An arrow in the Achilles' heel of sustainability and wealth accounting

SJAK SMULDERS

Department of Economics and Tilburg Sustainability Center, Tilburg University, P.O. Box 90153, 5000 LE Tilburg, The Netherlands. Tel: +31 13 466 3653. Fax: +31 13 466 3042. Email: j.a.smulders@uvt.nl

Introduction

How sustainable is the growth pattern of a national economy? At first, answering this question seems almost impossible, since this would require knowing what happens and what can happen in the future. One needs to assess whether the investments we make today will be sufficient to provide future generations with the means to cope with imminent disasters like the exhaustion of minerals and vital resources, or other problems like increasing population pressure and climate change. One also needs to assess which combination of investment leads to the desired result. If entrepreneurs, managers and households already have problems in finding out what is the best mix of investment for them in their micro-environment, how can we answer the aggregate question that needs so much more information?

After a bit of thought, economists would argue that at least some of the information we need to assess future welfare and for aggregation of different types of investment can be derived from observed market prices. Even a large group of researchers cannot do better than the entire market in terms of valuing investment activity, so current prices and current investment strategies can reflect the value of investment.

The 'pure theory of comprehensive national income accounting' (a phrase coined by Weitzman, 2001) has investigated how, under various conditions, measures can be constructed – in theory – which use current data (prices and quantities) to say something about future welfare. The theory almost routinely starts from an economy that optimizes welfare. In such an economy the sum of consumption and net investment, both valued at market prices so that the sum equals Net National Product (NNP), reflects an important part of (dynamic, i.e., intertemporal) welfare: consumption and investment are both a source of utility, in the present and in the future, respectively, and, since market participants substitute between spending on consumption and investment until their marginal contributions to welfare are equalized, the expenditures on both can be added.

To take into account the fact that welfare can change over time through exogenous technical change or other impacts that accrue exogenously over time (like terms of trade changes in a small open economy), NNP needs to be corrected for these 'time-dependent' forces. The corrected NNP figures would inform us about whether welfare increases or not. Unfortunately, the required corrections require knowledge of future variables that cannot be directly observed. Even when the theoretical welfare indicators could be calculated in practice, the policy relevance would be less obvious since it is developed for an economy that is already welfare maximizing.

Once externalities play a role, the correspondence between NNP and dynamic welfare is likely to break down. In particular, investments still somehow affect future wellbeing, but to what degree can no longer be derived from market prices only. The paper by Arrow *et al.* (ADGMO, henceforward), therefore, does not start from NNP, but from investment, building on previous work by Arrow, Dasgupta and Mäler, and formalizing and refining practices that have been used by the World Bank. A comprehensive measure of investment, valued at shadow prices rather than market prices, and augmented for exogenous 'time-dependent' increases in wealth (stemming from technical change and terms of trade changes), reflects 'changes in the potential for future well-being'. The use of shadow prices is theoretically obvious, since they are defined as the contribution of investment to welfare. The problem is that shadow prices cannot be observed, but a practical approach is followed by starting from market prices (whenever available) and adjusting them for externalities. Establishing a close link between theory and actual calculation is challenging here. Also with respect to the effect of population growth and technical change on welfare, the general theoretical results cannot be directly applied, but the authors derive the conditions under which the intuitive measurement is valid: the increase in per capita comprehensive capital and the rate of total factor productivity (TFP) growth should be decisive for potential future wellbeing.

Shadow prices

The Achilles' heel of the method is the determination of the shadow prices. The requirement to value investment at shadow prices makes the calculations less transparent and more hypothetical. A shadow price is forward looking, reflecting the contribution of current investment to future utility, where the future is weighted in accordance with the intertemporal preferences. The shadow price thus depends on – in principle – everything that happens (or can happen) in the future and – as noted above – we do not have the information about this. In theory, future shadow values are determined by current capital stocks, the 'resource allocation mechanism', and exogenous factors that capture (changes in) institutions, technologies and preferences. But this implies that, to calculate shadow prices, one should specify all these elements (e.g., in a Computable General Equilibrium (CGE) model) and, since our macro-economic models cannot be qualified as reliable prediction models, the resulting values are hypothetical. As long as we do not see the specified model used to generate the shadow prices,

the accounting is no longer transparent. Moreover, a paradox emerges here. If we need CGE models to generate consistent shadow prices to calculate whether over a short period potential welfare has changed, why not then use the outcomes of the CGE models to directly calculate welfare over a long time horizon?

A convincing way of using shadow prices requires the maximal use of market prices and a derivation of externality costs consistent with observed prices and behaviour. In this spirit, the calculation of investment in health in ADGMO extensively relies on empirical estimates of the value of a statistical live.

Essential in this research is sensitivity analysis that shows systematically how different assumptions on the shadow-price generating model generate different figures for comprehensive investment. In table 6 the authors show some (in)sensitivity results. While this is reassuring, one can imagine several other experiments. In the countries with negative wealth growth rates, (exogenous) terms of trade gains or resource discoveries that are currently not included (although they formally should be in the $r(t)$ term defined in (7)), might turn the growth rate positive; one could calculate how big such a compensating windfall gain needs to be and assess how realistic this is (cf. Van der Ploeg, 2010).

Picking average shadow prices for each capital stock from a meta-analysis of CGE studies is potentially inconsistent. Maybe a high social cost of carbon goes together with a low value of a statistical live, through the link between air pollutants, health effects and labour supply (see Ikefuji *et al.*, 2010).

Making sustainability measurable

The key question is whether ADGMO's method gives us a meaningful answer to the original question at the beginning of this comment. There are several notions of sustainability and the authors are explicit in what they intend to measure. While the opening sentence and title suggest the paper is on sustainability, it turns out later that the paper is about measuring whether the dynamic per capita welfare potential (wealth) of a country is sustained over a short horizon. Alternatively, sustainability might be defined as current consumption (or wellbeing) not exceeding the maximal sustainable level. Asheim *et al*. (2003) and Pezzey (2004) show how sustainability in the latter sense has an imperfect relation to ADGMO's concept of wealth changes.

The theory shows that over a short (vanishing) time period, welfare changes can be measured by investments valued at constant prices. The empirical application calculates comprehensive investment over five years at period-average shadow prices. The short horizon makes the link with sustainability in the traditional meaning somewhat weak. As the authors acknowledge themselves, increasing wealth over the current five-year window now does not preclude declining wealth in near future.

Over the longer horizon, one would like to know if the economy is heading in the right direction. If we take the model literally, we do not

need to extend the time horizon in order to check if the economy is on a sustainable path: once we know the initial stocks, future consumption and capital can be forecast (while ADGMO simply refer to 'a forecast', I interpret this forecast as being derived from the 'resource allocation mechanism' as introduced in Dasgupta and Mäler, 2000). Of course, this requires that we exactly know the forecasting function, but we need to know this function anyway to generate consistent shadow prices. In reality, policy might unexpectedly change within the considered time window. When observed investments do not correspond to the predicted levels, we misspecified the forecasting function or a policy reform occurred (or both). In both cases, the shadow prices should be recalculated. Thus, if we continue to take seriously comprehensive investment accounting in the coming decades, a revision of growth rates will get a completely new meaning.

Another way of making visible where the economy is heading would be providing information on relative prices. There is a parallel with conventional accounting. Where traditionally national statistics involve real NNP-growth and inflation rates, the comprehensive investment statistics should not only report real wealth growth (as calculated in ADGMO), but also (shadow) prices. If the shadow price of capital falls over time and that of depleted natural resources increases over time, sustainability is in danger. Similarly, the shadow price of the passage of time, r, is important here. If technical change is exogenous and mainly of a resource-using nature and if substitution between resources and manmade capital is poor, the rate of TFP growth falls with growing resource scarcity.

A final way to make sustainability more visible within the method of the paper is to think of other international spillovers and interdependencies. The paper calculates results for countries independently with the exception of the climate change damage. But there are other transboundary spillovers. China's comprehensive wealth growth rates seem to dwarf those in other counties. If, however, as a result of massive investment in China, the export capacity continues to quickly expand in this country, the terms of trade could move in favour of the rest of the world. And what to think of the hugely reduced cost of renewable energy (solar panels) available to Western countries willing to subsidize them, but importing them from China which massively invests in it? Or will China's demand for resources put a downward pressure on wealth accumulation in the rest of the world? The challenge here is to link investment in one country to wealth accumulation in other countries and thus assess the sustainability of the world economy.

Conclusion

Over the past two decades, tremendous progress has been made in green accounting and sustainability measurement but major challenges remain to be overcome. ADGMO's paper develops important theoretical results that can be, and actually are, implemented in practice. I expect this paper to inspire good theorists and clever empiricists to refine the sensitivity analysis and further close the gap between theory and practice.

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