How Can We Achieve a Physically Sustainable Economy?

Rebuilding Macroeconomics Discovery Meeting

28/11/2017

We originally asked the question, "How can we achieve a sustainably economy?" with two focuses: physical and social sustainability. Both areas of discussion were rich enough to warrant two separate research hubs on each topic. These are the summary notes from the physical sustainability half of that meeting. To view the summary notes from the social sustainability half, or as it is now called, the "Cooperation Hub," please click here.

This meeting discussed the implications of physical sustainability on economic performance. Topics of discussion ranged from reconsidering how macroeconomics deals with issues of: energy production, climate change, economic growth, economic modelling challenges in dealing with these problems and some possible solutions to them.

How Central Is the Role of Energy in Economic Growth?

Introduced by Michael Kumhof, Senior Research Advisor, Research Unit, Bank of England

Michael began with two key forward-looking questions: (a) what is the outlook for net energy availability; and (b) what are the implications of energy availability for GDP? Having looked at the history of these issues, he considers it possible that a "structural break" may not be too far ahead.

Under the first query, there is a sub-question on gross energy availability, for which there are, broadly speaking, two opinion camps: "optimists" and "peakists." Whilst this is an important area of debate, there was not sufficient time to engage with it in this particular session. The main question Michael addressed is net energy availability – energy return on energy investment (EROEI) defined as gross energy produced divided by the energy input required to produce that energy. The EROEI of oil, for example, rose to a high during the mid-twentieth century but has been declining ever since as production has been forced to move to less accessible locations. EROEIs have also been declining for other energy sources. On the extreme, tar sands and corn-based ethanol are relatively pointless energy sources on this scale, as almost as much energy is required to extract them as they provide.

The economic implications of energy availability for GDP – potentially in terms of very high energy prices, very large demand destruction, with less consumption and more investment – depend on key aspects of the production function such as the elasticity of substitution between energy and other factors, the output contribution of energy, and the connection between energy and technology. Mainstream economics would project a low elasticity in the short-run and higher elasticity in the long-run, under the assumption that high prices stimulate substitution. An alternative perspective, focusing on entropy, would forecast low elasticity in the short-run and even lower elasticity in the very long-run, given that low quantities of energy eventually make further substitution impossible.

The mainstream conception of the output contribution of energy implies that energy is only as important as its cost share, which is small, usually between 5% and 10%. This view is problematic, in that implies that labour and capital can function without energy, which is inconsistent with physics. This approach is more the production function of a shopkeeper than an engineer and physicist. Non-mainstream contributions in Biophysical Economics find much higher output contribution, sometimes up to 50%. Michael suggested that it would be important for Rebuilding Macroeconomics to at least listen to this Biophysical perspective as an important source of innovations. He suggested alternatives from two projects he is working on. Firstly, that energy is a critical enabler of key technologies (i.e. technology is only possible because of energy). Secondly, that capital per se does not matter and it is only harnessed energy that matters.

Michael finished with a plea for the rejection of complacency. Given that the continued growth of gross energy production may be difficult, the decline of EROEI seems certain and the substitutability between energy and capital/labour may have physical limits. It is possible that technological progress "may have been energy all along" in that it only existed because of energy and that "capital" only matters because it harnesses energy. These problems are of considerable macroeconomic importance and there has been insufficient research in this field thus far.

Angus Armstrong asked about our knowledge of the rate of decline of EROEIs. Tim Foxon noted the issue of measurement error involved in generating these indices, particularly with regard to low carbon technologies. Doyne Farmer stated the need, regardless of EROEI trends, to stop using fossil fuels within the next thirty years and focus on the EROEIs of renewable energies. An EROEI level of 8 poses no particular problem. Improvement levels are consistent and forecastable through time. An EROEI level of 2, however, would represent worrying inefficiency. Tim Jackson stated that reduced costs for alternative technologies are "piggy-backing" on lower costs for conventional energy sources, on which they depend currently for their construction and installation. We will find it difficult to predict long-run trends until we know how the costs between fossil fuels and alternative technologies interact. Doyne Farmer disagreed by pointing out solar pv is now competitive in its own right.

Tim Foxon noted that he had just co-written a book on Energy and Economic Growth. He thought it was important to not get too stuck in the technical measurement of energy production, and that the problems of understanding economics should be the main focus. He thought it plausible that the theoretical treatment of energy within physics could be adapted for use in economics. There are questions about the sustainability of a low carbon economy, and uncertainties about the transition to getting there; but the main uncertainty is the basic relationship between energy and economic growth. Doyne Farmer thought that a Cobb-Douglas functional form, which is often used in this area, is basically arbitrary – a mathematical convenience rather than empirically grounded. Moreover, once we question these often used production functions, we question our measurements in productivity and distribution theory. Everything is up for grabs. Simon Sharpe accepted this point, but still thought the relationship between energy and economic growth is of first order macroeconomic importance.

Daniel O'Neill brought in the issue of productivity and noted that the literature in the area of automation tends to look at the potential for productivity gains without considering the energy factors and costs involved. New technology needs considerable amounts of energy, as evidenced by several large technology companies. Angus Armstrong noted that real energy prices are historically low. Roger Morley accepted this, but said that this tells us nothing about potential price movements over even a few years. Doyne Farmer said that his own time series models indicate that, in real terms all energy price series are random walks without drifts over the last 120 years. Michael Kumhof suggested that the energy markets should be understood as having inelastic demand and supply curves making the spot price deceptive, and concealing the risk of future price shocks. He also noted that different energy sources are not perfect substitutes. Oil, for example, has some capabilities which other forms of energy do not possess.

Simon Sharpe said that people in his Department have contacted several senior macroeconomists to ask about the importance of Biophysical inputs, including energy, only to be met by indifference or incomprehension. Given the centrality of energy to so many economic issues, there appears to be a huge gap in current economic thinking in this area. The main question is whether the net energy supply to the economy is an important contributor to growth.

Does Macroeconomics Need to Take Planetary Boundaries More Seriously?
Introduced by Professor Doyne Farmer, University of Oxford

Doyne Farmer wanted to make the case for a Sustainability Hub. He noted that there are existential questions facing the planet relating to climate change as a result of our economic activity. For example, carbon dioxide accumulates in the atmosphere and takes thousands of years to flush out; there is 90 metres of potential sea level rise in the ice caps; the Western Antarctic ice shelf will itself inevitably melt into the ocean which itself will result in a 2-3 metre rise in sea level. The uncertainty surrounds when these events will happen.

However, there are relatively few provisions for these impacts in current macroeconomic models, such as those developed by Nordhaus. Future models need to incorporate a good understanding of technological change and a better understanding of what is driving technology. We need to understand the problem in order to make the necessary transition in an ordered way, and to appreciate the costs involved. Disaggregated models will be needed to cope with the number of alternatives available, and the interactions of potential technologies. The consequences of responding to environmental change could be a huge shift in investment.

Heterogeneity needs to be modelled, as people in different countries will be affected in varying ways. Neo-classical economics also does not allow for irreversibility or how we include catastrophic risk: these are both features of the reality we face. Both have critical problems in modelling strategies by creating discontinuities in functions. We need new ways of thinking about economics. Damage functions need to be better estimated and quantified. Current models have not been back-tested against historical data. We don't know whether the overall cost of transitioning to a low-carbon economy will be positive or negative; it is possible that the cheaper energy costs arising out of this shift will produce a net gain, but it is impossible to predict this outcome with any certainty because our macroeconomic models are not sufficiently strong.

Climate change is not the only problem: human pressure on fish stocks and other bio-systems is threatening to cause the collapse of those systems. We need better data and ecological macro models to describe the physical economy, and not just the monetary flows associated with inputs and outputs. We need to assume some things are fixed based on the physics and then solve our optimisation problems. We must find a way to take account of the planetary constraints and desire for technical progress. Improved macroeconomics is required to model the costs involved and to communicate clearly the issues to the public. Macroeconomics is certainly now about finance, but it also needs to be more about technology, growth and long-term change.

Doyne returned to the question of whether an economy can grow in a sustainable way. This depends critically on what "growth" means and what GDP actually represents in terms of physical output. It is already the case that GDP has been (spontaneously) dematerializing, so that a dollar of GDP now weighs less and emits less CO_2 than it used to. However, this process needs to be dramatically accelerated, so that a dollar of GDP in the future has no greenhouse gas emissions and a sustainable level of environmental impact. We need a transformational change and one that builds on system dynamics. If we want the system to change then we need to understand the system's dynamics. It may take a major crash for the impetus to make these changes.

Angus began by defending macroeconomics to the extent that irreversibility and catastrophe have been considered in the literature for some years, although admittedly not macro-models. Oliver Bettis pointed out that the use of standard cost-benefit models have to exclude the possibility of the economy itself being destroyed, which is by no means impossible under some of the potential scenarios; there would not be an "economy" to model at global temperature rises of, say, six degrees.

Daniel O'Neill said that climate change is the best researched of these environmental issues which would affect macroeconomics, but there are many others involved. Macroeconomic models are currently unable to deal with discontinuities; we have to look at extreme events and try to understand how they would affect economic policy. He has found over twenty alternative macroeconomic models under development, not all of them have been published. They generally do not take the common practice approach of optimisation, but rather a pluralist approach attempting to reconcile different and sometimes competing objectives. We also need to move beyond GDP as the principal measure of economic growth.

Simon Sharpe thought that the understanding of the problems is different from the approach to solving them. He agreed with Doyne that the Nordhaus model provides an insufficient basis for future projection. Given that uncertainty in this area is to a large extent irreducible in scientific terms, it is difficult for economists to build effective models. There are also significant subjective choices to be made. For example, London cannot currently be defended from sea level rises of more than five or six metres; and a global temperature rise of 2 degrees would result in double that level of sea level change. We thus do not know when London would cease to be a viable city, or what political choices might be made in order to try to sustain it. At the moment, macroeconomics does not tell us anything helpful for these scenarios. On solving the problems, given that we need transformation change, macroeconomics also does not help us much about how we need to make this movement.

Marion Dumas asked for clarification about the measure of productivity that is being used in this discussion; there are different implications depending on the indices being used. Tim Jackson noted that whether or not we regard the uncertainties mentioned earlier as being within the "frame" of macroeconomics, the implications of those uncertainties are nonetheless very substantial, given that we simply don't know what the costs of all these changes will be. One approach would be to ask what happens if we throw all these costs, including the uncertainty involved, into macroeconomic modelling. In terms of climate change, it would seem that the level and structure of investment alter considerably, with profound implications for labour productivity and the financial economy which go right to the heart of macroeconomics. Oliver Bettis suggested that the kinds of biophysical economics which have been discussed here should now be considered to be part of macroeconomics.

Concluding Remarks

Michael Kumhof felt that the two component parts of the discussion (physical and social sustainability) are linked, and were always joined in the limits to growth models. He wondered which issues should be dealt with first. Both topics lead to similar policy areas. He felt that this subject is one of pressing importance, which should be included in the *Rebuilding Macroeconomics* programme, and which has the capacity to generate considerable reform in macroeconomics.

Doyne Farmer said that the discussion had shown how the goals of integrating both the physical sciences, and the psychological sciences, into macroeconomics, can be seen to go side by side. It is through a major challenge for macroeconomics to incorporate these elements, given that macroeconomic models are all built around utility maximising, rational agents operating under frictions, and an assumption of equilibrium in which outcomes match expectations, which disregards uncertainty. The challenge is to make basic progress in what a macro model is, in order to deal with these questions; and the task would be to quantify the ideas discussed in the second half of this meeting in such a way as to allow them to be included in macroeconomic models.

This change will require fundamental alterations in the ways that the models were built, and doing so goes against the whole epistemological process by which economists are trained and told to operate. This procedure involves making variations to assumptions, and is driven by the "greedy" algorithm, which encourages actions which give most immediate progress. This works well under some conditions; but as soon as a "rough landscape" is encountered, the greedy algorithm fixes on the local maximum and stops there; and this is what may already have happened to top-level macroeconomics. Part of what we have to do is to knock macroeconomics off that maximum, and look for other maximums around it; this is a huge challenge, because macroeconomists will not instinctively agree or want to operate in this way.