the demand side

I have so far looked (in Section 3 above) at the supply side of the economy, focusing on four factors of production (physical capital, labour, energy and other materials) and their evolving supply and productivity, and their effects on long term growth. I also looked (in Section 4 above) at another aspect of the economy, which is essentially unconnected from the short term determination of GDP, and which is the share of wages and its effect upon the level of inequality. Its importance will become apparent in the next section on welfare (Section 6). We are now going to turn to the level of demand in the national economy, where there are two approaches which are normally seen as contending theories. The first is Keynes's familiar theory of aggregate demand, and the second is about the influence of money. I have no intention in getting into the complex battleground of the economic debate between these two groups of theorists, and their many sub-schools. Instead I treat each theory, both set out in very simple terms, as being a constraint upon the level of GDP, rather like the supply function. I ignore in particular any interactions between them, except for a very simple theory of aggregate price formation. But I will draw upon Werner's theory of money creation and its effects (Section 5.3), and an essentially historical and empirical analysis of what determines the net overall level of lending (Section 5.4).

5.2 Keynes and aggregate demand

The basic idea behind Keynes's theory of the determination of macro-economic demand is disarmingly simple. As a matter of accounting, GDP, as measured by expenditures, is simply the aggregate of the expenditures of four different sectors, that is to say consumers, investment, government and net exports. As an equation, in any one year

$$Y = C + I + G + X$$

where Y is GDP, C is consumption, I is investment (by both the private sector and Government), G is government current expenditure and X is net exports, that is exports less imports. For these purposes all this is in real terms; I will come to the effects of money later.

As it stands this is simply an identity, and is of no use for predicting GDP. However if we have a theory about how each of the elements on the right hand side depends upon the previous year's GDP, and perhaps some other factors, we can use the identity to predict the current year's GDP. The simplest possible theory is just to assume that the elements on the right hand side are a constant proportion of the previous year's GDP. Thus over recent years in the UK, consumption has been about 65.0% of the previous year's GDP, government expenditure 22.5%, investment 16.5% and net exports around -3.0%. Notice that these sum to 101.0%, implying that total aggregate demand will increase by 1.0% per annum if these percentages persist. Growth is built into people's expectations.

Now there are more complicated ways of doing this. For example consumption is normally reckoned to be a proportion of GDP in the previous year plus a constant. Investment in some theories is a function of changes in consumption. Government expenditure is essentially a matter of policy, which might be affected for example by demography. Net exports will be affected by developments in the world economy; for example the UK economy is currently very vulnerable to falls in demand for its exports in the Euro area. As a transparent and simple way of showing what assumptions I am making, I propose to retain the simple proportional theory. While this may be a very poor way of predicting recessions, it gives us a more controlled grip on long term aggregate demand and the effects on long term changes in GDP.

I contend that the significance of aggregate demand for GDP determination is that the real GDP cannot be *more* than aggregate demand. Leaving money out of the account for a moment (I will come to this in Section 7.2) I will assume that if the potential supply is greater than aggregate demand, then no more than the level of aggregate demand will actually be produced. In the short run the slack will be taken up by unemployment. Classical economists would no doubt argue that the price (and especially wage) level would fall to enable more to be produced and less to be supplied so that the economy comes into equilibrium in that way. Experience of actual recessions and depressions suggest this is a very slow effect.

5.3 Werner's theory of money

Most people believe that the present recession began in the financial system, though some have argued that the peak in oil and other commodity prices in 2007/8 was the straw that broke the camels back.[74] That is not to say that investment and consumption expenditure have not reduced, so reducing aggregate demand, but they have reduced because of causes initially to be found in financial system. Richard Werner has recently proposed a new and deceptively simple theory of the role of money in the economy, which he has used to great effect to explain some of the puzzling features of the Japanese economy since 1990.[75] The theory has two main components:

- using the total of *credit* as the quantity of money variable in the standard quantity theory of money relationship; and
- *disaggregating* that relationship into the part that relates to transactions within GDP and the part that does not.

The standard quantity theory of money is normally written in the form

$$MV = PQ$$

where, to quote a standard economics text,[76] *'M is the money supply, V is the velocity of money, P is the price level and Q is real output.'* The idea is that this is an identity derived from looking at the overall total value of transactions in the economy over a period in two ways. First we can look at each unit of money, and ask how many times it gets used in transactions in a period (its velocity). Then we sum that up for all the money in the economy, and use an average velocity. That gives

MV. Alternatively, each unit of output is sold at a price, and over the whole economy that gives *PQ*. These two must be equal over the period.

Werner points out, as the original proponents of the quantity theory and many other subsequent economists have realised, that the right hand side of this equation is not correct.[77] It should be *PT*, where *T* represents all the transactions in the economy, *including transactions that are not part of GDP,* such as financial transactions like buying and selling assets.

Thus we should disaggregate the quantity equation into two equations, an equation relating to transactions that count towards GDP, which we denote with the subscript Y, and an equation relating to all the other transactions, which since they are largely financial transactions, we denote with the subscript F:

$$M_Y V_Y = PY$$

$$M_F V_F = P_F F$$

where *F* is the real value of all the non-GDP transactions.

In these equations, total Money ***M*** is then given by

$$M = M_Y + M_F$$

The second question is what is total money? The usual approach is to use various aggregates of different types of cash and bank deposits, such as *M0* and *M4*. Werner objects to the use of these aggregates on the grounds that they also measure savings, that is money *not* used in transactions.[78]

Werner maintains that in economies with banks creating money through extending loans, '*the amount of money used for transactions can only increase … when banks create new credit.*'[79] He says this essentially because borrowers only take out loans in order to spend them. Thus Werner substitutes aggregate outstanding credit for ***M*** and its components in the above equations.

Werner, in common with the usual assumptions of monetarist theorists, now assumes that the velocities, V_Y and V_F are constants, though he does have some empirical justification from the Japanese economy to do so.[80]

Because of lending by non-money creating intermediaries, the change in the money supply over a given period, say one year, for transactions within GDP, ΔM_Y will consist of the new credit supplied for the purposes of GDP, ΔC_Y *plus* any loans of existing money, denoted here by *x*.[81] Similarly ΔM_F , the change in the money supply for non-GDP transactions will be ΔC_F less *x*; the total change in the money supply must equal the total change in credit, and so the non-money creating loans must cancel out. Thus we have

$$\Delta M_Y = \Delta C_Y + x$$
$$\Delta M_F = \Delta C_F - x$$

Using the monetary theory for the determination of nominal GDP ***PY*** above, that is:

$$M_Y V_Y = PY$$

we can re-write this in a more practical from as

percent increase in credit supplied for GDP = percent increase in price level + percent increase in real GDP.[82]

Notice that the credit supplied for GDP will consist of two elements. First there will be loans made by banks by the creation of money. Second there will be loans made with existing money which have no net effect on the money supply. Both are important; part of the current crisis has arisen from irresponsible bank lending, but part has risen from excessive profits (themselves arising from the fall in the share of wages) seeking profitable outlets (sub-section 4.4 above).

For all this to be actually useful in building a model of GDP determination, we need both a theory of what determines the level of overall credit creation, and a theory as to how that is split between GDP and non-GDP transactions. Neoclassical economics sees this as a standard question of supply and demand settling into equilibrium, with the interest rate operating as the price of money. As interest rates rise, borrowers become more reluctant to borrow while lenders are increasingly prepared to lend. Accordingly the level of credit and its distribution between different uses, and in Werner's model the money supply, should be determined endogenously through movement of the interest rate. Werner maintains however, partly because of the existence of limited liability (so borrowers with limited liability are protected from the true costs of default), that the demand for credit always greatly exceeds the supply at whatever interest rate, and that accordingly the market is not in equilibrium. Instead banks ration credit creation in ways that maximize their profits.[83] As a result interest rates have little effect on credit creation, which he shows empirically to have been the case in the Japanese economy. Banks settle on an interest rate that maximizes their profits (not unlimited as more borrowers will default as the interest rate increases), and then ration credit.

Once the interest rate is determined, banks will be mainly concerned about the security of their loans, and so customers who can provide good collateral will be favoured. Often this will favour those buying assets rather than investing in GDP related activities. The volume of deposits they attract will also affect banks. While unlike intermediaries they can *collectively* create credit, they are also *individually* like intermediaries, in that their deposits (including loans from other banks) ultimately limit their total lending. Since they have to pay interest on deposits received they will want to lend at least that amount; so up to a point if the level of deposits (as against money in current accounts) increases so will the creation of credit. Other things being equal, we would expect the volume of deposits to increase when wages as a share of GDP declines, since the bulk of wages pass into and through current accounts.

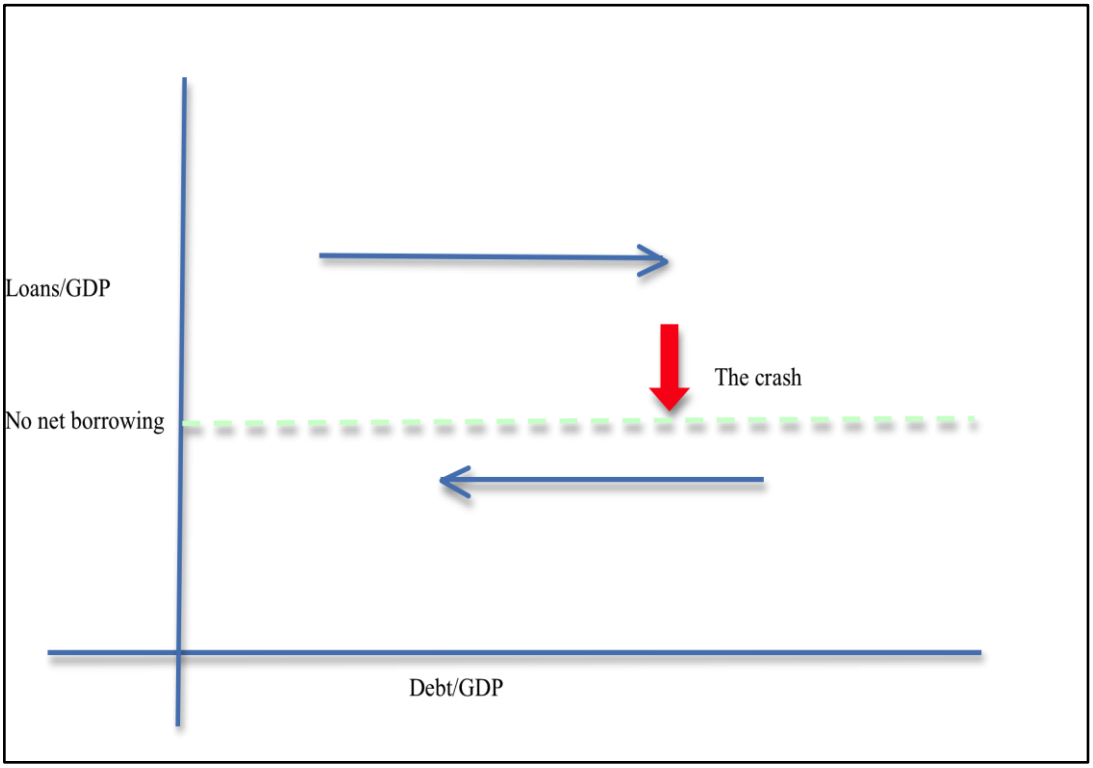
None of this however gives us any idea as to *how much* credit will be supplied to GDP relevant activities, and I turn now to this topic.

5.4 Lending and the overall level of debt

So what determines how much credit banks will create and where they will direct it? And what determines the overall level of lending and borrowing (that is the total of government, corporate and personal debt), including

lending that does not create money? Without some theory of this we will be unable, on the basis of sub-section 5.3 above, to predict nominal GDP. I maintain that the level of overall lending and, what amounts to the same thing, borrowing, as a proportion of GDP is a *catastrophic* function (to be explained below) of two variables: the level of overall debt as a proportion of GDP and the level of banking confidence.[84]

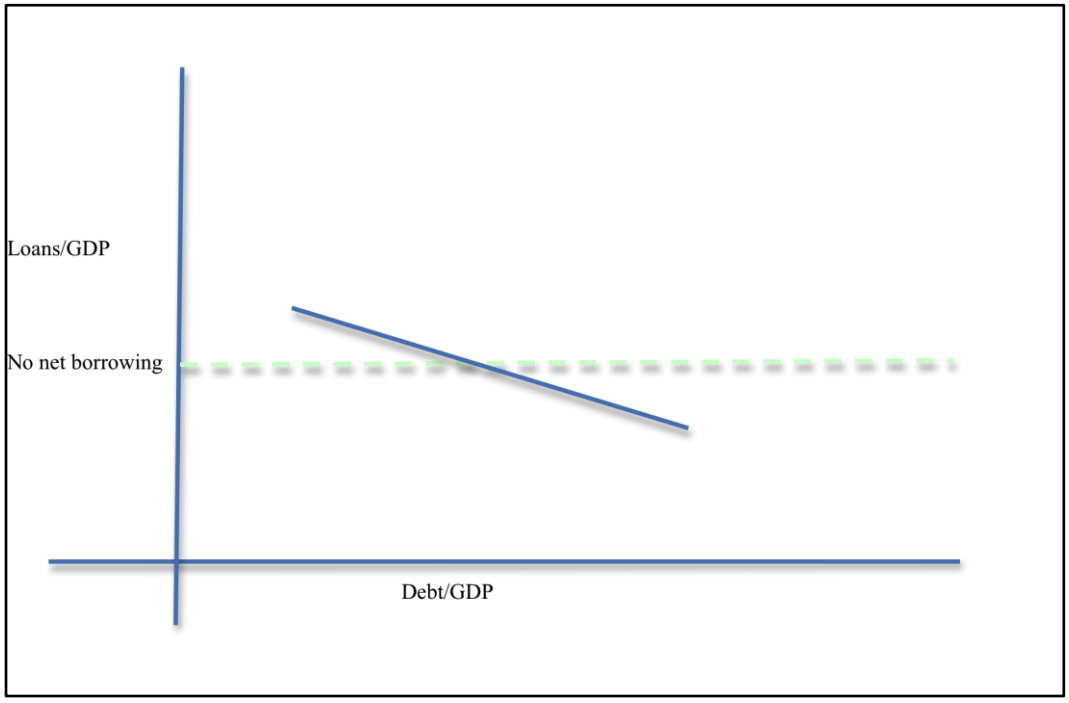
Catastrophic here has an exact and particular meaning set out below, and requires some explanation. As Steve Keen shows in the latest edition of his book,[85] the crashes of 1929 and 2008 were both preceded by high net lending, an ever increasing total volume of accumulated debt to GDP and a very high level of confidence within the banking community. Banking confidence seems this time to be a heady compound of the freedom brought about by banking de-regulation, and the lack of competition faced by banks that were too large to fail. The crash in both cases was sudden, indeed catastrophic in the ordinary sense of the term; while the overall stock of net debt remained very high, high levels of net lending changed *suddenly* into net repayment of much private debt, and pressure on governments to reduce net borrowing. We might show this situation graphically as follows:



where the horizontal axis is the overall level of accumulated debt as a proportion of GDP and the vertical axis is the rate at which net lending is taking place, also as a proportion of GDP. The graph also shows the (almost) horizontal line where there are no net loans being made, or to say the same thing, there is no net borrowing. Then in the period prior to the crash

the economy moves along the top line, which is high above the no net borrowing line, until it reaches a point of overall indebtedness when the crash takes place, borrowers are seeking to reduce their net liabilities[86] and the economy jumps to the bottom line, which represents net repayment of loans, so is below the no net borrowing line, and where it gradually moves to the left again as a result of this net repayment. But as we have seen above (sub-section 5.3), the period on the bottom line of the graph, because of negative net borrowing, will typically be a period of no growth in GDP, especially if the negative net borrowing is GDP related negative net borrowing.

However, one may ask why in practice we never see a sudden jump back to the higher line, with strong net lending, as the overall debt is paid off. That is because of the second factor, banking confidence. If banks one way or another are restricted by custom,[87] caution or regulation in their overall net lending – that is they lack confidence – debt as proportion of GDP remains within bounds. We see a gradual reduction in lending as overall debt increases and an increase as it reduces, but the changes will be smooth and without catastrophic jumps. When bank confidence is low, the two lines on my graph above merge into a single line representing continuous change:



and the level of borrowing oscillates about the point represented by no net borrowing, with sometimes new loans predominating over repayment and sometimes repayment predominating.

How can these two views be reconciled? The answer is via a now mainly neglected area of mathematics that was fashionable in the 1970s, *Catastrophe Theory*.[88] In the first diagram, as the level of bank freedom decreases, the distance between the two lines in the first diagram reduces eventually to zero, where the two lines

merge into one giving the second diagram.[89] As a matter of history what happens after a crash is that there is a decrease in bank confidence, perhaps brought about by increased regulation or at the very least a climate of extreme caution[90] – for example the 1933 Glass-Steagal Act in the US following the 1929 crash, and the current atmosphere of caution and debate on banking regulation in the UK following the Vickers Report. Developed economies crashed from the top to the bottom line in the first diagram in 2007-08, and net lending became negative. At the same time the crash provoked an atmosphere of lack of confidence and moved the behaviour gradually onto the second graph. Overall debt will gradually be paid down[91] and lending will eventually revert to more moderate levels, where it is likely to remain for many years while the memory of the crash persists. Whether there will then be a further crash based on a further increase in bank confidence depends on whether we are any better at remembering the lesson of history this time than last.

This gives us at least a *qualitative* explanation of the supply of credit, though it offers no help as to the proportion that goes in GDP as against non-GDP purposes. And there are in the UK no statistics available that can be used to test the theory. Later it will be used as little more than a guide as to what assumptions should be made about the level of credit supplied to GDP in our simulation; I will draw heavily on the historical evidence that levels of lending remain very cautious for many years after a major crash, and that policies like quantitative easing are unlikely to change this.[92] This very uncertainty of the provision of credit is a major feature in the instability of the economy, and this underlies our later recommendation that there needs to be control on the overall volume and direction of credit.

6. Welfare

6.1 Introduction

In many ways the overall picture is now beginning to look rather bleak if we continue existing policies. The ability of an unbridled finance sector to create instability remains untamed; while the memory of 2007/8 may restrain excessive, indeed even adequate, credit creation for a while, in the longer run a repeat of the cycle of excess seems to be built in to the system. There is nothing in current policies to prevent an even lower share of GDP for wages, even greater inequalities in those wages, and overall an increasingly inequitable distribution of income and wealth. And the global ecological, resource and pollution crisis will restrict, then end economic growth, and in the longer run gradually decrease real GDP. Most people will be worse off. Or must they be?

What is it that determines optimum welfare? No ordinary mortal would consider it lay in the economist's concept of the Pareto optimum; welfare is maximised in any situation in which any change would make at least one person (perhaps the very richest) worse off. Apart from the inherent injustice of such a view, there is now an empirically based theory of welfare, and we should pay attention to that rather than to an economist's conception whose principal motivation was that it made the mathematics easier.

The empirical foundations of welfare rest on two recent remarkable books and the vast body of data that underlays each of them. Richard Layard has identified the seven things that underlie happiness, which is a rather less esoteric concept for what we are getting at than the economist's 'welfare.'[93] Partly because of the focus on happiness and well-being that the debate on his book generated, the Office for National Statistics has begun collecting statistics on well-being, and published their first results in July 2012.[94] In the second book, Wilkinson and Pickett have shown that many factors relevant to Layard's dimensions of happiness (and many others important for the health of society as a whole, such as crime) depend upon equality rather than GDP per head.[95]

6.2 Happiness

Layard's list of the seven factors which contribute most to happiness is as follows, with the first five given in order of importance:

- Family relationships;
- Financial situation;
- Work;
- Community and friends;
- Health;
- Personal freedom; and
- Personal values.[96]

Economists might argue that only the second and third of these, financial situation and work, are actually affected by the state of the economy; the rest are entirely personal or the consequence of wider social factors. For the moment I will concentrate on those two, but in the next section, when we have some of the findings of Wilkinson and Pickett's work on the influence of economic inequality available, we will see that the economy actually has a far more pervasive influence.

The most quoted indicator of financial situation is GDP per head; surely people in richer countries will be happier, provided of course most other things are equal.[97] And we should

have got happier as GDP per head has improved. But there is evidence obtained both by comparing countries, and looking at single countries over time that once GDP per head exceeds a certain level, happiness does not in fact improve. Layard quotes evidence that in Britain '*happiness has been static since 1975, and (on flimsier evidence) is no higher than in the 1950s.'* [98] In 1975 UK GDP per head was around £11,500 (in 2008 real terms), compared to slightly more than twice that (£23,750) in the last year before the current recession 2007, and two thirds of that 1975 value, £7500 in 1955.[99] Layard's graph that compares happiness in different countries shows an association between happiness and income per head up to around $15,000 (1999 US$, and using purchasing power parities) per head, but little association beyond that, and none at all over $20,000.[100] Moreover many countries below $10,000, some well below, show happiness levels equal to some of the richest countries.[101] Thus, even on fairly conservative assumptions, a GDP per head of around the 1975 level at say £12,000,[102] is capable of securing comparable levels of happiness as current GDP levels.[103]

This data on how little income per head above a certain level affects happiness is replicated for one of the major components of happiness, health. If life expectancy (a simple indicator of overall health) for different countries is plotted against national income per head, there is no significant improvement once income per head is above about $15,000;[104] that is once again GDP per head above about £12,000 makes little difference to welfare.

Layard also reports on how different changes, including economic changes, affect people's happiness. If happiness is measured on a scale of 10 to 100, with 100 the most happy, then

- a one third fall in family income reduces happiness by only 2 points;
- whereas a separation from a spouse reduces happiness by 8 points;
- but being unemployed reduces happiness by 6 points; and
- the unemployment rate at 10% reduces *everybody's* happiness by 3 points.[105]

What is clear from this data is that the overall level of income is less important than the *security* of that income; or the stability of an economy is more important for welfare than its size.

6.3 Inequality

Turning to inequality, the basic thesis of Wilkinson and Pickett is that many social problems are worse in more unequal societies. Moreover many of these factors are highly relevant to Layard's determinants of happiness; for example Wilkinson and Pickett provide numerous examples to show that in more equal societies people are healthier.[106] In fact it is possible to create a more substantial relationship between Layard's main determinants of happiness and many of the social factors that Wilkinson and Pickett show are adversely affected by inequality. Some part of this mapping is shown in the table below,[107] together with some other economic factors relevant to happiness:

Layard determinant of happiness	Relevant Wilkinson and Pickett factor	Effect of inequality	Other relevant economic factor
Family relationships	A relevant factor is teenage pregnancies. Divorce in particular is not related to inequality.	Teenage pregnancies highly related to inequality, eg 50 births per 1000 between 15-19 in US, 30 in UK but 12 Norway, 8 France and 5 Japan (pg 122).	Working time
Financial Situation	Competitive pressure to consume	More pressure to consume in more unequal societies	Income reductions Unemployment Advertising
Work		Work relationships improved with shorter hierarchies. (pg 252)	Working time
Community and friends	Trust in others Proportion in prison	60% can be trusted in Scandinavia, Japan, only 30% UK (pg 52)	
Health	Mental illness, life expectancy	9% with mental health problems Japan, Germany, 22% UK, 25% US. Life expectancy Japan 82, UK 78, US 77.	Working time
Personal freedom	Social mobility	Social mobility is lower in more unequal countries (pg 160).	
Personal values	Arguably Crime	Crime far higher more unequal countries	

This work is a first step towards creating an empirical theory of welfare for economists. It ought to be possible to create an admittedly rough tariff as to how much happiness might be affected by say changes in working hours, or changing the distribution of income by a certain amount. While

this is clearly impossible on the basis of the data available so far (though there are indications in this direction, such as the fact that personal unemployment is almost as bad as separation), what is clear is the *direction* of certain effects. Thus health is clearly improved by equality, as is trust within communities. Other things make little difference, including in particular the economist's main talisman, GDP per head, above a certain level. This should be contrasted with the standard idea of Pareto optimality, which offers little practical guidance as to how to regard the welfare importance of different economic variables.

7. Joined up economics

7.1 Introduction

I am now getting to the point where I can bring it all together. We have seen that over the past 60 years the UK economy has grown in real terms, albeit with some recessions (sub-sections 2.2 and 2.3). We have identified four main factors of production, physical capital, labour, energy and other materials. We have looked at the past history of improvements in productivity for each of these factors that have underlain the growth of GDP (sub-section 3.1). We have also looked at the past history and likely prospects for the supply of each of these factors to the UK economy (sub-section 3.3), given in particular the material in McKinsey's report (sub-section 3.2).

We then turned aside to consider the essentially political history of the share of wages in the UK economy and its connection with inequality (sub-sections 4.1, 4.2 and 4.3). We also explored the idea that a reducing share of wages might be connected with diminishing aggregate demand, and an increase in the level of debt (subsection 4.4).

We then turned back to conventional economic theory, aimed more at understanding the fluctuations in the economy and the causes of recession. We considered the determination of the level of aggregate demand (sub-section 5.2), Werner's theory on the creation and economic role of money (sub-section 5.3), and a catastrophe theory on the overall level of net lending (sub-section 5.4). Finally we surveyed an empirical theory of the economic components of happiness, drawing on the work of Richard Layard, and drew on Wilkinson and Pickett for the effects of inequality upon wellbeing (Section 6).

I now need to draw all this together. The overall approach will be as follows. First I need a theory of how GDP is affected by these factors working in combination. I will argue that the *maximum* level GDP can attain in a particular year will be limited by *each* of the six factors involved, that is to say the four factors of production, aggregate demand and increase in the money supply. Second, because the heart of what I am trying to show is that growth in real GDP will be limited, I will argue that if I can show that there is no growth in that *maximum*, then that is *sufficient* for showing the growth in actual GDP will be limited.

Once I have established a theory of the maximum GDP that can be attained, I will do two basic simulations covering the years 2010-2050. The first will be based on 'business as usual' assumptions. The second will be based upon an alternative set of policy prescriptions. Each simulation does no more than tease out the implications of a particular set of assumptions in a very simple way; it contains in particular no model of interactions between the various factors and assumptions, and no process of bringing supply and demand into equilibrium through a variable price level.

For each simulation I will need to make a whole set of assumptions:

- first, based on the material in the Limits to Growth chapter (Section 3), I will argue for a set of plausible assumptions about both the growth in quantity (negative for energy and materials) and growth in productivity (generally declining) of each of the four main supply factors;

- second, I will make a set of assumptions about the likely evolution of aggregate demand by examining each of its components, and also all the supply of net credit, given existing trends and the likely behaviour of the financial system as predicted by my catastrophe theory of credit creation;

- third, I will combine the two proceeding elements to produce a maximum GDP that will be produced up until 2050;

- fourth, I will make assumptions about likely trends in the share of wages and therefore of inequality over this period that are associated with this set of policies. This will be influenced by what the maximum GDP implies for unemployment and hence the share of wages; and

- finally I will draw out implications for welfare for each scenario.

7.2 Determining maximum GDP

We now have three factors bearing on the determination of GDP, denoted in our equations by *Y* for a particular year:

- the constraint produced by our production function, that is that real GDP is constrained by

$$Y = Min(kK, lL, mM, eE)$$

where

K is physical capital, measured in real money terms and *k* is the productivity of physical capital; *L* is the size of the labour force, and *l* is labour productivity; *M* is the supply of materials, other than energy, and *m* is material productivity; and *E* is the supply of Energy, and *e* energy productivity;

and where we make assumptions about the development of *L, M* and *E* and also *k, l, m,* and *e* over time, and can calculate *K* from knowledge of investment and depreciation (see below);

- the constraint produced by the usual idea of Keynesian aggregate real demand,

$$Y = C + I + G + X$$

where *Y* is GDP, *C* is consumption, *I* is investment, *G* is government current expenditure and *X* is net exports, that is exports less imports. We will predict *C, I, G* and *X* from data concerning the previous period (as discussed in sub-section 5.2 above);

- Werner's monetary theory (from sub-section 5.3 above) of the determination of nominal GDP (that is GDP in terms of actual money in the year in question, not in the 2008 real terms that we have otherwise used throughout this paper)

$$M_Y V_Y = PY$$

where M_Y is credit directed towards the part of the economy relevant to GDP, V_Y is the (assumed constant) velocity of circulation, *P* is the price level and *Y* is real GDP. PY is then nominal GDP. From the previous discussion we see we have no very adequate way of predicting M_Y and for simulation purposes I will set it (actually its annual growth) exogenously.

How do we combine these together? Let us take the demand side, that is the Keynes and monetary equations, first. My proposal is that for modelling purposes we take the simplest possible route. If the annual percentage growth in M_Y is exogenously determined, then the growth in nominal GDP *PY* is equal to that. So from knowledge of *PY* in the previous year determine the current year's *PY*.[108]

We can now use the final equation in sub-section 5.3:

> percent increase in credit supplied for GDP = percent increase in price level + percent increase in real GDP.

As the Keynes equation gives us a value for real GDP *Y,* and hence its percentage increase, we can calculate the percentage increase in *P* and hence *P* itself.[109]

However, it is not quite as simple as that if the result of this calculation is to predict a *reduction* in price from one period to another. In practice prices very rarely adjust quickly in a downwards direction; workers are very reluctant to concede nominal wage cuts, and businesses tend to avoid nominal price reductions. I propose making the simplifying assumption that prices will not adjust downwards; in support of this the GDP deflator (the appropriate price index for the whole of GDP) has always increased in every year from 1949 to 2010.[110] So if the percentage increase in credit is less than the Keynesian proposed percentage increase in aggregate demand, actual aggregate demand will in the short run be *below* the level predicted from Keynesian aggregate demand, because it will be constrained by lack of money. In fact this may very well be the current situation in the UK economy; it may be the lack of new money and unwillingness to make and take up loans that is actually constraining GDP (though it is a close run thing between that and the effect on aggregate demand of large cuts in government spending). On the other hand, when the growth of credit exceeds the desired growth in GDP (or the growth that might be constrained by the supply side), then an increase in the price level will take up the slack.

Taken together then we end up with a very simple theory of maximum GDP determination from year to year:

In any given year, the real GDP is less than the *minimum* of the potential GDPs from the six possible constraints:

- the potential GDP from physical capital,
- the potential GDP from labour,
- the potential GDP from energy,
- the potential GDP from materials,
- the potential GDP from aggregate demand
- the potential GDP from money creation

and once that maximum possible GDP is determined, then two other important economic variables, the inflation rate and the minimum unemployment rate (from the equation for labour productivity) are determined.

This theory is completed with some exogenous assumptions, including in particular an assumption about the trend in the share of wages and its effect on equality. The resulting combination of GDP, inflation, unemployment, working hours and equality variables in turn affects the main welfare determinants that can be affected by the economy. Thus we have a theory which combines material limits to growth, normal longer run economic factors like physical capital and labour, aggregate demand and monetary factors, and which gives results in tangible welfare terms – a joined up view of the economy.

The theory presented here, if reasonably transparent, is clearly a massive simplification. However the proposition that GDP must be *less* than the minimum of the six other items, if not *equal* to it, *must* be true provided the assumptions about productivity rates, supply of resources, components of aggregate demand and the money supply are correct. The maximum GDP calculated is simply a consequence of those assumptions; the structure of theory is essentially tautologous. All the real content of the simulations is in the

assumptions, and whether they make up a reasonable set when taken together and taking account of their potential mutual interactions. Since our main aim is to convince you on reasonable assumptions that sustained economic growth is impossible, and I hope to demonstrate later on realistic assumptions that this *maximum* GDP will decline, this weakened macro-economic theory (that only determines a maximum GDP, not its actual value) is sufficient for the main argument that sustained GDP growth is not possible.

A second reason for pursuing such a theory is to present it as an aspiration, a minimal view of what a model of GDP determination should try to take into account, integrating in particular into the normal account the additional elements of environmental constraints, the question of equality, and empirically based welfare outcomes.

7.3 Simulation

For transparency I present here a simulation tool implemented as a simple EXCEL spreadsheet.[111]
The first 10 years of this simulation simply reproduce the actual data from 2000 to 2009. From 2010 onwards the 6 potential GDPs (ie those limited by energy, materials, labour, capital, aggregate demand and money) are calculated. The inputs to the model are its basic assumptions, set out as follows:

Assumptions	Starting value
Annual growth in non-energy materials	-2.0%
Annual growth in material productivity	3.5%
Annual growth in fossil fuel energy	-1.5%
Additional non-fossil energy capacity added per year mn tonnes oil equiv	0.5
Annual growth in energy productivity	2.8%
Energy price assumption expressed as oil price $ per barrel	$50.00
Participation rate of those 15+	61%
Frictional unemployment assumption	5%
Labour productivity growth	2%
Average hours worked full time workers	37
Annual change in average hours worked	0%
Depreciation rate	6.5%
Physical capital productivity growth	2.0%
Consumption as a percent of GDP(t-1)	65%
Government expenditure as percent of GDP(t-1)	22.5%
Investment as a percent of GDP(t-1)	16.5%
Net exports as percent of GDP(t-1)	-3.0%
Check sum of total percent of GDP(t-1)	101.0%
Net money creation as percent of GDP	5.0%
Year	2007
Net money creation	5.8%
Share of Wages	54.0%

where I will later specify average values for most of these assumptions for each of the three periods 2010-20, 2020-30 and 2030-50. The starting value is guided by figures from the years 2000-2009.

The most important output from the simulation is a graph which shows the maximum real GDP available from each of the 6 determinants of potential GDP. Following the previous section, maximum GDP is then the minimum of each of these. Maximum GDP does not have its own line in the graph as

keeping the separate lines for each of the six potential GDPs means it is possible to see which element is providing the constraint on maximum GDP at any given time. Other outputs are graphs showing inflation, unemployment, the Gini coefficient and GDP/head.

7.4 An example of how the simulation works: materials

I now work through in detail how the simulation works for just one of the six key variables, materials, which is probably the simplest. Similar details of how it works for the other five variables are given in the Appendix.

I start from the actual consumption of materials at 358m tonnes in 2009, the last date for which figures are available, and the rate of productivity of those materials in that year, which is £3830 of GDP per tonne of material. The product of those two numbers, 358m times £3830 = £1371billion is of course the GDP for 2009.[112] I then make assumptions about two things:

- the annual rate of growth (in fact decline) of the quantity of materials that will be used for each year between 2010 and 2050;
- the annual rate of growth of productivity for materials that will be used for each year between 2010 and 2050.

In practice I assign *average* rates for each of these items for the 10 year periods 2010 to 2019 and 2020 to 2129 and the 20 year period 2030 to 2050. I use these averages to calculate actual figures for each year in such a way that there are smooth transitions at the decade boundaries. If we have sudden jumps in these figures at decade boundaries, this will introduce unrealistic discontinuities into the results. That is not to say that in the real world there would not be such discontinuities, but we do not want to introduce them simply as an artefact of the mathematics.

Thus in our business as usual case we will be using the following *average* assumptions for the growth in volumes and in material productivity (the argument leading to these particular assumptions will be given later; the point here is simply to explain how they are used in the simulation):

Business as usual Assumptions	Starting value	Average value over period 2010-19	2020-29	2030-50
Annual growth in non-energy materials	-2.0%	-2.5%	-3.0%	-3.5%
Annual growth in material productivity	3.5%	3.2%	2.7%	2.3%

that is to say for example that we expect the volume of non-energy materials to decline (a -2.5% increase is a decline) on average by 2.5% each year from 2010 to 2019 and on average to decline by 3.5% each year from 2030 to 2050. By contrast we expect productivity to increase by 2.7% per year in the middle decade from 2020 to 2029. These average percentage growth rates are then converted into growth rates for each year by linear interpolation, ensuring that they match each other at the ends of decades. These growth rates are shown in the second and third

columns of the table below (remember that the figures up to 2009 are actuals):

Year	Growth in volume	Growth in productivity	Volume	Productivity	Maximum GDP from materials
2000	0.0%	0.0%	451.0	2628	1185
2001	-0.4%	3.5%	449.4	2721	1223
2002	-0.4%	3.0%	447.8	2803	1255
2003	-0.4%	3.9%	446.2	2912	1299
2004	-0.4%	3.3%	444.6	3009	1338
2005	-0.4%	2.5%	443.0	3083	1366
2006	-0.2%	2.8%	442.0	3170	1401
2007	0.7%	2.8%	445.0	3258	1450
2008	-7.6%	7.1%	411.0	3489	1434
2009	-12.9%	9.8%	358.0	3830	1371
2010	-2.0%	3.5%	350.8	3964	1395
2011	-2.1%	3.4%	343.5	4100	1408
2012	-2.2%	3.4%	335.9	4239	1424
2013	-2.3%	3.3%	328.2	4380	1437
2014	-2.4%	3.3%	320.3	4523	1449
2015	-2.5%	3.2%	312.3	4667	1458
2016	-2.6%	3.1%	304.2	4814	1464
2017	-2.7%	3.1%	296.0	4962	1469
2018	-2.8%	3.0%	287.7	5112	1471
2019	-2.9%	3.0%	279.3	5263	1470
2020	-3.0%	2.9%	271.0	5416	1468
2021	-3.0%	2.9%	262.8	5571	1464
2022	-3.0%	2.8%	254.9	5728	1460
2023	-3.0%	2.8%	247.3	5887	1456
2024	-3.0%	2.7%	239.9	6048	1451
2025	-3.0%	2.7%	232.7	6212	1445
2026	-3.0%	2.7%	225.7	6377	1439
2027	-3.0%	2.6%	218.9	6544	1433
2028	-3.0%	2.6%	212.4	6713	1426
2029	-3.0%	2.5%	206.0	6883	1418
2030	-3.0%	2.5%	199.8	7056	1410
2031	-3.1%	2.5%	193.7	7231	1401
2032	-3.1%	2.5%	187.7	7408	1391
2033	-3.2%	2.4%	181.8	7589	1380
2034	-3.2%	2.4%	176.0	7773	1368
2035	-3.3%	2.4%	170.3	7959	1355
2036	-3.3%	2.4%	164.6	8149	1342
2037	-3.4%	2.4%	159.1	8341	1327
2038	-3.4%	2.3%	153.7	8536	1312
2039	-3.5%	2.3%	148.4	8734	1296
2040	-3.5%	2.3%	143.2	8935	1280
2041	-3.6%	2.3%	138.1	9139	1262
2042	-3.6%	2.3%	133.2	9345	1244
2043	-3.7%	2.2%	128.3	9555	1226
2044	-3.7%	2.2%	123.6	9767	1207
2045	-3.8%	2.2%	118.9	9982	1187
2046	-3.8%	2.2%	114.4	10199	1167
2047	-3.9%	2.2%	110.0	10420	1146
2048	-3.9%	2.1%	105.7	10643	1125
2049	-4.0%	2.1%	101.5	10868	1104
2050	-4.0%	2.1%	97.5	11097	1082

The growth figures (shown shaded) after 2010 until 2050 are assumptions, deriving from our assumptions about average growth rates for the decades.

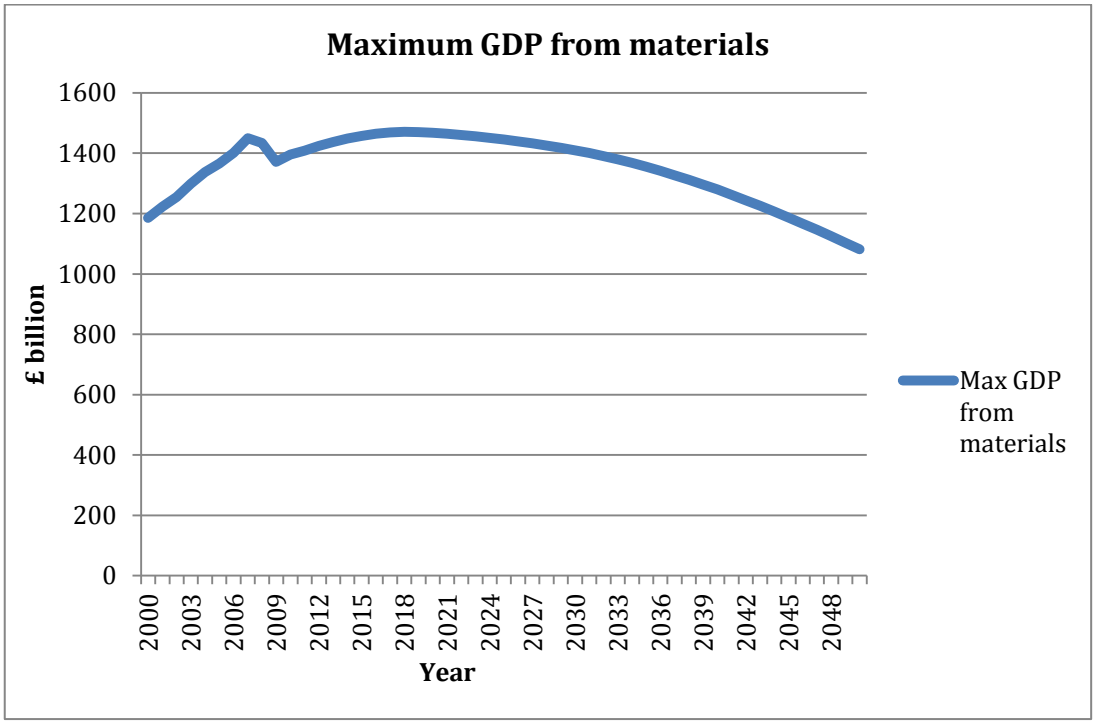
We then use our growth in volume assumptions and the actual figure for 2009 to compute successively the

volumes of materials that could be used by the economy in subsequent years according to the formula

> Volume used in a given year = volume used in the previous year
> X
> (1 + percentage increase/100).

A similar calculation then gives the productivities for each year. The productivity is then multiplied by the volume for each year give the total maximum GDP that can be obtained from materials for that year, given in the final column.

This yields a final result for the maximum GDP that can be obtained from materials that is best expressed as a graph:



where the horizontal axis shows the year and the vertical axis maximum GDP in 2008 £ billion.

Up until 2009 this graph shows actual GDP; after 2009 it shows the consequences of the assumptions. Broadly speaking this is saying that we expect the combination of the supply of materials and improving productivity to allow the maximum GDP from materials to continue to grow until 2020, but that after that the supply of materials may be a constraint on GDP growth.[113] The most important thing about the graph, and simulations of this kind is not the exact numbers produced but the overall nature of the behaviour revealed, in this case potential growth followed by decline.

There is clearly some importance to be attached to the year we begin, in this case 2009. It could be argued that 2009 is an exceptional year, the bottom of a recession. Had we started this extrapolation process in 2007, the

graph would have gone rather higher than it is above. However, for the other parts of this exercise, especially those connected with aggregate demand and the money supply, it is important to start with up-to-date data.[114] To maintain consistency, I have tried to start in the same place for the simulation of all the main factors determining maximum GDP. While the maximum GDP curve for materials would go higher if I started in 2007, its overall shape would still be much the same.

7.5 Summary of the rest of the simulation

The rest of the simulation for the other five factors that each determine a maximum level of GDP work in broadly similar ways. The details are set out in the appendix. The major differences are as follows:

- on energy I make a distinction between renewable energy and energy deriving from fossil fuels. Renewable energy requires considerable investment up front, and is not subject to the volume constraints of fossil fuel energy. This enables us to explore scenarios with much greater investment in renewable energy in the short and medium-term;

- on energy I also make a correction to GDP depending upon the oil price. As the oil price increases, more resources have to be devoted to buying oil, and so overall real GDP declines. It can also be used to simulate the higher costs of renewable energy;

- on labour the potential size of the labour force depends partly upon the population of relevant age, and also upon the participation rate. I use the Office of National Statistics central population projections, and make assumptions about the participation rate. Once we know the size of the labour force, we need also to make an assumption about a normal level of unemployment, and upon working hours. This normally employed labour force is then used with productivity figures to generate a figure of the maximum GDP that can be produced from labour;

- on capital I start from an investment rate, which itself comes from the Keynesian calculation of aggregate demand. Each year however a certain amount of capital is lost through depreciation, and we assumed a depreciation rate. Then the capital stock for each year is computed, starting from the previous year, and adding on investment but taking away depreciation. The maximum GDP from capital is then computed from productivity figures in the usual way;

- the calculation of the components of aggregate demand is a little different, in each case being made as a fraction of the previous year's GDP. For the previous year's GDP, we use the minimum of the six maximum GDPs we have calculated for the previous year. So if fuel shortages for example lead to a constrained

GDP, then aggregate demand the following year will be reduced. The assumptions are simply assumptions on the proportion of GDP that will go to each of consumption, investment, government spending and net exports;

- on money we simply make an assumption each year of the level of net credit creation supplied for GDP purposes (so it excludes credit created to fund purchase of assets), guided by our overall theory on the quantity of net credit set out above. Up to 2029 this assumption is made explicitly for each year, rather than through the use of averages and linear interpolation. This allows us to model sudden contractions of credit. There is no attempt to simulate asset price variation; and

- on the share of wages I simply make an assumption about the share of wages, and then relate it to the Gini coefficient. However our assumption on the share of wages is related to the overall political scenario that goes with an entire set of assumptions. Thus under business as usual we will be assuming that the share of wages continues to decline as in particular unemployment increases substantially, weakening the position of working people. Under our alternative case we will be deliberately increasing the share of wages as a matter of policy.

Once we have a curve for each factor, we can plot them all on the same graph, and maximum GDP will then have to run along underneath the bottom line of the graph or be equal to it. The simulation also produces figures for GDP per head, the Gini coefficient, unemployment, inflation, and the relative shares of renewable and fossil fuel energy.

7.6 Business as Usual

The first task is to construct the business as usual simulation. In this section we will work our way through the list of assumptions given on page 41 above. In some cases we will want to revise our first estimates to take account of interrelations between the factors. For example, if it looks that unemployment is going to turn out to be very high in our simulation, we will probably need to revise down the share of wages as the political position of working people declines. The point is to produce a set of assumptions that look politically, physically and economically realistic when taken together. This is very much a matter of judgement; no mathematical model exists or is likely to exist that combines all the elements of judgement required. The simulation then works out the consequences of those judgements in a very simple and transparent manner.

Materials

We begin with materials. Over recent years the supply of non-energy materials to the UK economy has declined at about 2% per year. McKinsey's point to the ever increasing demand for materials from other parts of the world (particularly those parts that are growing rapidly) and the increasing difficulties in

expanding the supply of many important materials, especially for example iron and steel. Against that background, and taking account also of the U.K.'s declining relative military and political power, and our reliance on imports for many resources, it seems prudent to assume that this declining availability of materials will accelerate over the period. We assume here that materials used will decline at an average annual rate of 2.5% over the 10 years to 2019, 3% over 10 years to 2029 and 3.5% up to 2050. These are modest changes;[115] as we have emphasised above it is entirely possible that a particular and severe supply bottleneck will occur in some particular material at some point. And we are not assuming that policy will change to deliberately accelerate this decline, so as for example to reduce the pollution or loss in biodiversity associated with a particular rate of use of materials.

What are we to assume about the growth in material productivity? In recent years it has been very high, running at around 3.5% to 4% per annum. This is largely reflects the decline in manufacturing in the UK, and the fact that we are importing more and more manufactured products; we don't import the raw materials, we import the finished goods. Our ability to do this depends on our ability to pay for these imports, and in recent years that has been dependent upon the strength of our financial industries and strength of the pound as a reserve currency. I do not believe that this will continue for the next 40 years, and that accordingly the growth in material productivity in our economy will decline to a more normal level. We assume here that it will fall gradually to around 2% per annum by the end of 2050. I regard this as a rather optimistic assumption: it is not at all clear where the increases in material productivity are going to come from. On the other hand we are also assuming that no very special effort is being made to increase material productivity, through say extensive re-cycling or lengthening of product life.

These changes to material availability and productivity growth may appear to be very slight. But we have seen from the projections above that they are sufficient to imply a declining GDP for the last 30 years of the period.

Energy

The next series of assumptions concern energy. This is split into two calculations, fossil fuel energy and non-fossil fuel energy. The latter includes both renewable energy (solar, tidal, wave power and biofuels etc) and nuclear energy. Very roughly this is a split into energy sources that clearly cause climate change and energy sources that are usually represented as not causing climate change.[116] In the business as usual case we assume that the UK is very slow at adding either renewable or nuclear capacity, with fossil fuels still contributing just over half of energy supplies by 2050. This means we are assuming the UK will not meet its Climate Change Act obligations. I think this is reasonable given the current level of inaction,[117] and the historical evidence in McKinsey that without extraordinary action it takes a very long time to replace one energy source by another. Translated into actual investment, it means that the UK will continue to add non-fossil fuel energy capacity at up to about 1 million tonnes of oil equivalent per year.

Fossil fuel use in terms of volume has been pretty much static over the past 20 years, at around 230 million tonnes per year, though there was some

increase up to the top of the boom in 2006. Given McKinsey's projections that worldwide supplies will be harder to find over the next 20-40 years, and burgeoning demand elsewhere in the world, I think it is prudent to assume that UK use of fossil fuels will have to decline over the next 40 years. I have assumed a rate of decline of about 1.5% per year in the first 10 years, 2.3% per year in second 10 years and 4% per year in the 20 years up to 2050. This assumption is driven by what I think the UK will be able to buy, not by what I think it ought to do as a matter of climate change policy.

Turning to energy productivity, it has grown at around 2.8% per annum in recent years. I would expect energy productivity to continue to improve, but many of the more easily achieved improvements have now been carried out, and there are physical limits as to how far energy productivity can go. I assume that energy productivity will grow at 2.2% pa in the 10 years to 2019, 1.7% per annum in 10 years to 2029 and 1.1% per annum in the 20 years to 2050.

I also assume that the fossil fuel energy price will rise substantially, reflecting increased extraction costs and burgeoning demand. Specifically I assume an average price of $100 per barrel to 2019, $200 per barrel to 2029 and $300 per barrel in the 20 years to 2050. I think these assumptions are justified by the peak oil price of around $150 per barrel in 2007 and the strong recovery in prices in recent years.

Labour

We need assumptions that enable us to work out the size of the labour force, and how long on average it works each week. We start from the Office of National Statistics 2010 based population projection. We extract from that the total population age 15 and above, and interpolate for the individual years after 2036 that this projection does not provide figures for. The participation rate of the 15 plus population has in recent years been around 61%, and historically this figure has grown only very slowly. I anticipate that it will fall slightly to around 60% by 2050, reflecting the aging of the population. The average hours worked per week for full-time workers has in recent years being around 37 hours. I anticipate that this will fall slowly over the period, to around 27 hours by 2050 (but see below). We make an assumption throughout the entire period that around 5% of the labour force will be unemployed due to frictional unemployment, and at maximum capacity the economy can only employ 95% of the total labour force. Labour productivity has been growing at about 2% per annum in recent years. I expect this rate of improvement to decline as less energy in particular becomes available to the economy. However, this is not a return to the spade and the horse and cart. Rather we would expect less energy to be used for non-essential applications, such as private transport and heating houses to high levels. Thus though we will expect labour productivity growth to decline, so that labour productivity growth is pretty much constant by 2050, it still remains positive.

Looking ahead to the results of the simulation, it is worth pointing out that these assumptions coupled with other assumptions still to be made will lead to high and rising unemployment so

that by 2050 almost half the workforce will be unemployed. In practice, it is unlikely that a democratic government could allow this to happen and survive. I will leave these rather conservative assumptions as they are for the moment, since part of the point of a simulation like this is to explore what combinations look politically and economically feasible.

Physical capital

The current depreciation rate is around 6.5% per annum. I expect it to rise slightly over the period to 7.0% as material and energy constraints mean that some plant is no longer appropriate. Physical capital has shown a productivity growth rate of around 2%. I would expect this rate of growth to decline with declining energy use, but perhaps not as rapidly as the declining rate of growth of the productivity of labour. Accordingly I have assumed that the growth in physical capital productivity settles down to around 1% per annum by 2050.

Aggregate demand

In the case of aggregate demand we need to make assumptions about what percentage each of consumption, current government expenditure, investment and net exports are as a percentage of the previous years GDP. The figures in recent years have been, successively 65%, 22.5%, 16.5% and -3%. Note that these add to more than 100%; the excess is expected growth. Apart from net exports these figures have historically been fairly stable.

Net exports cannot continue at -3.0%. Eventually, adjustments in the value of the currency must bring this into balance. Accordingly we assume that net exports are 0.0% by 2050. We will have to reduce consumption, government current expenditure and/or investment to take account of this. We assume in the business as usual case that government expenditures remain stable as a percentage of GDP. We will see later that physical capital is not in fact a constraint on GDP (as money, materials and energy do create constraints), and so we have reduced the amount spent on investment from 16.5% to 13.5% by 2050. Consumption is assumed to remain constant at 65%.

Money

The simulation allows us to make assumptions about the new net credit available for GDP purposes for each year until 2029 and thereafter an average amount for the period up until 2050. The catastrophe theory of credit creation outlined above suggests that net credit creation will remain at about 0% until at least 2015, and then only gradually grow, say to around 1% for much of the period until 2030. While high confidence may return thereafter, perhaps sufficient to create a further boom and slump cycle, I have elected simply to assume a 2% growth rate in money thereafter. But a further boom and slump cycle is of course entirely possible.

Share of wages

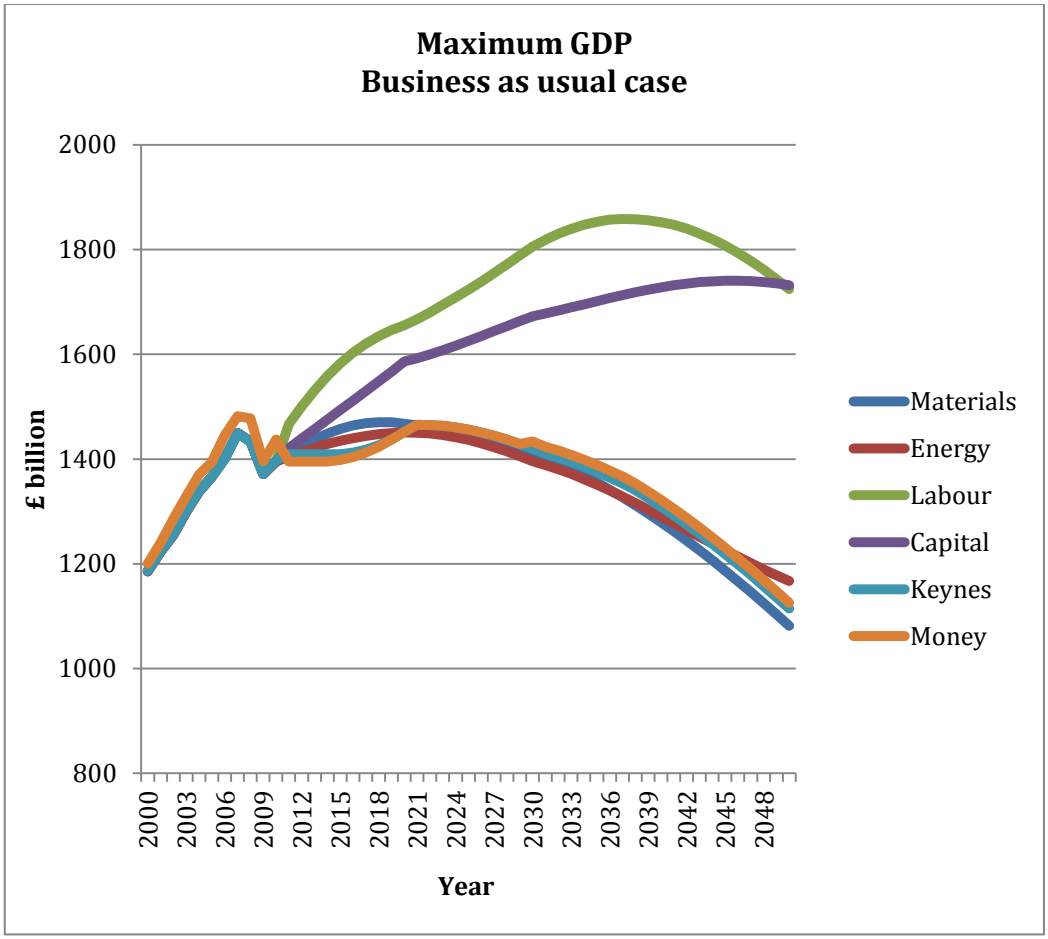
As I have remarked above, unemployment rises considerably in this business as usual case. This will weaken working people in wage negotiations, and so I assume that the share of wages falls from the current average around 54% to only 52% by the end of the period.

Result of the business as usual simulation

Now I bring these assumptions together into a summary for the business as usual case:

Business as usual Assumptions	Starting value	Average value over period 2010-19	2020-29	2030-50
Annual growth in non-energy materials	-2.0%	-2.5%	-3.0%	-3.5%
Annual growth in material productivity	3.5%	3.2%	2.7%	2.3%
Annual growth in fossil fuel energy	-1.5%	-1.5%	-2.3%	-4.0%
Additional non-fossil energy capacity added per year mn to	0.5	0.7	1.0	1.5
Annual growth in energy productivity	2.8%	2.2%	1.7%	1.1%
Energy price assumption expressed as oil price $ per barrel	$ 50.00	$ 100.00	$ 200.00	$ 300.00
Participation rate of those 15+	61%	60.7%	60.5%	60.0%
Frictional unemployment assumption	5%			
Labour productivity growth	2%	1.5%	0.8%	0.3%
Average hours worked full time workers	37			
Annual change in average hours worked	0%	-0.5%	-0.7%	-0.9%
Depreciation rate	6.5%	6.5%	7.0%	7.0%
Physical capital productivity growth	2.0%	1.8%	1.4%	1.2%
Consumption as a percent of GDP(t-1)	65%	65.0%	65.0%	65.0%
Government expenditure as percent of GDP(t-1)	22.5%	22.5%	22.5%	22.5%
Investment as a percent of GDP(t-1)	16.5%	15.0%	14.0%	13.5%
Net exports as percent of GDP(t-1)	-3.0%	-1.5%	-0.5%	0.0%
Check sum of total percent of GDP(t-1)	101.0%	101.0%	101.0%	101.0%
Net money creation as percent of GDP	5.0%	0.3%	1.0%	2.0%
Year	2007	2008	2009	2010
Net money creation	5.8%	2.0%	-2.7%	4.8%
Share of Wages	54.0%	53.5%	53.0%	52.0%

These assumptions produce the following results for the maximum GDP that can be obtained from each of the six factors:



In this graph the vertical axis is GDP measured in £ billion in 2008 real terms. The horizontal axis is the year. The figures up until 2009 are actuals apart from the money line. After 2009 each is the result of a simulation. Thus for example the darker blue line marked materials shows the maximum level of GDP that may be obtained from materials over the period to 2050. The red line shows maximum GDP from energy, the green line labour, and so on. The line marked Keynes shows the level of aggregate demand. GDP is then constrained by all of these lines and must lie either equal or below the minimum of all of them. In practice we would normally expect it to run along at the minimum of all six.

While money and the consequences of the financial crisis are restraining maximum GDP from 2010 to 2020, energy and then materials determine GDP thereafter (which is, following the section on resources above, just about what we would expect). The simulation is suggesting that GDP will remain practically constant in real terms until the end of the current decade, and then may begin to rise slowly. But early in the decade beginning 2020 energy takes over as being the factor that limits GDP. Finally, after about 2035, the availability of other materials becomes the factor that limits GDP. However, as the very high lines for both on the graphs show, both potential GDP from labour and from physical capital (incidentally the usual determinants of the capacity of the supply side of the economy in standard economic theory) rise rapidly on these assumptions and unemployment reaches 40% by 2050.

Overall GDP per head declines from almost £24,000 in 2007 to £14,000 by 2050, still above the £12,000 welfare threshold identified in the section on happiness. The Gini coefficient rises to about 37%, lowering many of the Layard factors affecting happiness. And the UK will have continued to contribute massively to probably catastrophic climate change, other environmental degradation and biodiversity loss. Business as usual points to economic, social and environmental decline.

This may be the point too to remind readers of the caveats I attached to the idea of a 'business as usual' case in sub-section 3.3 above. There may well also be wars, disruptions of trade, conflicts over resources that are not reflected in the smooth development modeled here; mathematical modeling of this kind cannot reflect these.

7.7 A scenario of investment in green energy and controlled descent

There is an alternative future. Green Parties in Europe have been advocating a Green New Deal, a programme of massive investment now in renewable energy resources, designed to reduce climate change, coupled with measures to reduce material throughput, and combat inequality, unemployment and public indebtedness.[118] In the longer run green economists like Peter Victor or Tim Jackson[119] have been arguing for a substantial reduction in not just fossil fuel use which this strategy would allow, but also in throughput of other materials, and a gradual reduction in the size of the economy. Can we combine these ideas and aspirations into a coherent set of assumptions?

Obviously there are many combinations of policy choices that might meet these sorts of aspirations, and the bundle here represents just one set of suggestions. A possible set of simulation assumptions is as follows:

Investment and controlled descent Assumptions	Starting value	Average value over period 2010-19	2020-29	2030-50
Annual growth in non-energy materials	-2.0%	-3.0%	-4.7%	-6.0%
Annual growth in material productivity	3.5%	3.7%	4.2%	5.0%
Annual growth in fossil fuel energy	-1.5%	-3.0%	-7.5%	-10.0%
Additional non-fossil energy capacity added per year mn to	0.5	3.0	4.0	0.5
Annual growth in energy productivity	2.8%	2.3%	2.0%	1.5%
Energy price assumption expressed as oil price $ per barrel	$ 50.00	$ 100.00	$ 150.00	$ 200.00
Participation rate of those 15+	61%	60.7%	60.5%	60.0%
Frictional unemployment assumption	5%			
Labour productivity growth	2%	1.0%	-0.5%	-1.2%
Average hours worked full time workers	34			
Annual change in average hours worked	0%	-0.4%	-0.4%	-0.5%
Depreciation rate	6.5%	7.0%	7.0%	7.0%
Physical capital productivity growth	2.0%	1.0%	-0.5%	-0.1%
Consumption as a percent of GDP(t-1)	65%	63.0%	62.0%	61.5%
Government expenditure as percent of GDP(t-1)	22.5%	22.5%	22.5%	22.5%
Investment as a percent of GDP(t-1)	16.5%	17.0%	17.0%	17.0%
Net exports as percent of GDP(t-1)	-3.0%	-1.5%	-0.5%	0.0%
Check sum of total percent of GDP(t-1)	101.0%	101.0%	101.0%	101.0%
Net money creation as percent of GDP	5.0%	0.8%	1.0%	1.0%
Year	2007	2008	2009	2010
Net money creation	5.8%	2.0%	-2.7%	4.8%
Share of Wages	54.0%	55.0%	56.0%	60.0%

I discuss each of these assumptions as before in the sub-sections below.

Materials and Energy

On materials and energy:

- use of materials is assumed to decline *faster* than the UK would be forced to do in the base case, partly to conserve them (including over-exploited natural resources), partly to reduce pollution and bio-diversity loss, and partly to encourage materials saving technology. Materials use is reduced to 10% of 2010 levels by 2050 as against about 20% in the business as usual case;

- on the other hand efficiency in the use of materials (through re-cycling and longer product life for example) is assumed to improve much more rapidly than in the base case. The overall combination of decline in volume with improved efficiency in fact produces a path for GDP from materials that is little different from the base case. But as with energy below, investment will need to be increased to produce the greater increase in material productivity;

- use of fossil fuels declines very fast, at a rate which is about what is required to get to an economy which uses only 3% of the fossil fuels currently used by 2050, almost a zero carbon economy. It is this kind of level of reduction which is required by the richer countries if we are to contain climate change within the target 2 deg C of average global temperature rise, the target adopted at Cancum;

- to partially replace this, there is a huge programme of investment in non-fossil fuel alternatives, with especially heavy investment in the first twenty years;

- with also heavy investment in energy productivity (energy efficiency), so this rises a little faster than in the business as usual case;

- which also inflates the investment line in aggregate demand (in practice such a programme could only get off the ground quickly enough with massive government investment, and it is the government line that should perhaps be changed); and

- the energy price rise is not so pronounced as in the business as usual case, reflecting the greater proportion of energy (nearly 100% by 2050) that is coming from renewable sources. But we still assume that renewables will be quite a lot more expensive by the end of the period than current fossil fuels.

Labour

Turning to the labour market I assume that participation rates are the same as in the business as usual case. The demographic effect is the same for both, and while people may be less inclined to participate in a smaller and less important formal economy,[120] the proposals below on shortening the working week might well offset this. In practice I would argue for a manipulation of the working week so as to keep unemployment at modest levels whatever the participation rate moves to.

For this set of assumptions I have modeled an immediate reduction in the working week to 34 from the current 37 hours. This should have a rapid effect in reducing unemployment. Working hours are then gradually reduced to around 28 hours by the end of the period. These assumptions are combined however with quite different assumptions about labour productivity growth as compared with the business as usual case. While I assume that labour productivity will continue to grow for the first 10 years, I assume that after that production of GDP becomes *more labour intensive*. This is because energy inputs fall (effectively there will be some substitution of labour for energy), servicing older durables (often made abroad) supplants replacing them with new ones, and recycling and organic sustainable agriculture expand. The combined effect of these changes is to produce an economy with little unemployment and considerably more time not in formal employment (but not necessarily at *leisure*).

Physical Capital and Aggregate Demand

Turning now to physical capital, like labour productivity it seems reasonable to assume that with a more constrained energy supply physical capital productivity will begin to fall later in the period, rather than continue to rise, albeit more slowly, as in the business as usual case. To maintain adequate physical capital so that physical capacity is not a constraint on GDP, the investment part of aggregate demand will have to rise slightly over the period. This is simply an alternative reflection of what we have

said above about increasing energy investment and making things that last longer. If investment in aggregate demand increases, and government expenditure remains about the same, then if as in the business as usual case we are also to move net exports to 0%, consumption as a proportion of aggregate demand will need to fall, from 65% to about 60% by the end of the period.

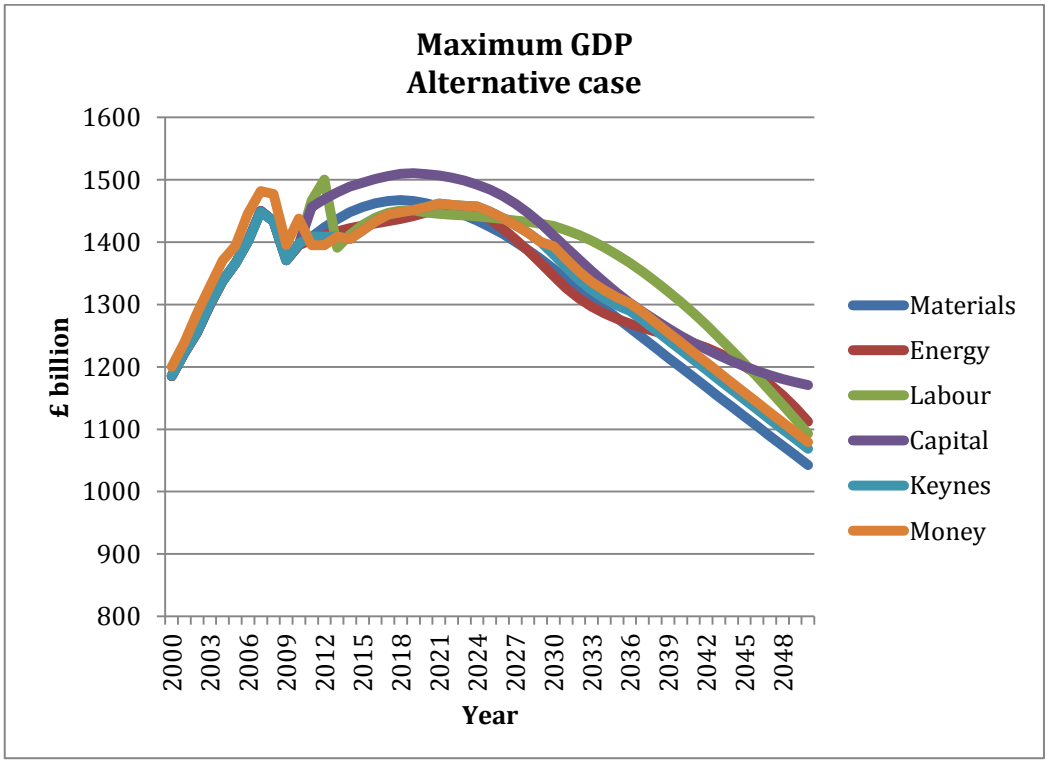
Money

I assume in this scenario that the government has secured control from 2013 over the volume of the creation of credit for GDP purposes (see the next section for some policies to achieve this). I propose that the policy to be adopted is to provide a modest 1.0% expansion of the money supply each year, so that the (relatively stable) economy is never frustrated by lack of money, but that there is no danger of either a speculative credit explosion or of significant inflation.

The share of wages

Finally, we will see that unemployment under this scenario is much lower than in the business as usual case. This will strengthen the position of working people, and will result in a higher share for wages. A higher share for wages might also be achieved by reducing working hours without reducing nominal wages, though this simulation makes no attempt to model the trade off between the increased share of wages and the reduction in working time involved.

The result for the evolution of GDP is as follows:



The broad evolution of the economy will then be an investment led recovery into modest growth for the first few years, until first energy and then material constraints force contraction over the rest of the period. GDP per head will fall from its 2007 peak of almost £24,000 to around £14,000, still

above the £12,000 welfare minimum. Unemployment is reduced to and kept to around 5% until 2025 when it begins to rise again as GDP begins to dip, primarily because of energy constraints; more aggressive action on the working week, or a more rapid reduction in labour productivity might reduce this. Inequality will be substantially reduced, with the Gini coefficient dipping beneath 30%, increasing welfare. By 2050 the UK would be effectively fossil fuel free, independent of foreign sources of fossil fuel and will have made a very substantial contribution to reducing emissions. While in conventional GDP per head terms we will be poorer, both welfare and the environment will be much improved.

7.8 Conclusion: policies for stabilisation and controlled descent

What are the conclusions to be drawn from this?

Major conclusions

There are three major conclusions.

First the era of real GDP growth is over forever, at least in the medium and long term. It will not return, *whatever* demand side economic policies we adopt. The coalition's austerity, Labour's stimulus (whatever it is) and even the Green Keynesianism adopted by many both from a green or a left perspective will all at best lead to a brief recovery, just one last party, adding a final layer to the midden of industrialism. The constraint on GDP will very soon be *physical*, and with declining energy and material resources whose decline will not be matched by improvements in productivity, conventional GDP will inevitably begin to decline. So instead of continually aiming for or simply assuming long-term growth, we need to make the best of what will happen, concentrating on the things that really affect us, like equality, avoiding climate change and leaving the environment in the best possible state we can for our successors. This will be a profound change; growth is deeply embedded in all our assumptions. In particular, the end of growth will have a profound effect on our politics.[121]

Second, one major effect on our politics is that the issue of inequality will no longer be obscured by growth. It will no longer be a matter of fighting over the increase in the size of the cake. We will fight over the cake itself, and the battle will become a zero sum game. All those concerned with reducing inequality and so increasing welfare should take seriously the relationship between equality and the share of wages set out above. If you believe that in a post growth society greater equality would be required, then an important political route to achieving that is to support working peoples' traditional fight for a higher share for wages.[122]

Third, there is no real (as against rhetorical) conflict as some in the environmental movement have feared between stimulating the economy now with green investment, particularly in energy infrastructure, and preparing for a longer term reduction in the real size of the economy. [123] If the aim of any 'Green New Deal' is simply to replace our fossil fuel energy infrastructure and incidentally restore employment in the short to medium-term, but not to return to material based growth for ever, then it is to be encouraged.

However, as Bill Blackwell has warned in a recent article, it is quite wrong to think, even on economic grounds, that green investment is the royal road to *sustained* real 'green growth.'[124] He argues that the energy sector is small, that investment in it will be profitable and substantial only if the economy as a whole expands, and that expansion of the economy as a whole is not possible because of environmental constraints. The extra costs of renewable energy will dampen the whole economy, just as a rise in oil prices has done in the past.

Specific policies

More specifically, the assumptions I have made above in the controlled descent case suggest a number of specific short to medium term policies:

- I support a 'Green New Deal' plan for immediate and substantial investment in renewable energy infrastructure, including investment in improved energy efficiency, though the latter must be done in ways that avoid the rebound effect;[125]
- there is an immediate problem of accumulated government debt and the continuing deficit that must be faced. There may be scope for reducing accumulated government debt through processes to audit the debt and not pay some of it. Controlling the continuing deficit depends mainly on the design, volume and delivery of public services and taxation. Both of these will be considered in forthcoming papers in this series;[126]
- the overall volume and destination of the creation of credit must be controlled, both to prevent instability and to channel funds into appropriate uses. Relying on an independent central bank, interest rates and consumer goods inflation targets is simply insufficient. Interest rates seem to have very little actual influence on the overall volume of credit, and inflation controls that do not include asset price inflation encourage asset bubbles. The latter are damaging both because they promote instability and because they create inequality; the social consequences of high house prices are just one example of the problem. There are at least two ways of controlling credit, either through direct guidance, as in the system of 'windows guidance' in Japan described by Werner,[127] or by effectively nationalising money and hence credit creation;
- it is not inevitable that labour productivity will continue to rise, so it is not inevitable that the economy must get bigger simply to sustain full employment. Even so, despite the promotion of labour intensive activities like small scale low labour productivity but high land productivity organic agriculture, there may be less paid work overall. To spread that work around, policies will be needed to reduce the working week in ways that assist the primary determinant of happiness, our family relationships. In the short term there is a case for an immediate reduction in the working week to less than 35 hours;

- moreover, we need a rebalancing of power in favour of labour in the workplace, not least to increase the share of wages, and with it reduce inequality. This means restoring some of the rights previously enjoyed by Trades Unions and encouraging industrial democracy. It may also mean a return to incomes policies, including the implementation of a living wage policy, and reducing working hours without loss of pay; and
- the increased importance of using and disposing of materials apart from fossil fuels in the economy needs far greater attention. Particular attention needs to be paid to physical development and the construction industry, which not only is responsible for the bulk of material use, but which also by the design of infrastructure determines how we live and so what impact we have on the environment for many years ahead. Some materials may need to be rationed, or taxes imposed to encourage re-use. We will be returning to this in a later paper in this series.[128]

8. Appendix: details of the simulation

8.1 Introduction

As stated before, the Excel spreadsheet[129] of the model itself can be downloaded from http://www.greenhousethinktank.org/page.php?pageid=recentpublications and if you are interested in seeing in detail how it works you are urged to do so.

8.2 The Summary page

The front sheet of the spreadsheet, called 'Summary', is designed as an input output page. On the section marked 'Assumptions' at the top left, all of the numbers in the cells shaded brown are assumptions,[130] and can be changed to produce different results. The numbers in yellow cells are simply notes, which largely show starting values of the parameters concerned, and changing them will have no effect on the results (with the exception of average hours worked, see the Labour section below). The dark grey cells are simply check cells, cannot be altered, and should be ignored. Cells underlined twice in orange are the results of calculations.

Graphical representations of the results are given to the right of and below the assumptions. On the right is a graph of the maximum GDP that can be assigned to each of the limiting factors. The graph has six lines, each representing one of the factors materials, energy, labour, capital, aggregate demand (called Keynes on the graph), and money. Before 2009 all the lines follow a single course, which is actual GDP, apart from the line representing money. The difference between the lines representing money and the real GDP lines is effectively inflation. Since each line represents a possible maximum for GDP, GDP itself must fit beneath all the lines. At any one time there will normally be just one factor that is limiting GDP. For example at the moment it is lack of credit. Later on the constraints are energy or the supply of materials. But it would be perfectly possible to superimpose a financial crisis upon these later cases.

Subsidiary graphs below the assumptions cover GDP per head, unemployment, inflation and the Gini coefficient, and energy supplies.

Behind the summary sheet there are sheets on the six main factors, a sheet on GDP bringing together the six factors to work out a maximum GDP, and then sheets on wages and equality and on welfare. The assumptions are exported to the relevant sheet on the particular factor concerned, the calculations are done on that sheet, and then the results are imported back into the summary sheet.

The following sections discuss each sheet in turn, apart from the sheet on materials which has been covered on page 42.

8.3 Energy

The first assumption concerns the additional non-fossil energy added each year. This is measured in terms of million tons of oil equivalent that that capacity supplies to maintain consistency with the measurement of fossil fuels. The next line then simply calculates the total non-fossil energy cumulatively available. There are two points to note about this. First, there is no provision here for the depreciation of that equipment. We simply assume

that we are making net additions, and the lower figures for the end of the period reflect this. Second, no adjustment has been made for the non-fossil energy already available in 2010. While this slightly affects the figures for the proportions of renewable and non-renewable energy, it has no effect on the economic result.

The total fossil fuel available is worked out from the assumptions in the same way as the availability of materials, using the annual growth in fossil fuel energy consumption. This figure is then added to the total non-fossil energy cumulatively available to give the total energy available in million tons of oil equivalent. Future rates of energy productivity are worked out from the assumption about the rate of growth of energy productivity in the same way as material productivity was worked out on the previous sheet. The next line then works out the maximum GDP that can be obtained from this volume of energy and level of productivity.

The bottom section of the spreadsheet makes an adjustment to GDP depending upon the price of oil. This is done in an extremely simple way. The basic idea is to work out how much extra energy costs across the entire economy as compared with what it would have cost in 2010. This sum is then deducted from the calculated GDP. This makes no assumption about how use might go down as cost goes up, but I have made those assumptions in the assumption on the overall volumes of energy.

While this price correction is expressed in terms of fossil fuel costs, it actually works across all sources of energy, including renewable energy. Thus in the final years of the controlled descent case, the "oil-price" is actually effectively a price for renewable energy, and setting it high reflects how much we think renewable energy will cost compared to fossil fuel energy now. Thus more expensive renewable energy will depress GDP.[131]

8.4 Labour

The labour force sheet starts from the ONS 2010 based population projection for those aged over 15. Ideally we should be working on those aged between 16 and retirement age, but with retirement age changing I doubt whether the gain in accuracy is worth the work involved. I then apply the assumption about the participation rate in line 23 to those aged over 15 to obtain a figure of the total workforce in line 19.

Next we work out in line 26 the labour productivity per person in employment by using the assumptions on the labour productivity annual improvement in line 27. Then we work out the potential GDP from labour with no change in working time in line 29. This uses the assumption we have made for the level of unemployment that we cannot go below (frictional unemployment) and the labour force figures and labour productivity figures.

The figures for working time are worked out using the starting value and the annual changes in hours worked. However, it is possible to make a once and for all change in the starting value, and in the controlled descent case this is done, reducing working time immediately to 34 hours. Finally in line 35 we make an adjustment to

potential GDP from labour to take account of working time. This is done on a simple pro rata basis; I make no assumption that productivity per hour will increase with shorter working hours.

8.5 Physical capital

This spreadsheet first works out total physical assets from the previous year's total physical assets by adding on investment and then subtracting depreciation. However, this is not completely straightforward as a correction has to be made to investment to correct for the fact that this includes investment in residential buildings which are not included in physical assets (see endnote 26 below). Table 9.5 of the Blue Book (ONS 2011b) shows that in any one year around 30% investment is in residential buildings. Accordingly this 30% is subtracted from total investment. The investment figure is taken from the worksheet marked Keynes which we have yet to come to. Depreciation in recent years has run at about 6.5%, and this assumption can be adjusted for the years of the simulation. This depreciation figure will include depreciation of residential buildings, but since their depreciation is so slow it is unlikely to affect the overall result.

And then in line 19 productivity of physical capital figures are worked out, using the assumptions for the improvement in the productivity of physical capital. These are then combined with the productive assets figure in line 15 to produce a potential GDP from capital in line 22.

8.6 Keynes – aggregate demand

This worksheet works in a basically different way from the others. It essentially computes the components of aggregate demand, that is to say consumption, government spending, investment and net exports as functions of the previous year's GDP.

The calculation is very simple, taking as assumptions the proportion of the previous years GTP that are likely to be the current year's consumption, government spending, investment and net exports. Thus in line 16, consumption is worked out by taking the previous years GDP figure in line 14 and applying the assumption about consumption as a percentage of GDP in the previous year in line 17. The other components of aggregate GDP are calculated in the same way.

The figure for the previous year's GDP is taken from the GDP worksheet. Strictly this is a figure for maximum GDP, and so the calculation of aggregate demand may be too much.

And then total aggregate demand is simply calculated by adding consumption, government spending, investment and net exports. Note that as usual in these calculations the government spending figure excludes transfers, such as welfare benefits. These are counted as part of consumption.

8.7 Money

This is the simplest worksheet of all. It starts from the assumption about bank created credit that is advanced for GDP as a percent of money – in any more respectable model this assumption would be generated endogenously, but monetary theory seems to be some way

from providing an adequate view of that. This figure is then applied to GDP in the previous period taken from the GDP worksheet to work out monetary demand for the year in question. Where GDP real growth is less than monetary growth, this translates into an inflation rate.

8.8 GDP

This worksheet now brings together the preceding six worksheets. It simply summarises in lines 14 to 19 the maximum GDP that can be obtained from each of the six factors, and takes the minimum of these to calculate maximum real GDP. It also works out the real GDP growth rate year on year.

8.9 Wages and Equality

This simple worksheet converts the percentage of the share of wages into a Gini coefficient expressed as a percentage. This conversion relies upon the discussion in sub-section 4.3. The correlation coefficient between the share of wages and the three year lagged Gini coefficient over the two decades beginning in the late 1970s years is -0.93. A linear regression gives

3 year lagged Gini = -0.9 X share of wages + 83%.

This formula has been used to calculate the Gini coefficient into the future depending on the assumption about the share of wages.

8.10 Welfare

This worksheet simply calculates GDP per head, using the figures for GDP from the GDP worksheet and figures for total population from the labour worksheet. The population figures come from the ONS 2010 population projections.

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Endnotes

[1] The Royal Society, 2012.
[2] See http://royalsociety.org/news/iap-population-consumption/ accessed 19 June 2012.
[3] Like others (see for example for a conventional approach Chrystal 1999, 351 or Jackson 2009, 40 for references to other literature), I am very well aware of the deficiencies of GDP as a measure of anything very much, let alone welfare, sustainability or happiness. For example it excludes even very conventional things like depreciation of capital equipment, quite apart from things not bought or sold, the depletion of natural resources, damage to the environment, and expenditure on bad things like crime. But for the moment GDP is, as a matter of fact, the focus of economics and politics, not least because of its original historical motivation, which was the capacity of governments to raise taxes. So this is largely an essay with GDP as conventionally measured at its centre; a proper account of political ecology would probably eschew it; in my view the urgent task for economics now is to detach itself from GDP.
To do so I think it is inescapable that economics needs to revert in some way to the classical idea of *value* independent of price. To treat the supply of food as potentially equivalent to gambling, to treat healthcare as potentially equivalent to professional football, is clearly a nonsense, the more so as we face more constrained times. To ignore all the things that are done outside of the market is equally ludicrous. To take account only of production and to ignore reproduction ignores a fundamental part of sustainability and is particularly to marginalise women, but not just women. To not account physically for the good things we take out of the earth and the bad things we put back into it is to ignore a literally essential part of the picture – essential to our very survival. And to focus on GDP per head with no account of distribution is to take no account of the very nature of the society in which the economy is embedded. The next task is an account of macroeconomics like this without the dominant but flawed intellectual support that is GDP.
[4] See http://www.bbc.co.uk/news/business-20078231 accessed 25 October 2012.
[5] See http://www.guardian.co.uk/business/2012/aug/08/bank-of-england-cuts-uk-growth-forecasts accessed 14/08/12.
[6] See May 2012 Labour Market Statistics available at http://www.ons.gov.uk/ons/dcp171778_264236.pdf accessed 19 June 2012.
[7] See for example a typically unspecific but bullish statement from the Shadow Chancellor Ed Balls at http://www.guardian.co.uk/politics/2012/apr/28/ed-balls-george-osborne-economy.
[8] There really is a sharp dip in the current year 2012/13. See Table A.1, line 'Total managed expenditure' in the 2012 Budget Report where the money terms figures from 2010-12 on are successively £696.4, 683.4, 720.0, 733.5, 744.0 and 756.3 bn. Converted to real terms this gives a sharp dip in 2012-13, recovery in 2013-14 and then smaller reductions. Of course this was the plan at the beginning of 2012, it is possible that the actual cut will not be so sharp this year, with a greater cut next.
[9] In a later paper in this series I plan to explore the future for public services in an economy without growth: Brian Heatley – *Post-growth public services.*
[10] If there is growth of 2.5% pa and the government borrows 2.5% of GDP, then its accumulated debt as a proportion of GDP remains constant.

[11] There is a debate about the causes of the deficit, and how much it is due to either excessive public spending, the bailout of the banks or the fall in taxation. This is explored further in Scott Cato, 2012.
[12] See Rupert Read's first paper in this series, *Green House's 'Post-Growth' Project,* available online at http://www.greenhousethinktank.org/files/greenhouse/home/1Post_growth_inside.pdf
[13] See Werner 2005, 19-25 for an amusing account of the implications of this assumption.
[14] See Werner, 2005, 158 for a discussion of an inductive approach.
[15] The Royal Society, 2012, 11.
[16] The use of the word 'growth' is itself interesting. It makes it seem the natural thing for the economy to do, like an organism, and loads the argument against those who question it. If we said the economy 'swelled' we would have a quite different picture; even simply to talk of the market economy as 'a growth on nature' changes the terms of the debate. Rupert Read and Matt Wootton will be exploring these issues in a later paper in this series called *A new post-growthist common sense – challenging the hegemony of growthist discourse.*

[17] ONS 2010 based population projection.
[18] For a brief account see http://en.wikipedia.org/wiki/Harrod–Domar_model.
[19] This latter approach is the focus of Niall Ferguson's 2012 Reith lectures, see http://www.bbc.co.uk/iplayer/episode/p00tbs58/The_Reith_Lectures_Niall_Ferguson_The_Rule_of_Law_and_Its_Enemies_2012_The_Human_Hive/.
[20] Related to this is the enlargement of the part of the economy where profit and accumulation is possible through the privatisation of formerly public parts of the economy, such as the Conservative privatisations of nationalised industries in the 1980s and 1990s, and the pressures for privatisation in health and education now. While additional profits may be created, this does not necessarily increase GDP.
[21] There is a separate debate about whether growth is economically inevitable in a capitalist economy. That it is inevitable but nevertheless doomed by the limits to growth, thus bringing about the end of capitalism, is the essential claim of many eco-socialists (See for example Kovel 2002 or Smith 2010). On the other hand many advocates of low or non-growth or a stationary economy (eg Daly, Porritt, NEF 2010, and even implicitly Victor 2005 and Jackson 2010), either explicitly assume capitalism can, will or should continue, or avoid the issue. I do not pursue this question here; I regard the case for the ecological inevitability of the end of capitalism as highly probable but not proven.
[22] See Harvey 2010, 116.
[23] In practice a firm might be at all these points at one time, and different firms maybe at different points. But that does not change the analysis. And while the language is that of manufacturing, essentially the same cycle exists in other industries, including service industries.
[24] Not normally identified separately in Marx or Harvey, who use the traditional schematic M → C → M.

[25] Not true of course of green or ecological economics, but some of that is environmental economics, which is mainly microeconomics, concerned with individual consumers, firms or markets.
[26] See Keynes, 1936, 23.
[27] This is expressed in Okum's rule of thumb: a 2% decline in GDP will result in a 1% decline in employment. It's not 1:1 because firms may hoard labour and some who leave the labour force will not show up as unemployed.
[28] It's not immediately clear where to find this concept in the Blue Book (ONS 2011b). I've used here Total Tangible Assets (line CGRE from Table 10.2) minus Residential buildings (line CGLX), as the latter are not productive in the usual sense. Removing residential buildings is a major subtraction – in 2010 residential buildings were 62% of the total of tangible assets. Arguably one might also include intangible assets, like intellectual property, though that's not clearly part of the concept of *physical* capital stock.
[29] Indeed there is also a huge argument about whether the idea of capital is really a well formed concept (the problem is one of circularity; the monetary value of a piece of machinery depends upon what profit can be made with it. But using the idea of productivity, we are going to work out what can be made with it from the monetary value.) Also there is a problem distinguishing capital from other commodities. Classical economists tended to place far more attention on the raw material inputs to production processes, which is an approach I partially revert to by considering material inputs far more seriously. Sraffa set up a whole scheme whereby there was no capital as such, and commodities were produced from other commodities and labour (this is all discussed in Keen 2011,142 onwards). While I sympathise with Sraffa, like GDP the idea of capital stock lying at the base of both short run cyclical theories and long run growth theories is so well established, I am not going to challenge it in this paper; the point is to assail the main political assumptions now being fought over, not tilt at slightly irrelevant windmills.
[30] There is a very good case for considering land, in the broad sense of natural capital, as a separate factor of production, and also for considering food as a separate and essential component of GDP. I don't go down this road here entirely to keep the account as simple as possible.
[31] This section is inspired by the programme suggested by Tim Jackson (see Jackson 2009, 210).
[32] Author's own calculations with figures taken from ONS 2011b, and some linear interpolation where data was not available.
[33] It's important to note once again that this is growth in GDP, and that that might reflect changes in the composition of GDP as much as changes in its overall volume. For example, how much of the growth simply reflects increases in the relative proportion of entirely financial activity?
[34] This incidentally accords with Sraffa's views on the production function, see (Keen 2011, 108). It also corresponds to the 'short-side principle' when markets do not clear and are rationed, see Werner 2005, 27.
[35] Office of National Statistics, 2011c, 43.
[36] See http://www.greenhousethinktank.org/page.php?pageid=gases.
[37] Though the original *Limits to Growth* report in 1972 (Meadows 1972) had the downturn in production in its standard run (no major changes in physical economic or social relationships) due to resource depletion and pollution coming early in the 21st

century. They did not revise their opinions in later editions of the book, and their predictions to date in the standard run been surprisingly accurate.
[38] McKinsey Global institute, 2011.
[39] Ibid, 1.
[40] Ibid, 5.
[41] See http://www.hbs.edu/environment/docs/McK_Q_Voices%20on%20the%20Resource%20Revolution.pdf accessed 13/03/12.
[42] Ibid, 2.
[43] See http://www.transatlanticacademy.org/blogs/raimund-bleischwitz/resource-revolution-its-gonna-be-alright accessed 13/03/12.
[44] Ibid 33, 36.
[45] Ibid, 33.
[46] Ibid, 37.
[47] Ibid, 44.
[48] Ibid, 45.
[49] Ibid, 47.
[50] Ibid, 48, Exhibit 13.
[51] Ibid, 49.
[52] Ibid, 61.
[53] Ibid, 70.
[54] Ibid, 71.
[55] Ibid, 119.
[56] See an alternative analysis by Cambridge University's Wellmet team on potential to halve global CO2 emissions in global metal production. They conclude this cannot be done by market incentivised efficiency improvements alone but also requires a change in the way we use materials (see withbotheyesopen.com).
[57] This reflects McKinsey data that suggests that if it is left to the market new forms of energy supply take at least fifty years to establish themselves as a significant part of the mix, albeit at quite a low level. I've taken McKinsey's global view of the prospects for nuclear: for the view that new nuclear plants might very well not be built see David Toke's Green House Gas *Britain's Disappearing Nuclear Power Programme* at http://www.greenhousethinktank.org/files/greenhouse/admin/Britains_disappearing_nuclear_power_programme_final.pdf .
[58] ONS 2010 based Population Projections.
[59] Changes in immigration policy in particular could alter this assumption.
[60] Keen 2011, 129.
[61] Polyani 1944.
[62] Adam Smith was concerned to justify profits as the source of prudence and investment, Ricardo sought to show that rents were parasitical, and Marx, using the labour theory of value sought to show that the labourer received less than the value they created.
[63] Office for National Statistics, 2011, 26.
[64] Office for National Statistics, 2011, 32.

[65] Named after the consensus between the Conservative Rab Butler and the Labour leader Hugh Gaitskell in the twenty five years after the war.
[66] The turning point was memorably encapsulated by the title of Eric Hobsbawm's 1978 essay '*The Forward March of Labour Halted.'*
[67] There is a related question as to whether in some economic sense high rates of growth *cause* inequality. While recent UK experience might suggest this, the period after the Second World War tends to suggest the opposite. It may be that right wing policies designed to promote growth, such as reductions in worker's rights, also cause inequality. But against this a smaller share for wages probably on balance reduces aggregate demand, and with it growth if that demand is not made up some other way.
[68] The correlation coefficient between the share of wages and the three year lagged Gini coefficient over these years is -0.93. A linear regression gives 3 year lagged Gini = -0.9 X share of wages + 83%.
[69] Some argue that technological change is the sole cause of increasing inequality. A reference to an article debunking this and asserting, as here, the primacy of policy is discussed at http://www.guardian.co.uk/commentisfree/cifamerica/2012/jul/16/technology-inequality-policy-change.
[70] A much more murky area is how far at the higher levels classification of income as salaries or profits has moved income from one of these categories to the other for tax reasons.
[71] Lansley, 2009, 5
[72] See Harvey 2010.
[73] Lansley 2009, 5.
[74] See Sarkar 2012 for example. I will argue below that the financial system can get into a position where a very small change in other factors can provoke a very large change in the provision of credit. It may be that relatively small increases in the prices of certain commodities, especially oil, brought about by scarcity, were the immediate cause which provoked the financial crisis. To put it another way, in Aristotelian terms, the structure of the financial industry was the formal cause, while the peak in oil prices was the efficient cause.
[75] Werner 2005.
[76] Nordhaus 2005, 695.
[77] Werner 2005, 182.
[78] Werner 2005, 187.
[79] Werner 2005, 188. He also devotes some time to showing that this is not actually a new view, and that it has been espoused by Law and Schumpeter amongst others. It seems to me that this view ignores money that moves from savings into a current account to be spent, that is existing money used to create credit. Excess profits being lent to consumers would be a case in point. I correct for this below with my term *x*.
[80] Werner 2005, chapter 14.
[81] As I suggested above, I am departing from Werner here, in that he places no emphasis on loans of existing money. I regard this as important, not least because of the influence of excess profits created by too low a share of wages outlined above.
[82] This is one of those elementary but not completely trivial mathematical maneuvers which economists simply assume but which puzzle non-economists or non-mathematicians. The full derivation is as follows. We start with:

$$M_Y V_Y = PY$$

Taking logarithms of both sides we have

$$LogM_Y + constant = LogP + LogY$$

Differentiating both sides with respect to time, t, and noticing that the constant disappears upon differentiation:

$$\frac{1}{M_Y}\frac{dM_Y}{dt} = \frac{1}{P}\frac{dP}{dt} + \frac{1}{Y}\frac{dY}{dt}$$

or putting into words

percent increase in credit supplied for GDP = percent increase in price level + percent increase in real GDP.

This works whenever you have a product of two (or more) variables like *P* and *Y*. The percentage change in a constant multiple of the product (*PY*) is equal to the sum of the percentage changes in each of the variables *P* and *Y* separately.

[83] Werner 2005, 195.

[84] Use of 'banking confidence' is inspired by a presentation on the New Economics Foundation website (at http://www.neweconomics.org/blog/2012/08/08/including-banks-in-macroeconomic-models-finally accessed 29/08/12, slide 19 onwards) by Emanuele Campiglio. I'm grateful to David Smith for drawing my attention to this.

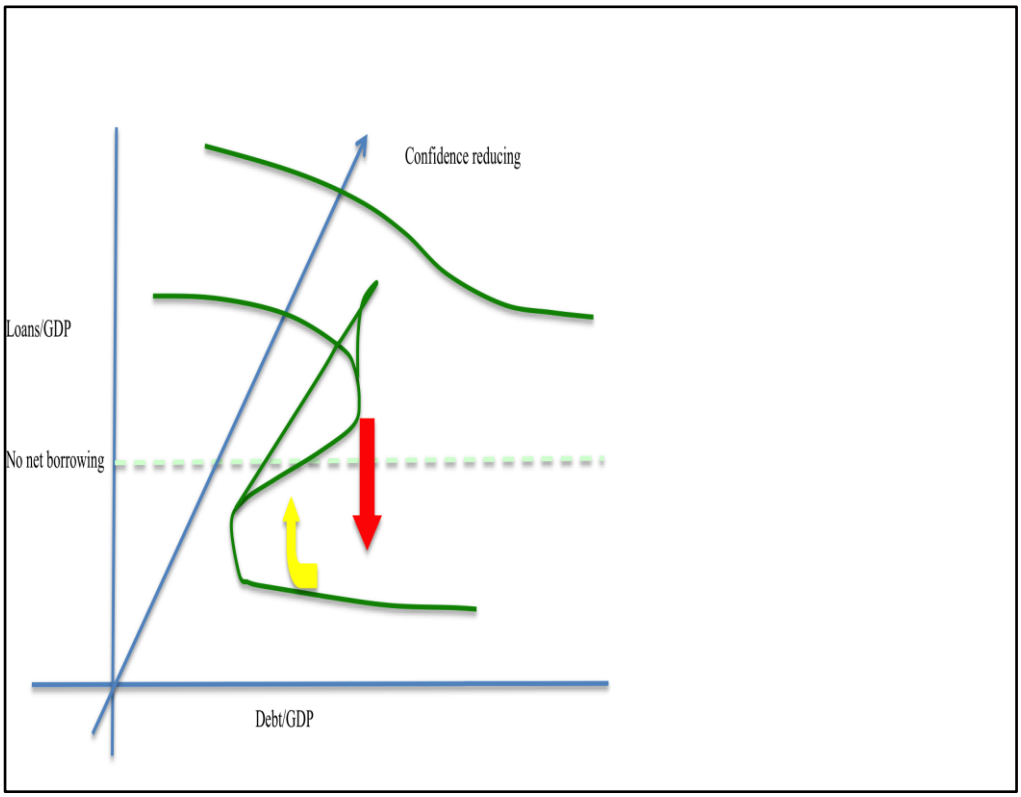
[85] Keen, 2011, Chapter 13.

[86] See the video by Richard Koo at http://www.youtube.com/watch?v=5zCJy84Yvvo accessed 10 July 2012 on the importance in the Japanese slump of companies simply seeking to reduce indebtedness and repay loans.

[87] The role of custom and institutional factors in determining bank behaviour is set out in Thomas Lines earlier Green House Paper, *The Dog that didn't Bark: When banking crises did not occur and what we can learn from that,* available online at http://www.greenhousethinktank.org/files/greenhouse/home/Banking_inside_final_3.pdf.

[88] A good overall account of Catastrophe Theory can be found in Zeeman, 1977; the Wikipedia account (http://en.wikipedia.org/wiki/Catastrophe_theory) is purely mathematical and no help in understanding the theory's potential applications. There is no explicit account of application of the theory to credit cycles in the set of essays cited, although the essay on Stock Market instability (Zeeman, 1977, 361) bears some resemblance to the account given here.

[89] One can combine these two diagrams into a single three dimensional diagram, with the third variable, confidence reducing as you look into the page:



The dependent variable, net lending as a proportion of GDP, is a folded surface above the plane representing the two explanatory variables, debt as a proportion of GDP and confidence. In the language of catastrophe theory, confidence is a *splitting* variable; as banks become more free from regulation and less cautious about potential failure we move into the section of the graph where there can be two values (the third intermediate value in the above diagram represents an unstable equilibrium that will not in fact be achieved) of net lending for each value of overall debt, and where excessive movement in either direction can lead to a sudden change, as in the initial two dimensional graph above. When banks are not confident, we operate on the portion of the surface where there is only one value of net lending for each combination of debt as a proportion of GDP and confidence.

[90] Tom Lines Green House paper, *The Dog that didn't Bark,* explains how culture and practice reduced bank freedom in the UK in the thirty years following World War II (available at http://www.greenhousethinktank.org/files/greenhouse/home/Banking_inside_final_3.pdf accessed 2 August 2012.)

[91] Unless of course there is resort to more radical measures to reduce debt, especially government debt, as will be described in the forthcoming paper in this series *Can't Pay; Won't Pay: Austerity, Audit and Odious Debt*, by Molly Scott Cato.

[92] Given what I said about empirical methodology above, it might be worth an observation on the nature of what I have done here. While the use of a graph might give the *impression* of a precise mathematical relationship that is fitted to some numerical data, that is not what I are trying to do. All I are doing is suggesting the *qualitative* nature of the kind of curve that describes the relationship between the

three variables – net lending as a proportion of GDP, the stock of debt as a proportion of GDP and bank confidence – which is described in the narrative above. It is significant qualitative difference that it is a folded surface rather than an ordinary flat one as that gives rise to the possibility of sudden large changes, or catastrophes. Because of the qualitative nature of what I am saying, it doesn't matter that I have no precise numerical measure of bank confidence.

[93] Layard 2005.

[94] ONS 2012. One year's results while interesting, does little to understand how other factors affect well-being, other than the most basic, such as geographical location and age. But it was interesting nevertheless that the happiest people seemed to live in the Hebrides, and the least happy in run down ex-industrial areas.

[95] Wilkinson 2009.

[96] Layard 2005, 63. 'Personal freedom' is about the ability to make personal choices of belief, where you live, what work you do and so on. 'Personal values' is rather less well defined, but is to do with having a strong set of personal values that you live by, often but not always associated with religion. There is a fascinating empirically unexplored area about how effective a set of personal values based on materialism and consumption is as a set of personal values contributing to happiness.

[97] Of course, much also depends on the distribution of that GDP, and median income would probably be a better measure.

[98] Layard 2005, 29.

[99] Author's calculations based on lines ABMI (GDP) and DYAY (Population) in 2011 Blue Book, ONS 2011b.

[100] It has been argued that this leveling out of happiness at higher levels of GDP per head simply reflects the fact that happiness is typically measured on a bounded scale, say from 1 to 10, while GDP per head is potentially unlimited. Once people reach the top of the happiness scale, there is nowhere for the extra happiness associated with extra income to go. It seems to me that this is belied by data that shows the percentage of people saying that they are very happy – which is of course bounded at 100% – barely changing in the US since the 1960s from around 30%, while incomes have grown substantially (Layard 2005, 30).

[101] Layard 2005, 32.

[102] The international level of $15,000 1999 US$ was equivalent about £10,000 in 1999, which is itself equivalent to about £12000 in 2008.

[103] That's not to say that we wouldn't be unhappy, at least temporarily, at having our incomes halved.

[104] See the graph in Wilkinson 2009, 7.

[105] Layard 2005, 64.

[106] Wilkinson 2010, Chapters 5, 6 and 7.

[107] Page references are to Wilkinson 2010.

[108] This dodge eliminates the constant but unknown velocity V_Y.

[109] Notice that if this very simple route is followed, money has no effect on real GDP at all, it simply determines the price level.

[110] See line YBGB in ONS 2011b.

[111] This spreadsheet is available online at http://www.greenhousethinktank.org/page.php?pageid=recentpublications.

[112] All in real £ 2008 terms.
[113] There's nothing surprising in the 2020 turning point, it's inherent in our assumptions. If you look at the table you will see that 2020 is the year when productivity growth can no longer outweigh the effects of volume decline.
[114] While of course there is much more up to date economic data than 2009, the last year for which we have a *complete* set of data, including all the physical variables, is 2009.
[115] It's important to appreciate just how potent small changes in percentage growth rates compounded over 40 years can be. At a 1% growth rate a quantity grows to less than 50% more than its original size over 40 years; at a 2% growth rate it becomes more than 2.2 times its original size. If some of our adjustments seem small, it's in appreciation of this arithmetic.
[116] I are well aware nuclear energy creates substantial emissions as part of the mining and construction processes, and that many biofuels are extremely inefficient in terms of the emissions saved.
[117] This includes inaction on nuclear as well as genuine renewables – see David Toke's Green House gas *Britain's Disappearing Nuclear Power* at http://www.greenhousethinktank.org/files/greenhouse/admin/Britains_disappearing_nuclear_power_programme_final.pdf.
[118] See for example http://www.greennewdealgroup.org/.
[119] Victor 2008, Jackson 2009.
[120] Paticularly if there has been welfare reform resulting in some kind of Citizen's Income proposal. See for example the Green House paper *Mutual Security in a Sustainable Economy* by Molly Scott Cato and Brian Heatley, available at http://www.greenhousethinktank.org/files/greenhouse/private/welfare_inside.pdf.
[121] The effect on politics will be considered in a forthcoming report in this series by Andrew Dobson, *Post-Growth Politics*.
[122] It would be nice to think that the current Labour enthusiasm for 'pre-distribution' rather than state sponsored re-distribution stemmed from something more than fear of the politics of re-distribution.
[123] See for example the motion C02 passed by the England and Wales Green Party Conference in Autumn 2010 and put to it by a number of members of Green House contrasting the Party's support for the Green New Deal and its basic commitment to building an economy within ecological limits.
[124] Blackwell 2012.
[125] If our houses are made more energy efficient creating savings on our energy bills, we might very well adjust to this by increasing the setting on the thermostat. Moreover, if we then spend the money we saved by flying off on holiday to the Bahamas, the whole gain of our greater energy efficiency might be lost.
[126] See the forthcoming reports in this series by Molly Scott Cato *Can't Pay; Won't Pay: Austerity, Audit and Odious Debt* and Brian Heatley, *Post-growth public services.*
[127] See Werner 2005, 268.
[128] *Industrial policy and infrastructure – the depth of the challenge of a green transition* – Jonathan Essex
[129] I began doing these simulations using the Systems Dynamics programme Vensim. But I became convinced after a while that the results for a simple simulation like this would both be more transparent and could be more flexibly presented using Excel.

[130] I use the default Excel scheme for styling different types of cell.
[131] See Blackwater 2012 for a fuller exposition of this, and a counter to arguments that such green investment will lead to *long term* sustainable growth.