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Words to the Wise: Stock Flow Consistent Modeling of Financial Instability

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Abstract

The crisis has exposed the failure of economic models to deal sensibly with endogenously generated crises propagating from the financial sectors to the real economy, and back again. The goal of this paper is to review the method of stock flow consistent modeling to highlight areas in which it is deficient. I argue there is a fruitful research agenda in shoring up these deficiencies. The objective of stock flow modeling should be the ability to practically model unstable macro-economies, and in particular their interactions with the financial sector. These models should provide 'Words to the Wise', and until they do, they are just thought experiments.

Keywords: Instability, finance, stock flow consistent models.

JEL Codes: *E32; E37; E51; G33*.

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Pre-Precursors

Sir William Petty amassed a fortune dispossessing Irish landowners during the Cromwellian invasion in the 1650s. As the author of the 'Down Survey' published in 1656, Petty was able to marshal more than 1000 cartographic assistants to map out 22 of Ireland's 32 counties, so that Cromwell's soldiers could be paid in dispossessed Irish lands and debentures rather than English coin.

Petty's experience of collection and aggregation of statistical data did not end there. John Graunt produced the first piece of medical statistics in England in 1662 with Petty's help. Graunt's *Natural and Political Observations upon the Bills of Mortality* was an aggregation of mortality bills by district in London, and helped Petty to estimate the population of England at 6 million people in the 1660s by counting chimney pots, estimating the average number of people around each hearth, and extrapolating to the whole of the nation. From this back of the envelope calculation, Petty calculated the annual income of England, it's expenditure, showed for the first time they were equal, described the relation between the stock of wealth and the flow of income for taxation purposes, and derived the important relation between the stock of money and the price level.

Petty's *Verbum Sapienti,* (*Word to the Wise),* written in 1664 but published posthumously in 1691, was tacked on to his *Political Anatomy of Ireland* (Petty, 1769, quoted in Murphy, 2009 and Straus, 1954).

In 19 paragraphs Petty establishes the basic principles of macroeconomics we teach today, including the notion that a set of national accounts should form the basis for a rational system of taxation.

The object of study for Petty was a statistical aggregation of the individual behaviors of many classes of economic actors. Thanks to his Irish adventures, Petty was a rentier (he owed large tracts of Meath, Kerry, and Limerick), and sought in his writings to free himself and those like him from what he saw as excessive taxation by the government. Petty's solution was to tax other classes of worker, and to provide public works—including pyramid building—for those unemployed. The main object of Petty's analysis was a systematic and detailed empirical description of the functioning of the economy, as he felt it applied to him.

Petty's *Verbum Sapienti* is not known generally as the founding document of modern macroeconomics, which is a shame. The *Verbum Sapienti* is today acknowledged in footnotes and in subordinate clauses of sentences devoted to the development of macroeconomics—the average author generally wants to get onto Marshall and Keynes as quickly as possible without losing the reader's interest—and to be fair the *Verbum Sapienti* was hidden amongst some of Petty's lesser writings for quite some time. But these accidents of history do not alter the document's importance, nor do they blunt the lessons this prescient little document has for us now, more than 300 years later.

The core of macroeconomics is the empirical and statistical description of the behavior of aggregations of economic actors. The goal of policy—the word to the wise—is to allow the most spending, the most income, and the most expenditure, to enrich society if not the largest number of people in society.

The primals of any modern textbook are all there within the *Verbum*: population, expenditure, income, the multiplier effect, the general balance of trade, saving, investment, the role of government, the effects of exports and imports, and the proper use of public funds, all combined rationally to try to ensure the correct policies are chosen given the prevailing economic and political conditions. Petty championed a balance sheet approach to macroeconomic modeling backed with empirical measurement which he called Political Arithmetick—today's econometrics.

The first six pages of the *Verbum* present a balance sheet approach to the study of national income and expenditure. Writing nearly 300 years later Minsky (1975, p. 118) observed that "an ultimate reality in a capitalist economy is the set of interrelated balance sheets among the various units, so that one way every economic unit can be characterized is by its portfolio: the set of tangible and financial assets it owns and the financial liabilities on which it owes".

When looking at balance sheet descriptions of the macro economy, we are therefore in good company. The stock flow consistent approach to macroeconomic modeling developed by Copeland, Stone, Tobin, Cripps, Lavoie, and above all by Wynne Godley essentially emphasizes the same connections as Petty (Godley and Lavoie, 2007, chapter 2).

In the modern stock flow treatment, we have the emphasis on statistical aggregates, on interrelationships, and obviously, on stocks and flows between these aggregates. In particular, running right through Petty and later through Richard Cantillon and Francois Quesnay is the notion that finance is required for the sustained evolution of the fortunes of the nation, and that finance as an activity is inherently unstable. The sources of instability are the credit money creation process, and the changes in fortunes of the investor relative to their environment. It is the investor, who buys at a known price and to sell at an unknown price that generates much of the cycling in macroeconomic systems. The crucial element of feedback is also apparent: within a recursive system, the possibility of negative and positive feedback loops of various types—balancing loops, amplifying loops, dampening loops—allows the system to cycle and change even further.

In this paper I'll first review some basics of stock flow modeling. Then I'd like to present three important areas I think stock flow consistent models can work on to develop as tools to produce words to the wise. First, I'd like to discuss their inherent complicatedness. (Here I'm deliberately not using the word *complexity*, for reasons that will become apparent later). Second, I think the nature of expectation formation amongst economic actors within stock flow consistent models should take more account of advances in behavioral, experimental, and computational economics, to provide more realistic layers for the sectors most stock flow models are built out of. Third, the role empirical data plays within these models needs to be altered. I'm not advocating a *calibration* approach to this type of modeling, but rather an *estimation* approach, understanding the limitations of macroeconomic data gathering, even in 2011.

Of flows and stocks and stocks and flows

Stock flow modeling emphasizes the connections between classes (or sectors) of economic agents. These models do not have a representative agent maximizing away in a corner somewhere. The economy is treated as a set of sectors interacting with one another, for example: households, firms, private banks, the central bank, and the rest of the world. Exactly as in Petty and Cantillon, the

households buy from firms; the firms sell to the households, netting out to zero at any moment in time. The sectors are tied together within a balance sheet for the economy, and their transactions recorded within transactions flow matrices and revaluation matrices for capital gains.

Every flow and every stock variable is logically integrated into the accounting so that the value of any one item is implied by the values of all the others taken together; in other words the system of accounts is stock-flow consistent[2].

The model is actually written out as hundreds of balancing and identity equations, with, for example, the amount of consumption, C, demanded by households C_d equal to the amount of consumption supplied by firms, C_s. So it goes for wage bills, investment in capital goods, bonds issued by banks to firms and households respectively, and so on.

Next come the behavioral equations. Here we care about how much consumption will increase when disposable income increases, and what proportion of the increase in consumption will come from current income, and how much from past wealth.

The models can normally be solved for their steady state, and the behavior of the entire system can be simulated. Choosing stock-flow norms, which must be stable, is a serious concern at this stage—the models require attention to their initial conditions that must give any modeler cause for concern.

The simulated system is then shocked, via a drop in investment, say, or a change in wages, or a change in inflation, and the behavior of the system can be analyzed and discussed. Stock flow consistent models can also naturally model the distinction between wage earners and the recipients of capital income (van Treek, 2009), financial imbalances (Godley and Lavoie, 2006), contagion effects,

[2] Godley and Cripps (1983, page 18) make a play for an analogy with Wignerian invariance principles using the principle of quadruple accounting: "[T]he fact that money stocks and flows must satisfy accounting identities in individual budgets and in an economy as a whole provides a fundamental law of macroeconomics analogous to the principle of conservation of energy in physics". I personally feel this claim is a bit strong, but the motivation is clear.

(Khalil and Kinsella, 2011) and as well as income distribution effects (Dos Santos, 2005).

Every modeling choice has positives and negatives. On the positive side, stock flow models capture several important Keynesian and post-Keynesian insights. They are monetary economies that evolve in historical time; there is no representative agent or production function (there is a production function, it's not explicit), households and firms are assumed to have a crude procedural rationality, in that they don't really form expectations about the future in a rational manner, relying on past trends to guide future performance. It is natural to model the income distribution within these models. The flows between each part of the model can be traced out explicitly. The ability to model flows into and out of financial sectors like banks and central banks, and explicitly see the effects across the macro-economy of a change in interbank lending, say, that leads to a credit crunch (Khalil and Kinsella, 2011), is for me the main benefit of stock flow modeling. In fact, the only limit to the inclusion of economic variables of interest is the time, patience, and sanity of the individual modeler. There is, more or less, unlimited scope to model the macro-economy using this framework.

On the negative side, so far most of these models, with the honorable exception of the Levy model run by the Levy Institute at Bard College, have next to no grounding in empirical macroeconomics. The models are explicitly designed as tools for thought experiments rather than practical tools to guide policy, to give Words to the Wise, which is why when recent Nobel Laureate Chris Sims addressed the last INET conference, he was able to say that there was no credible alternative to dynamic stochastic general equilibrium modeling to guide central banks through the crisis. The major proponent of stock flow modeling, Wynne Godley, in his treatise on the subject with Marc Lavoie wrote that simulating macro-economies in layers of increasing complicatedness allowed one to "build up knowledge, or 'informed intuition', as to the way monetary economies must and do function" (Godley and Lavoie, 2007, pg. 9). There is much to be said for informed intuition at the personal level. But at the level of policy formation and evaluation, we need to return to where Petty started in the *Verbum Sapienti*—estimation and extrapolation based on

aggregate statistics generated by the economy and collected through the national accounts. In short, we need to estimate these things.

The estimation of stock flow consistent models is in its infancy, and there are very few researchers with the ability to build and simulate stock flow models who are also adept at time series econometrics and the gathering of national income and product account data[3]. Modern times series techniques can be used to make allowances for the large number of lag structures and autoregressive effects found within these models (Hamilton, 2010).

The complication of the models means that to actually simulate one, the modeler requires a set of equilibrium stock-flow norms that are attained in the steady state of the model. Ideally, stylized facts (e.g. Kaldor 1957/58; Jones and Romer, 2009) should guide choices of stock-flow ratios. I'm here to tell you: they do not.

Finding stock flow norms is, at present, a black art, and more error than trial is involved in finding them (Taylor, 2008). This is unsatisfactory intellectually, but also raises a practical concern over the stability of these models. If they are sensitive to small changes in the values of simple parameters like the propensity to consume out of past income by households, say, then how valid are they as representations of reality?

There may also be a problem of chaos and complexity within these models. Obviously sensitive dependence on initial conditions does not mean the models are intrinsically chaotic or capable of generating complex dynamics, but the recursive nature of the modeling, the existence of multiple feedbacks within each models and the computation issues I and my co-authors have come across when practically trying to model a real economy give me pause that there might be the seeds of a complex system somewhere within stock flow modeling. The stability of a stock flow consistent model has only been analyzed correctly once by Foley and Taylor (2006), at least to my knowledge.

The role of prices in stock flow models is not well understood at the basic levels. It takes Godley and Lavoie nearly 250 pages to allow prices to move in

[3] INET can help in the training of such scholars by funding Summer Schools and helping to increase awareness of this type of modeling. Having open access to data sets, software and code, and to a public profile of the stock flow methodology, as well as links to central banks, will also be of great benefit.

their models, and even then the treatment of prices is complicated and cumbersome. Prices and pricing behavior are obviously vital in the description of the macro-economy, so it makes sense to consider them as primal to the modeling effort. In the last section I give some thoughts on how to remedy this.

Why'd you have to go and make things so complicated?[4]

Today students of macroeconomics generally learn what Paul Krugman, echoing Joseph Stiglitz, calls the 'MIT approach' to macroeconomic models: small, tractable models that tell you one or two things, in parable form, about the behavior of a subset of the economy, keeping other areas suppressed for clarity. The emphasis in this approach is on pattern fitting and simple stories (Leamer, 2009).

The MIT approach has many benefits as a tool to clarify thought and expose important economic issues for discussion. One of the best examples of this approach in my opinion is Akerlof's *Market for Lemons* paper. Here, in a few equations and a motivating example, we see the foundations for asymmetric information in economics. Beautiful stuff.

Another example, though slightly more complicated, is Hicks' ISLM model. Here again we have the parable, the example, and the thought-clarifying lesson. These models are excellent examples for students who will largely *consume* economic information rather than produce it for others to make decisions with.

Let's face it, the majority of the students we teach will not become professional economists, and so the tradeoff is the correct one, in my opinion, between the simplicity of economic parables for consumption, and the complicatedness of stock flow consistent models for production of new economic knowledge[5].

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[4] Yes this is an Avril Lavigne reference. I regret nothing.

[5] The problem with that vision is that if you let these simple MIT models being used to teach, most voters use these models to analyze policies and politicians can't afford to have different models. Basic example: when a household face tough times, it saves in order to be able to live through the crisis. Thus when neo-liberals claim that the state should save it looks like it makes sense but a state is not a family. Thus oversimplification leads to fallacious results.

The benefit of the MIT approach breaks down at the professional level, where one is required to *produce* economic knowledge. At the professional level, the current workhorse dynamic stochastic general equilibrium models have several failings that are by now widely acknowledged.

Their models can't deal sensibly with uncertainty. There is a lack of modeling of financial markets and their interactions. Dynamic stochastic general equilibrium models have inappropriate behavioral assumptions for households, firms, governments, private banks, and central banks. There can be accounting 'black holes' within modeling schema. There is an incomplete treatment of macroeconomic dynamics, especially when economies are 'far from equilibrium' in the sense of Amendola and Gaffard (2006). They contain a limiting of the analysis of macroeconomic fluctuations to flows without taking stocks into account, especially with regard to treatments of debt. Not enough attention is paid to money and financial assets, and not enough attention paid to capital gains and losses. Finally, these models are not actually computable general equilibrium models in the true sense of the word *computable* (Velupillai, 2006).

I could go on, but I'm not interested in being overly critical. It is important to note that when a policy maker asks a general equilibrium model a specific 'how much' type of question, it gives an answer. That answer may be subject to the caveats above, but the policy maker does not care about that. They want to know if policy A or policy B (or doing nothing) will lead to an increase in unemployment or a decrease in inflation, *and by how much.* The dynamic stochastic general equilibrium model will tell them. The stock flow consistent model won't. Sims' critique of heterodox approaches to macroeconomic modeling does hold.

The stock flow approach has however the potential to overcome many of these problems inherent in general equilibrium modeling, but only the potential. As it exists now, they are tools of 'informed intuition' for the most part.

The nature of the complication of stock flow models is important: in addition to degrading one's eyesight with subscripts, writing out balance and transactions matrices serves to clarify for the modeler the exact set of hypothesized relationships between variables, and between sectors.

As an example consider the issuance of T-bills by a central bank. Who buys them? Firms? Households? The government? All three? What interest rate will be charge? In which period will they be repaid? Which entity receives the 'profits' of the transaction? The central bank? The government?

This one, simple example is repeated dozens of times within a stock flow model. It grants one an appreciation for the intricacies of the macro-economy, but it rapidly makes the model cumbersome, and the larger the dimensionality of the model, the trickier it is to find stock flow norms which will satisfy the requirements of a simulation of this economy. For models with plausible levels of descriptive accuracy, we are talking about hundreds of equations, and dozens of parameters[6].

The tradeoff relative to the MIT approach is apparent: we are sacrificing descriptive simplicity for apparent increases in descriptive reality, but, as yet, without much recourse to *actual* reality via empirical estimation. Future work in this area should concentrate on three fronts. First, establishing notational conventions and simplifications to increase the readability of stock flow models, and second, to expose them to data as soon as possible. Third, there needs to be a fuller appreciation of the delicacy of initial conditions and/or stock flow norms, with a view to ensuring these models are indeed stable systems for plausible parameter ranges. Whether these models are capable of complex dynamics is an open question at this point.

Back to thinking about the future

Stock flow models tend to incorporate expectations in the following way. In stock flow consistent models, agents set themselves norms and targets, and act in

[6] The only 'translation' I have seen between standard dynamic modeling and stock flow modeling is Foley and Taylor (2006). In their canonical heterodox growth and distribution model, we see a model where both the standard dynamic description of an economy, together with a fully worked out social accounts matrix description plus a stability analysis can be carried out.

accordance with these norms and targets, and with the expectations that they may hold about the future. These norms and targets ensure agents are rarely ever right about things, because they focus on past performance mainly. Mistakes in any period brought about by mistaken expectations in the last period create gluts or shortages of stocks in the form of inventories, money balances, or wealth. These stock buildups function as feedback mechanisms that change behavior in the next period, for example a firm having a sale if inventories get too high above their target level.

For example, consider a household trying to balance its disposable income *YD* in one period relative to its expected disposable income YD^e. The difference between the two will be experienced by the household as too little or too much cash on hand, H_h, relative to the amount it would normally demand, H_d depending on the circumstances it finds itself in in the next period. Thus we will have:

$$H_h - H_d = \mathrm{YD} - \mathrm{YD}^e.$$

The treatment of expectations in stock flow models is in accordance with post-Keynesian theory that fundamental uncertainty dominates thinking about the future, and so a rough type of expectation formation—inert or delayed expectation formation—is all that is required.

The expansions of the behavioral economics, experimental economics, and computable and computational economics research programs show that expectation formation is not as simple as described above. The insights of behavioral and experimental economics around rationality and inter temporal choice discounting can and should be modeled within a stock flow consistent framework. The key insights of computational economics, that heterogeneity amongst economic agents can lead to realistic modeling of behavior, has already been ported into stock flow consistent models in a small way (Kinsella, Greiff, and Nell, 2011), but much work remains to be done.

Much experimental work has been done on norm formation and institutional specificity. The inclusion of explicit norm formation by agents within stock flow consistent modeling might give us a better handle on why financial markets react as they do, and will certainly give a guide to stock flow norm value choice.

I mentioned above that price formation is not well handled in the current versions of stock flow consistent models. One easy route towards a realistic price system is to allow prices can enter through heterogeneous actors and agents interacting individually within sectors, but aggregated by sector into a balance sheet representation. This allows for the simulation of multi-sectoral inflation, deflation, and (I conjecture) even hyperinflation, all within an endogenous money framework.

Data, Data, Dataaaaa

Despite the deluge of macroeconomic data, reliable high frequency time series exist for a fraction of the world's advanced economies. Flow of funds accounting, which would form the core of a stock flow consistent data set, exists for an even smaller number of countries and for a much shorter time span. For example, Ireland began producing national income and product accounts in the mid 1950s, but only began flow of funds accounting in 2002.

Macroeconomic modeling wants to observe cycles, and as Shalizi et al have observed, there have been perhaps only 7 or 8 complete business cycles observed since the 1940s, giving a very small amount of truly aggregate data to work with. Only time will produce more data, of course, but in the meantime a set of conventions is required when one 'fills in the blank' for some time series, say sales data in Ireland pre 2002. Moreover, a translation from input-output tables to flow of funds tables will be quite difficult, so a standard way to acknowledge these data limitations in order to be able to evaluate the models correctly is vital.

Finally, every dataset and every piece of code should be placed online for replication, repetition, and learning.

Modeling financial instability: Wise to the words?

INET was created because economics failed in its main task of preventing a recurrence of the Great Depression. Stock flow consistent models have the

potential to support, supplant, and substitute for the prevalent macroeconomic modeling methodology. To do this modelers need more extensive training in econometrics and data handling, to be aware of stock flow models' strengths and weaknesses, and to accept a broad church of options when refining and broadening the application of these models theoretically and empirically. Stock flow modeling can incorporate innovations from behavioral, experimental, computable, and computational economics, as well as allowing their estimation using real world data.

In 2011, Richard Barwell and Oliver Burrows of the Bank of England produced a report looking at balance sheets in the great moderation. They found that balance sheet fragility contributed to overall financial instability, that the other models of the Bank of England did not pick up on, and their work suggests that there were linkages between many of the macroeconomic puzzles the Great Moderation and the balance sheet developments that led to financial instability.

We are interested as macroeconomists in 2011 in dealing with the sources of financial instability. The work of Barwell and Burrows (2011) shows that, at least in the case of England, the sources of instability were the balance sheets of financial actors, and the linkages between them and the real economy's balance sheets. Stock flow models have the ability to track and react to these linkages, and so should be developed to give words to the wise. Of course, whether policy makers are wise to the words is another's day's work.

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