The Value of Simple Models

Geoff Davies (Australian National University, Australia)

Neoclassical economic theory predicts equilibrium, yet the prediction is based on a string of patently absurd assumptions. Furthermore, evidence for instability is pervasive in the behaviour of real economies, implying that real economies are far from equilibrium and their behaviour potentially complex or chaotic. Therefore the neoclassical approach to understanding the behaviour of economies is futile and misleading [1], as many heterodox economists understand.

However the development of better theories seems to be significantly hindered by a feeling that any superseding theory has to be thoroughly quantified before it can be useful, and a feeling that the neoclassical theory has set a benchmark for sophisticated mathematics that must be matched before another theory can be respectable. Less fundamentally there seems to be a common perception that empirical insights can only be gained through elaborate statistical treatments of observations.

Here I offer some discussion from my experience as a natural scientist, and some examples regarding the Global Financial Crisis, to counter these hindrances. Useful and relatively simple models can be constructed that can immediately overcome major neoclassical limitations, for example by permitting non-equilibrium behaviour. The solution of the mathematics can be done using very standard numerical integration methods that are readily available in commercial packages. Mathematical machismo is not required. There are also situations in which the empirical lesson is obvious with no analysis, as will be noted here.

I should be clear that there are certainly many modellers who operate outside neoclassical confines, reported for example in Beinhocker's excellent survey of "complexity economics" [2]. The lessons offered here will not be news to them. Also some of them are constructing quite complex models that are nevertheless very instructive, such as models with many interacting adaptive agents. This article is prompted by my reading of some heterodox blog discussions, and is addressed to anyone who may have some difficulty seeing how to move beyond the neoclassical approach. Nor are the models here are offered as original investigations, though they may lead to such.

General points on quantification and mathematics

Theories do not necessarily even have to be quantified to provide important insights. I have argued that the recognition of economies as self-organising systems with many possible states already implies three important conclusions: that economies can be restored to their appropriate place serving society, that there can be a diversity of economic styles rather than a monoculture, and that economies can be compatible with the living world.

Nor does quantification have to be comprehensive or to involve highly sophisticated mathematics to yield useful insights. Indeed when a field is new, useful insights can often be gained from rather simple models, even from back-of-the-envelope, order-of-magnitude estimates. Some striking examples of this difference in outlook between physicists and economists are recounted by Waldrop in his excellent book *Complexity* [3].

Economics is new in this sense, as the recognition of its complexity (in the technical sense) requires that it be thoroughly re-explored and re-conceived. In the natural sciences quite rough approximations are frequently used in such situations to, in effect, roughly map out the territory. More careful quantifications can then be appropriate to clarify and refine early findings. Indeed, unless guided by clear preliminary concepts and rough estimates, a more elaborate quantification can turn out to be a waste of time, or even misleading, if inappropriate parameter values have been used.

An example from my own field is an estimate that a magma ocean, resulting from the collision of two proto-planets, might solidify within only a few thousand years [4]. Even if this estimate is uncertain by one or two orders of magnitude it still makes clear that the magma ocean will freeze much more quickly than the time it takes for the final planet to aggregate, which is tens of millions of years. That is an important insight.

More basically, neoclassical economists seem to have a fundamental misconception that if they are doing sophisticated mathematics then they are doing science. This misconception goes back, via Milton Friedman, to the founding work of Walras among others. In science, mathematics is a very useful tool, but it is only a tool. In science, a hypothesis is proposed and its implications are compared to observations of the world. The objective is to find a hypothesis (or theory or story) that provides a useful guide to how the world is observed to behave. Mathematics is very useful for deducing the implications of a hypothesis, which can then be compared to observations. It can also be useful for processing observations (e.g. via statistics). The crucial distinction between mathematics and science is the comparison with observations, and the subsequent judgement as to whether the hypothesis is proving to be a useful guide. Neoclassical economics seems to have missed this fundamental distinction at the beginning, well over a century ago, and never to have noticed the oversight.

The importance of dynamics, and the role of money and debt

A financial market bubble and subsequent crash is an intrinsically dynamical event. In other words the market is driven by internal forces or feedbacks that move it through and beyond any perceived “true” value or equilibrium state. In October 1987, financial market values changed by thirty to forty percent in a single day, though there was no corresponding external event affecting the real economy. This demonstrated, starkly and with no analysis required, that financial markets are strongly affected by internal forces, and that they must have been far from equilibrium before, after or both. Such events clearly cannot be modelled by the equilibrium or quasi-equilibrium concepts that are the foundation of neoclassical economics. Indeed it must be doubted if the highly volatile financial markets could ever be so modelled.

Money must play a pivotal role in the internal dynamics of economies; more specifically this applies to token money, which is money without its own intrinsic worth. This is because token money links the present to the future, so in dynamical terms it operates on the time-derivatives of economic variables. This can be explained as follows. If I receive a ten-dollar note I am, in effect, receiving a promise from the community that it can be exchanged, in the future, for ten dollars’ worth of real goods or services. Thus the token (the ten dollar note) amounts to an implicit social contract between me and my community. That contract links the present (when I receive the note) to the future (when I spend it, i.e. when I exchange it for real goods or services).

The implicit contract involves a debt (the community owes me) and a corresponding credit (I am owed by the community). Because token money, like all debt, links to the future, it involves our expectations of the future, which fluctuate within the uncertainty of whether the future will actually deliver. Before I spend the note, it is merely a token of potential wealth. If the future does not turn out as we expect, my potential wealth may not be realised. This is also true of other forms of token money, such as entries in books and bits in computers. It is also true of other forms of debt, and in this context there is no difference between money and debt: both involve contracts, implicit or explicit, for delayed payments. Therefore both money and debt must be included in modelling of the dynamics of an economy, meaning its development in time.

Yet according to Keen [5, 6], the role of money in macroeconomics has been seriously neglected. Indeed much economic theory ignores both money and debt and treats exchange (the fundamental event of economics) as barter. Notable exceptions have been Keynes' qualitative discussion of a revolving fund of finance [7], and the circuit theories of money initiated by Graziani [8]. Keen has been, according to his claim, the first to show quantitatively how Keynes' revolving fund of finance works, and the first to show, building on circuit theory, quantitatively that a manufacturer can borrow money and still make a profit [9].

Simple dynamical models of economies

The models by Keen [5], and extensions of them by Davies [10] illustrate the intrinsically dynamic nature of economies, and the role of money in those dynamics. They also illustrate the value of relatively simple models, and contrast with the opaque complexity and irrelevance of neoclassical equilibrium models.

Keen [5] starts with a simple economy that develops by its own internal workings into a steady state. This steady state demonstrates how Keynes' "revolving fund of finance" can work, and also serves as a reference state from which to explore other things. Keen goes on to demonstrate how a credit squeeze causes a drop in the bank deposits of business and employees and a rise in unemployment. He extends this model to demonstrate that a government stimulus directed to households is much more effective in quickly restoring employment and circulating money than is a stimulus directed to boosting bank reserves. These are potentially important findings from rather simple models.

Davies [10] extends Keen's model to include property, as well as goods and services, so an asset price bubble might be simulated. The following examples come from this work. The methods are explained in detail in the references.

Keen's economy comprises banks, firms and employees ("workers"). Firms borrow money from banks and use the funds to manufacture goods. Those goods are sold to employees and bank personnel. Employees work for the firms in return for wages, and bank personnel work for the banks, deriving income from the interest charged on loans. Starting with the firms having no money, this little economy quickly approaches a steady state.

Davies' version includes housing property and employee mortgages and it comes to an analogous steady state, which is illustrated in Figure 1.

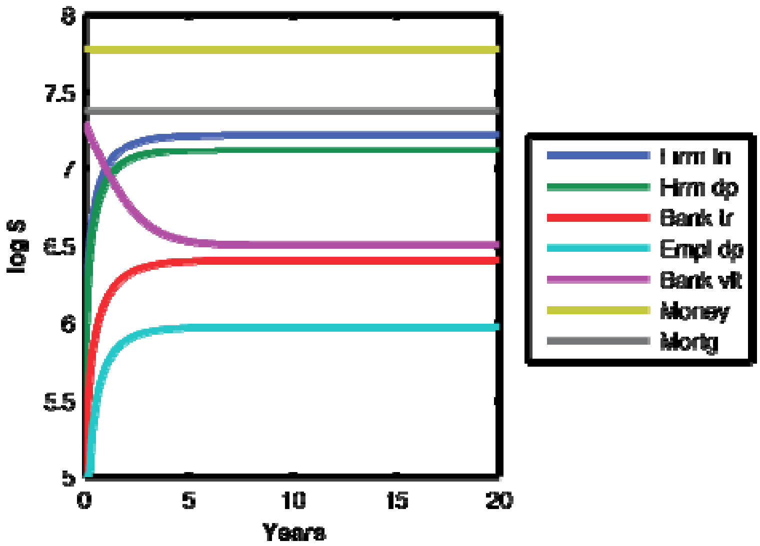

Figure 1. Approach to steady state in a simple economy. Quantities shown are accounting balances: Firm loans, Firm deposits, Bank transaction account, Employee deposits, Bank "vault" account, total money supply and total employee mortgages. From Davies [10].

In this example the population is steady and the total amount of money is constant. The money starts off in the bank's reserve account. To avoid common confusions, Keen suggests it is useful to think of paper money, and to regard the reserve money as being kept in the bank's vault. The model is started with some of this money already in the possession of employees, through their mortgages (otherwise it takes generations for the mortgages to come to steady state). However the firms start with no money, and both the Firm Loan and Firm Deposit accounts rise from zero. As firms take loans the bank vault is further depleted, and as firms conduct their business money flows to employees' deposit accounts. The bank's transaction account also rises from zero as interest charges are added. After a few years a constant amount of money circulates through the various accounts.

This example illustrates fundamentally non-neoclassical behaviour. During the initial transient phase, lasting 3-5 years, quantities change rapidly - they are dynamic. The subsequent steady state is not the same as a neoclassical model equilibrium, because the model is not constrained *a priori* to reach or approach a steady state, it does so through its internal interactions. During the initial transient the economy is far from a steady state, and a neoclassical model is not capable of representing this phase. Furthermore the model can deviate far from equilibrium under the action of internal forces, as two more examples will illustrate.

In a variation on the steady model, the price of property is assumed to rise exponentially, simulating a speculative bubble. If the money supply is also taken to rise exponentially, and some of the bank's profit is re-invested in its reserve fund, then an economy with perpetual inflation results, as shown in Figure 2 (note the logarithmic vertical scale, in which exponentials become linear). This "growth" behaviour is readily induced in the model. It is true that the growing property prices and money supply are imposed from the outside, but this type of model accommodates these influences just as readily as it accommodates the steady state of Figure 1.

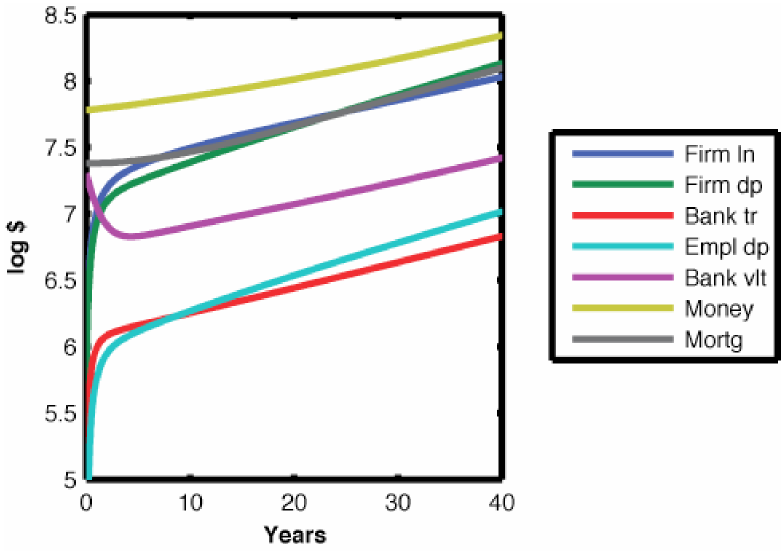

Figure 2. An economy with perpetual inflation, driven by inflating property prices, with the money supply increased to match.

It is easy to experiment with this model. One can, for example, keep the money supply constant as property prices increase. In that case, not surprisingly, the bank vault is soon depleted, but the response of the other variables is also instructive: firm and employee deposits and the bank transaction account continue to increase, but the firm loans peak and decline. A recession would soon ensue.

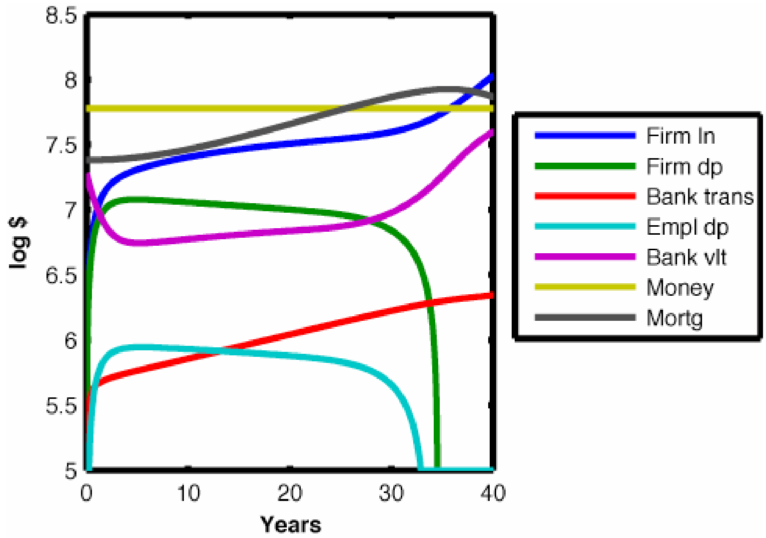

Figure 3. Primary variables for the case of a property crash.

Another experiment was to couple the property price to employee indebtedness. Although the total of employee deposits was increasing in the model just mentioned, some deposits went into overdraft (not shown here: more detail is in the reference). Therefore the rate of increase of the property price was reduced in proportion to the overdrafts. The result was that property prices peaked and crashed, taking the rest of the economy with them. The primary variables are shown in Figure 3.

Prices and wages are compared in Figure 4 for the three cases. Prices are nominal prices for goods, whereas property prices are prescribed as already described. Wages and unemployment (below) are calculated from a Phillips curve. The exponential increase in land prices in the inflationary case (Figure 4b) can be contrasted with the peak and decline in the crash case (Figure 4c). Wages and goods prices both decline in the latter two cases, though in proportion so that real spending power is roughly maintained. However many employees are heavily in deficit.

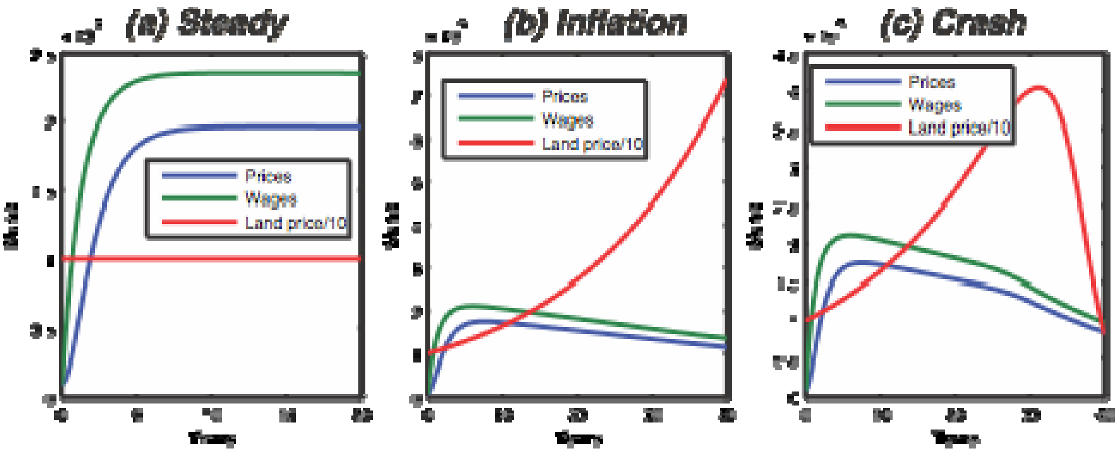

Figure 4. Nominal prices for goods, wages and land prices for the three cases considered.

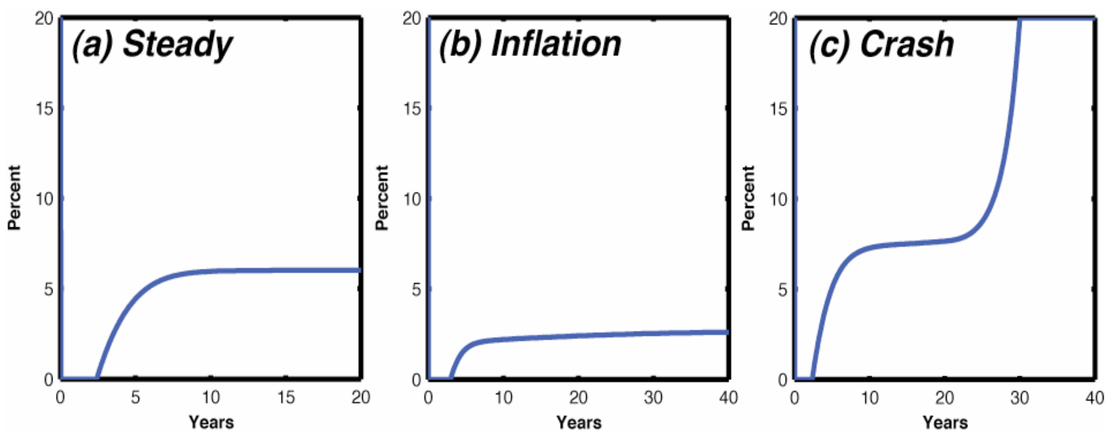

Figure 5. Unemployment for the three cases considered.

Unemployment is dramatically different in the three cases (Figure 5). It is near 6% in the steady case, only about 2.5% in the inflationary case, but high early and then skyrocketing in the crash case. It should be borne in mind that the unemployment rate is calculated from an empirical Phillips curve that merely characterises the way economies have behaved over the past few decades. Further details of these models can be seen in the reference [10].

The point being made here does not so much concern the details of the models, nor their potential veracity, but rather the relative simplicity of the models and their ability to yield instructive detail on the interactions among the variables characterising the model economy. They are also readily amenable to experimenting with various assumptions, as these examples illustrate.

In an example of instructive detail, Figure 3 shows that during the crash the bank vault reserves increase as firm deposits and employee deposits crash. In other words money is withdrawn from circulation, and this will slow the productive economy. Keen also found that bank reserves increase during his simulated credit crunch. The important policy implication of this is that it does little good to boost bank reserves, as was done in the United States. It does more good to boost consumer spending, as was done in Australia.

The mathematics

The mathematics behind these models comprises a coupled set of ordinary, first-order differential equations. An example is the equation for the balance, E_D, in Employees' deposit accounts.

$$\frac{dE_D}{dt} = \phi_D F_D + r_D E_D - \varepsilon_D E_D$$

where t is time F_D is the balance in Firms' deposit accounts, and the other factors are rate constants representing the rate of pay received from Firms, the rate of interest received from the bank, and the rate of consumption expenditure.

Such a coupled set of equations may not easily yield analytical solutions, but it is readily integrated numerically. Commercial packages such as Matlab, MathCad or Mathematica will do this routinely on a desktop computer. Analytical solutions can be valuable if they can be obtained without undue simplification, because they reveal the internal interactions of variables explicitly. However these equations are still simple enough (even though the set of them is quite large in Davies' models) that the behaviour resulting from numerical integration can be understood fairly readily with careful examination. Therefore these models can lead to useful insights.

Contrast with a neoclassical approach

Keen [6] has drawn attention to a draft paper by prominent economists Gauti B. Eggertsson (NY Fed) and Paul Krugman (Princeton, NY Times columnist, Nobel Laureate) that attempts to apply equilibrium modelling to the Global Financial Crisis [11]. Their paper illustrates fundamental problems with the neoclassical approach. Keen gives a detailed critique, and only a few main points will be made here.

Most basically, equilibrium models cannot follow the system through a bubble and crash like that illustrated in Figures 3, 4(c) and 5(c). They have to make do with before-and-after models. However the “before” condition was not at equilibrium (otherwise it would not have crashed) so they cannot properly represent it. Neither is there any assurance that the “after” condition is at any equilibrium. Indeed, as there has been no fundamental reform, the global financial system is probably moving into another boom and bust sequence, which is intrinsically out of equilibrium.

Next, the models do not include money, or debt of any form, astounding as this seems to an outsider to the field. The authors reveal a fundamental misconception by stating “Ignoring the foreign component, or looking at the world as a whole, the overall level of debt makes no difference to aggregate net worth - one person's liability is another person's asset.” In the real world, when banks issue money by creating it out of nothing and “loaning” it, the “borrowers” can spend it, even though there is the formality of a book-keeping entry treating the borrower’s debt as a bank asset. People can also fail to pay back the “loan”, thus creating a problem for the bank. This is central to the dynamic of a boom and bust. Keen notes that the authors also reveal their ignorance of Minsky and Schumpeter.

Lacking money, the authors contrive obligations between “impatient” agents and “patient” agents, where what is borrowed is not money, but “risk-free bonds denominated in the consumption good” (whatever that might mean). They assume there is a ceiling on the amount that impatient agents can borrow and they contrive a crisis by lowering that limit for the second of their two equilibrium models. Such contrivances are not necessarily a bad thing, if the model is carefully posed to reasonably represent an observed aspect of the world. They might still be instructive in principle, if carefully interpreted, but in this case the models are so unrealistic that little useful is likely to be learned.

The neoclassical situation can be contrasted with the simple non-equilibrium models presented above. Analogous contrivances have been used in the cases illustrated in Figures 2 and 3. In Figure 2, the price of property is assumed to rise exponentially with time. In Figure 3 the price is assumed to respond negatively to the level of overdraft of employees. However these models were conceived as steps towards a more satisfactory kind of model. Although they are already instructive in some respects, they have the potential to do much better. The land price and the money supply can be made mutually dependent, which creates the potential for an internally-driven instability, and the model will then follow the dynamics that result, however far from any notional equilibrium it may stray. Neoclassical models can never do that.

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SUGGESTED CITATION:
Geoff Davies, "The Value of Simple Models, with Examples of Economic Dynamics", *real-world economics review*, issue no. 57, 6 September 2011, pp. 106-114, http://www.paecon.net/PAEReview/issue57/Davies57.pdf