Comprehensible Macro-economics

Part One: The Closed Economy

David W. Brown, 2015

Comprehensible Macro-economics
Part One: The Closed Economy

David W. Brown, 2015

Revised 28 June 2015

A number of textual errors on page 15 have been corrected and the short paragraph under Other Resources has been added.

30 September 2015

A few more typos corrected.

Table of Contents

Introduction

Economics is a subject few people profess to understand, although it shapes our lives in many ways. It is a determining factor in where we live, what we eat, what sort of work we do, how we occupy our leisure time (and whether we have any leisure time), and even such intensely personal issues as how many children we have.

Nevertheless, for most of us it is a mystery of which we have little understanding and over which we have virtually no control. Such control as we do have is limited to our ability to influence which political party holds the reins of government, and whose policies are therefore brought to bear on the levers of the economic system. It is crucial therefore that we should have a sufficient understanding of how the economy works so we can make a sound judgment on the question of whom to vote for.

Do we? Absolutely not! How could we when our only sources of information are academic works that few people read and fewer understand, and the facile but almost entirely inaccurate punditries of the national media and politicians?

It is often said by people who have taken the time and trouble to look into the issues carefully that 'everything you know about economics is wrong'. Sadly this seems to apply not only to the public at large, but also to the politicians – from the chancellor down – who are notionally responsible for the regulation of the economy. Many, possibly most, government interventions in the economy are counter-productive and have the opposite effect to what was (ostensibly at least) intended.

One thing of the untrue things we all know about economics is that it is difficult. This is perhaps *partly* true. No doubt there are highly complex technicalities that would be difficult for a lay person to follow, but the basic principles and mechanisms – how it 'works', in fact – are simple.

Key Issues

We are all familiar with a relatively small number of key economic terms that affect or appear to affect our lives: terms such as 'taxation', 'government spending', 'austerity', 'recession', 'deficit', 'debt', 'benefits' and 'welfare'. But though we may be familiar with the terms, our grasp of what they actually mean and how they interact is rather slender. Worse than that, the things we do 'know' (for example that taxation pays for government expenditure) are mostly just plain wrong. This is important. It is largely on the basis of how governments regulate or try to regulate these factors that they seek to justify their existence, and we need to have a sufficient understanding of them to be able to assess their performance.

Economics is about the role of money in the creation and distribution of wealth. In very broad terms the part of economics that is about wealth creation is known as 'macro-economics', and the part that is concerned with its distribution comes mostly under the heading of 'micro-economics'. I mention this simply because all I will be considering in this note is the wealth-creation part of the story – macro-economics – for the simple reason that that is all I have researched so far.

But, you may protest, it's all very well understanding how wealth is generated, but what about poverty? Shouldn't the 'abolition of poverty' be our primary concern?

I'll say more about this later, but essentially I would agree with you. There's no point whatever in generating more wealth for the already rich, and we need to understand micro-economics as much as macro-economics. But there is also an interaction between the two. Suppose that a government decides, for misguided macro-economic reasons, to embark on a totally unwarranted programme of austerity. The worst that the rich will suffer in consequence will be a mild irritation. The poor by contrast will go hungry, be obliged to live in sub-standard housing, and have constant money worries and a host of attendant miseries. On the other hand if we understand that the proposed austerity programme is at best economically illiterate we will eventually vote that government out and replace it with one that understands economics. This may not solve the poverty problem, but it is a necessary first step and should at least avoid making it much worse.

Analysis

As a first approximation we can consider a sovereign economy as consisting of three ‘sectors’: households (*H*), government (*G*), and producers (*P*). Everything that goes on in the economy implies a transfer of funds between or within these sectors. As our main interest in the sectors will be to keep track of their financial (money) balances we can ignore the transactions that go on *within* them as they clearly leave the balances unchanged. Our concern will be solely with the transfers *between* them, and the resulting balances.

So far we have described a ‘closed’ economy – one that only trades internally and has no imports or exports. This is unnecessarily restrictive and can be overcome simply by adding a fourth sector, which we will designate the ‘foreign’ sector (*X*).

A more detailed analysis could also include a financial sector and others, but these four will be sufficient for our purposes. (I use *X* to refer to the foreign sector in order to leave *F* free for possible use later for the financial sector.)

The Households Sector

The households sector (*H*) is all of us. Although our individual roles may differ widely, collectively we have five functions. These are:

1. Domestic consumption. This simply means payment for goods and services from the producers sector.
2. To earn. This means to be paid by the producers sector in return for work done enabling it to sell goods and services for consumption by the household or other sectors.
3. To pay taxes to the government sector.
4. To buy goods and services (imports) from the foreign sector. This is of course also consumption, but we need to distinguish it from domestic consumption as it is paid to a different sector.
5. To receive welfare benefits from the government sector, including, as appropriate, basic income (if paid), unemployment, sickness, and disability benefit, and pensions.

We designate the amounts of these transfers as *c* (consumption), *w* (wages), *t* (taxes), *m* (imports) and *b* (benefits).

The Government Sector

The government sector (*G*) has three functions:

1. Levying and collecting taxes (*t*) from the households sector.
2. Providing funds to the producers sector for such things as public works and public services. We will call this primary government expenditure (*g*) to distinguish it from:
3. Provision of funds directly to the households sector for what may be roughly described as welfare benefits (*b*), noting in passing that the term ‘welfare benefits’ is somewhat politically loaded. Fortunately *b* could also stand for basic income.

Note that, unlike the households sector the government sector does not consist of people. The term refers only to the functional institution. The human beings that make it up (as I have no doubt some of them are) are all members of the households sector.

The Producers Sector

The financial functions of the producers sector (*P*) are:

1. To pay wages (*w*) to the households sector for work done in producing goods and services. This will be in response to orders not only from the households sector but also the government and foreign sectors.
2. To receive payments (*c*) from the households sector to pay for domestic consumption of goods and services.
3. To receive payments (*g*) from the government sector for goods and services ordered by the government (i.e. primary government expenditure).
4. To receive payments (*x*) from the foreign sector for goods and services produced for export.

It is important to note that this sector is assumed to pay out as 'wages' all the funds it receives, so maintaining a zero financial balance. This, of course, stretches the meaning of the word a little as it must include profits paid to business owners, who are members of the householders sector.

The Foreign Sector

The foreign sector (*X*) allows us to consider imports and exports:

1. Exports (*x*) are payments by the foreign sector to the producers sector. For the time being we ignore the question of exchange rates as we are not concerned with the economics of the foreign sector itself. Payments may be made in the home currency (if the purchaser has access to them) or in the foreign currency at the going exchange rate – which for the sake of this exercise we assume to be unchanging. This is not, in general, a safe assumption, and would need to be accounted for in a more complete analysis.
2. Imports (*m*) are payments from the households sector for goods and services provided by the foreign sector. As with exports, we are not concerned with the exchange rate and assume payments are made in the home (not the foreign) currency.

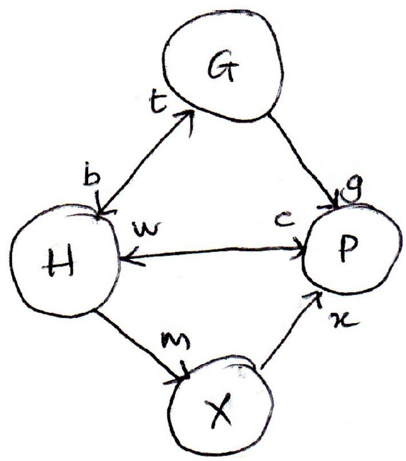

Illustration 1: Sectors and Transfers

Stocks, Flows, and an Equation or Two

All this can be summed up in Illustration 1, which shows the four sectors we have defined and the transfers (or in economics-speak, 'flows') between them. We immediately begin to see the power of this sort of analysis (known as 'sectoral analysis') as some of the relationships quickly become apparent.

Looking at sector *P*, for example, we can see that there are three sources of incoming funds: *g*, *c*, and *x*, and one outgoing: *w*. But we have already said that the producers sector maintains a zero balance, from which it immediately follows that $w = c + g + x$. An English translation of this would be, ‘Wages paid are equal to the total of all money received from sales.’ As indeed (given our loose definition of wages) they have to be – where else would the money go?

G, on the other hand, *is* allowed a non-zero balance, which is evidently $t - g - b$, and which we call a deficit if it’s negative and a surplus if it’s positive – another couple of highly loaded terms..

The Basic Model

Well, this is a start, but if we really want to understand what’s going on we must be a lot more systematic. First, let’s put our definitions of inter-sector transfers on a more rigorous footing. We’ll adopt the convention (that we’ve followed informally above) that sectors are represented by upper-case letters (or words beginning with a capital letter). Thus G, H, P and X are sectors. Next, we’ll define transfers by writing the name of the transfer (lower case), followed by a colon, followed by the source and destination sectors separated by an arrow (‘→’). Thus we have:

$g : G \rightarrow P$	(government primary expenditure)
$b : G \rightarrow H$	(benefits, social security, welfare, etc.)
$t : H \rightarrow G$	(taxation)
$w : P \rightarrow H$	(wages and other remuneration)
$c : H \rightarrow P$	(domestic consumption)
$x : X \rightarrow P$	(exports)
$m : H \rightarrow X$	(imports)

Of course, this merely restates what we have already said less formally. The benefit of doing this is that it is computer-readable and can be used as input to a suitable economic modelling system.

Now it’s time to pin down the relationships between the transfers. First we can write down the equation we already derived:

$$w = c + g + x \tag{1}$$

Next we look at each of the terms on the right-hand side and see what we can say about them. First c. This represents consumption, so the question is, how, typically, does anyone decide how much to spend? Our answer to this thorny question doesn’t have to be right – we can modify it later – it just has to be plausible.

Clearly, this must depend on two things (possibly among many others): disposable income, and accumulated money. The latter may be money in the bank, notes under the mattress or in the cookie jar, whatever – we’ll call it the ‘money stock’. It’s basically any money that has been left over from earlier spending. Let’s say, for the sake of argument that a person typically spends a certain fraction of disposable income (we’ll call it a_1) plus a different fraction (a_2) of the money stock. So we have:

$$c = (a_1 \times \text{disposable income}) + (a_2 \times \text{money stock}) \tag{2a}$$

Looking down our list of transfers we see there’s nothing corresponding to disposable income, so for now we’ll just call it d. As for money stock, this is the same thing as the balance for the sector – i.e. H. So it looks as though we can write this more simply as:

$$c = a_1 d + a_2 H \tag{2b}$$

This is a big improvement, certainly, but it's not quite right. Consumption cannot depend on the sectoral balance because the sectoral balance depends on consumption! If we put this into the computer it will complain bitterly. It really is a classic 'chicken-and-egg situation'. Fortunately there's a way around it.

In real life we avoid this problem because when deciding how much we're going to spend we're not going to look at the balance that we will have at the end of the month, but the balance that's left over from the previous month (or week, or year, or, in general, period). I haven't mentioned this before because I didn't want to overload you with too much information, but this is actually easily accessible. Instead of writing *H*, we simply write *H'* – read it, if you like, as "*H* (previous)".

Now we have the correct version of the equation:

$$c = a_1 d + a_2 H' \tag{2c}$$

That's fair enough, but we still don't know what the values of a_1, a_2 and *d* are. Well, we have said that a_1 and a_2 are fractions. They don't depend on anything – they can be anything you like as long as they are positive and not more than 1. In other words they are 'parameters' of the system, and what we generally do with parameters is just give them arbitrary (but plausible) values, and try adjusting them to see what happens. OK, let's say that a_1 is 0.6 and a_2 is 0.4. In other words in each period a typical householder might spend 60% of his or her disposable income, and 40% of other available cash. Plausible, if arbitrary.

$$a_1 = 0.6 \tag{3}$$
$$a_2 = 0.4 \tag{4}$$

When we come to examine the system more carefully we can try out other values and see what difference it makes. We could even carry out research to find out how people really decide how much to spend – I expect someone already has!

That still leaves us with *d* to define. Simple – it's disposable income, wages minus taxation. But not $w - t$ I'm afraid. Again, we must take the figures for the previous period:

$$d = w' - t' \tag{5}$$

So now we've taken our analysis of domestic consumption as far as we can go. The next value to look at is *g* – which like *a1* and *a2* doesn't depend on anything. It's the amount the government *decides* to spend, and it can decide whatever it likes. Economists like to say it's 'exogenous', whereas quantities like wages and consumption are dependent on what else is going on in the economy – they are 'endogenous'. Be that as it may, we'll assign an arbitrary value of 100 to *g*, noting that this still leaves the possibilities wide open because we haven't defined the units. It could be £100 or £100bn. But whatever we take it to mean, we must use the same scale for everything else as well.

$$g = 100 \tag{6}$$

Taxation, t, is another endogenous quantity. The government can fix the tax rate, or rates, but as we shall see, it cannot fix the amount of tax – not directly, anyway. I won't try your patience by spelling out the minute details of the equation for t. Suffice it to say that for our purposes we can regard it as a percentage (r_1) of wages, plus a percentage (r_2) of consumption. The first of these corresponds to income tax and the second to purchase tax (or VAT, or whatever). This gives us the equation

$$t = r_1 w + r_2 c \tag{7}$$

r_1 and r_2 are exogenous parameters, to which we will assign default values of 10 (percent) and 0 (percent), representing an economy that imposes income tax but no purchase tax. What happens for different combinations of the two tax systems is something we can investigate.

$$r_1 = 0.1 \tag{8}$$
$$r_2 = 0 \tag{9}$$

What's left? Benefits (b), imports (m), and exports (x). We'll set these all to zero in the first instance, so we're back with a closed economy in which all government spending is on public works and public services, with none on welfare. Fortunately this is only going to happen in our computer model – no one is suggesting it as a real-life programme!

$$b = 0 \tag{10}$$
$$m = 0 \tag{11}$$
$$x = 0 \tag{12}$$

So that's it. We have defined a model of a simple economy. We can now feed it into a program that is designed to work out how the system will evolve through time. It does this simply by applying each of the transfers we defined at the outset, calculating the values of the variables that result, and plotting the results on a graph. It does this repeatedly, each iteration representing a period. What a period is, exactly, is rather difficult to pin down, particularly as the different agents in a real-world economy would work to periods of different lengths, ranging from a day for some 'casual' workers to a quarter of a year for a government or large corporation.

These caveats imply that we shouldn't (as if we would!) look to our model for precise timely predictions. Rather, what we can expect it to reveal are general principles, such as that increasing certain parameter in a certain situation causes an increase, or reduction, in some other variable. It may, for example indicate that the tax take will increase or reduce to a certain point and no further, but it will probably not be able to tell us accurately how long this will take.

Investigation

The program that we use for this is called SimX. There's only one copy of it, and that's on my computer, because I wrote it. To be more accurate, I'm still writing it: what I have at present is an incomplete prototype. However, it is fairly robust as long as you know what to avoid, and sufficient for the present task. The main output from the program is in graphical form, but it also stores the results in tabular form in a file that can be read into a spreadsheet for further analysis or to change the style of the presentation.

Even with a simple model like ours the number of interacting variables can be confusing. The approach we adopt initially is to keep the model (as defined by its equations) constant and to note the effect of varying the parameters one at a time. Once we have gained an understanding of how that model behaves we can try changing the model itself (i.e. its equations) to determine whether the changed model behaves similarly.

The model, then, is defined by equations (1), (2c), (5) and (7), which describe the relations between wages, consumption, disposable income, and taxation. The remaining equations give the default values of the parameters For ease of reference, here’s a summary:

Formula	***Description***
$w = c + g + x$	Wages
$c = a_1 d + a_2 H'$	Consumption
$d = w' - t'$	Disposable income
$t = r_1 w + r_2 c$	Taxation
$a_1 = 60$	Proportion of wages spent on consumption
$a_2 = 40$	Proportion of ‘money stock’ spent on consumption
$g = 100$	Primary government expenditure (excludes direct payments)
$r_1 = 10$	Income tax rate
$r_2 = 0$	Purchase tax rate
$b = 0$	Government expenditure on direct payments such as welfare
$m = 0$	Cost of imports
$x = 0$	Receipts for exports

Table 1: Equations and Default Parameters of the Basic Model

If we ignore the the time being the last four parameters (which are all set to zero) we see that we have a very simple model indeed: four equations and four parameters. By zeroing the m and x parameters we have also eliminated foreign trade so sector X will have no bearing on proceedings and we have effectively reduced the model to just three sectors. This is all to the good – the simpler the better at this stage – but we must be sure to re-introduce these extra factors later. *For the time being we just have to be aware that we are now dealing with a closed economy, and that the results may be changed in as yet unknown ways once foreign trade is accounted for*.

Experiment 1: Overview of Sectoral Balances

As a preliminary experiment, after setting up the basic model as described we simply get it to display the sectoral balances for a hundred iterations, or periods. (Illustration 5)

Before going any further, let's reiterate what we mean by a 'sectoral balance'. We have already noted that a transfer (between sectors) is a 'flow'. Wages, for example are a flow. They are paid every period, and only have meaning 'during' the period to which they apply. A balance, on the other hand is a 'stock' and amounts to the cumulative result of transfers into a sector up to and including a given period. And note that although stocks and flows *can* can be represented on the same graph this can easily cause confusion because they do not actually have the same units. In financial terms a stock is an amount of money, while a flow is an amount of money *per period* – i.e. the rate of change (of a stock) with respect to time.

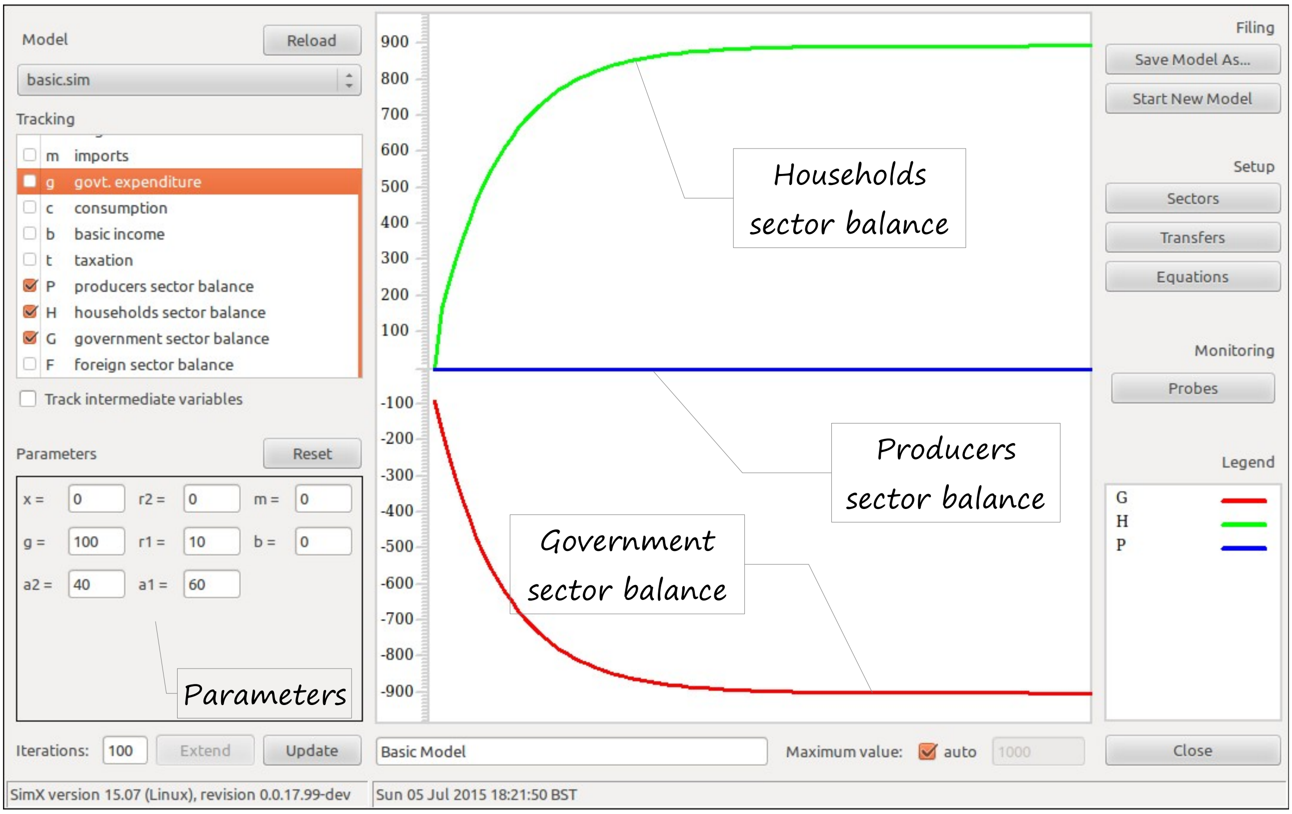

Illustration 2: Sectoral Balances of the Basic Model

In Illustration 6 we see the change, or evolution, of our three sectoral balances over 100 time periods. As expected, the producers sector remains at zero throughout – everything that comes in from sales goes out again immediately as wages, so this is not surprising, and helps to confirm that we have set the model up correctly.

The government and households balances are more interesting though, and reveal some very important aspects of economic behaviour. They start at zero, of course, because we start all sectoral balances at zero. But once the system gets under way each is an *exact* mirror image of the other – one positive, the other negative. When (after 74 iterations) $H = 899.589$, $G = -899.589$. This is clearly not just a coincidence!

In fact there's nothing mysterious about it. No money comes into the system and no money leaves it. We start off with all the sectors having zero balances, so the total of all the balances must always be zero. From which it follows immediately that if one sector has a balance of £x, and one has a balance of £0, the remaining sector must have a balance of £($-x$).

This doesn't explain why G is negative and H is positive however. It must surely have something to do with the fact that the government sector generates the money in the first place and injects it into the economy in the form of government expenditure (g), while the household sector *earns* money and accumulates some of it. Some of the flow – notably taxes – is in the other direction, but this clearly doesn't cancel out the flow into the household sector, and it would therefore be interesting to see how it relates to government expenditure. We look into this in Experiment 2: Tax and Spend.

The other interesting thing about the H and G curves is that they appear to flatten off at about 900. Actually they have only reached 899.973 after 100 iterations, but they do eventually – after another 39 iterations – reach 900 exactly and remain there. Again, 900 is a surprisingly round number. Checking out other rates confirms the relationship:

$$H = \left(\frac{1}{r_1} - 1\right) g \tag{13}$$

if $0 < r_1 < 1$ and $r_2 = 0$, and

$$H = \left(\frac{1}{r_2}\right) g \tag{14}$$

if $0 < r_2 \leq 1$ and $r_1 = 0$. The explanation is left as an exercise for the the reader!

Experiment 2: Tax and Spend

I said earlier that tax – but not tax rates – is endogenous. This may seem a little counter-intuitive since a government can, in principle levy whatever taxes it wishes. Suppose a country has a population of 10 million and the government wishes to raise a billion pounds in taxes. It could simply say everyone had to pay £100 (10m x £100 = £1bn). The problem would be in collecting the taxes. Not everyone would have £100 to spare, and some would feel that the enterprise was so unfair that they would refuse to pay on principle. The upshot would be that the government would not be able to collect all the tax it demanded.

For tax to be collectible, it must have the payers' consent, even if that consent is grudging. This means it has to be related in some way to the payer's ability to pay, and will be at least partly dependent on the payer's circumstances, which in turn will depend on the economic situation. In other words although you (as the government) can create the rules which determine tax liability, you cannot simply determine how much tax you will take, as this will be influenced by a number of other factors.

Our next experiment is a very simple one. To get an idea what the relationship, if any, is between taxation and government spending we ask the model to plot these two quantities over a time-scale of 100 periods. The result is Illustration 3. Taxation, like everything else, is initially zero, and in the course of about 50 iterations it rises to be equal to government expenditure. Having reached that point it stays there.

The default value for government expenditure is 100. We would not expect the shape of the graph to change if we changed it to, say 200, or 10,000, or anything else since government expenditure is the only absolute quantity in our model – everything else is a proportion of something else, and so, ultimately a proportion of government expenditure. Double government expenditure then, and you will automatically double the tax take. The only thing that changes on the graph is its scale.

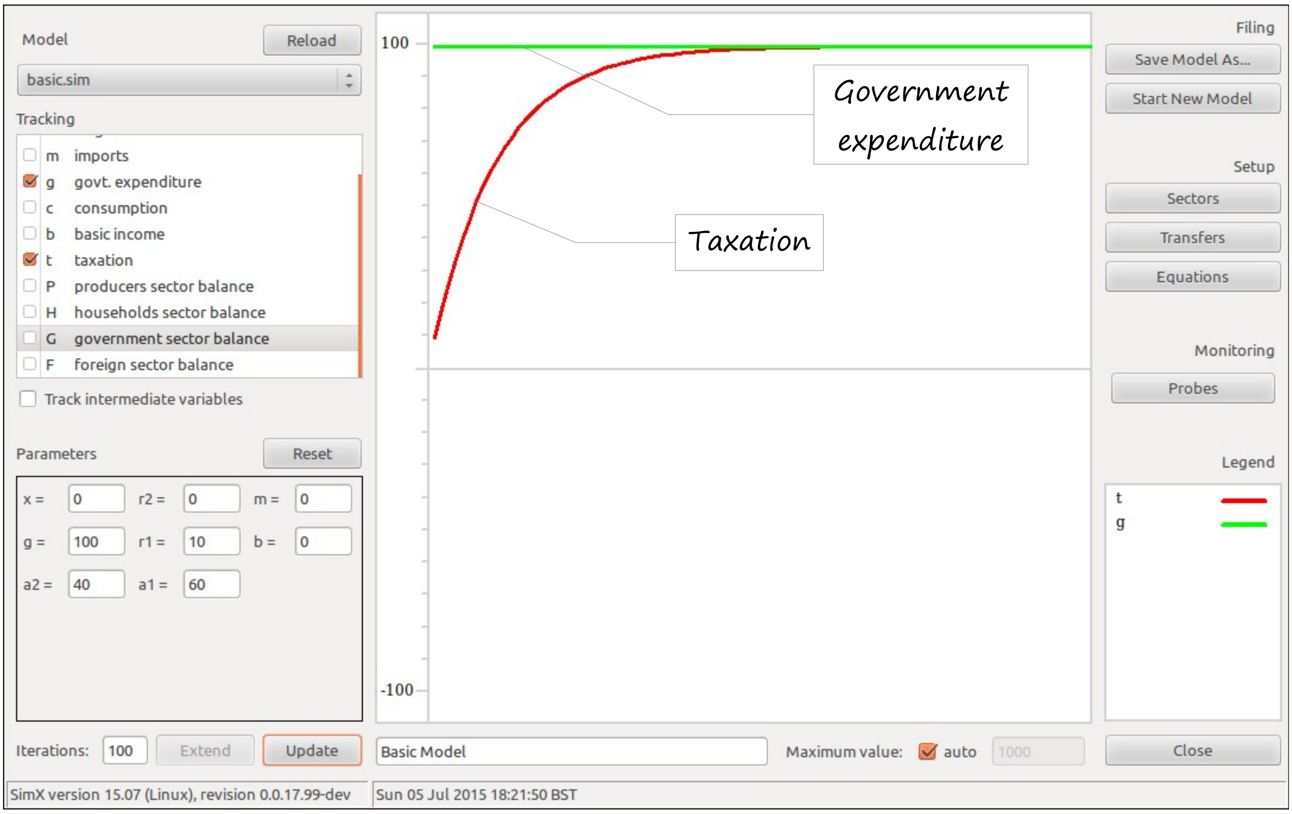

Illustration 3: Government Expenditure and Taxation

This simple fact has important implications. Suppose, in a real economy, the government decides it should run a 'budget surplus' – in other words arrange for revenue (i.e. taxation) to exceed expenditure. It will try to do this either by raising taxation or by reducing expenditure, but it is doomed to failure either way since (subject to a small caveat – see Oops! below) everything will adjust automatically, to keep them in synch.

Experiment 3: Changing the Tax Rate

If that last statement sounded a bit rash, take a look at Illustration 4, which shows the effect of increasing the tax rate r_1 (from 10%) to 25%. The only effect is to make the amount of tax taken rise more quickly, but it doesn't rise any further than government expenditure. Conversely, if we reduce the tax rate the slope gets shallower. At 1% it takes about 500 iterations to more-or-less reach government expenditure, and at 1000 iterations it is still 0.0043% short of its target.

This holds as long as r_1, however small, is greater than zero. When it's zero the tax take is also zero and the curve lies flat along the time axis. You could say that it takes an infinite amount of time in this case to reach 100 – the question is academic. And if you go beyond zero into negative territory the model breaks down completely. Each time the system adjusts the tax becomes more negative, and at an ever increasing rate.

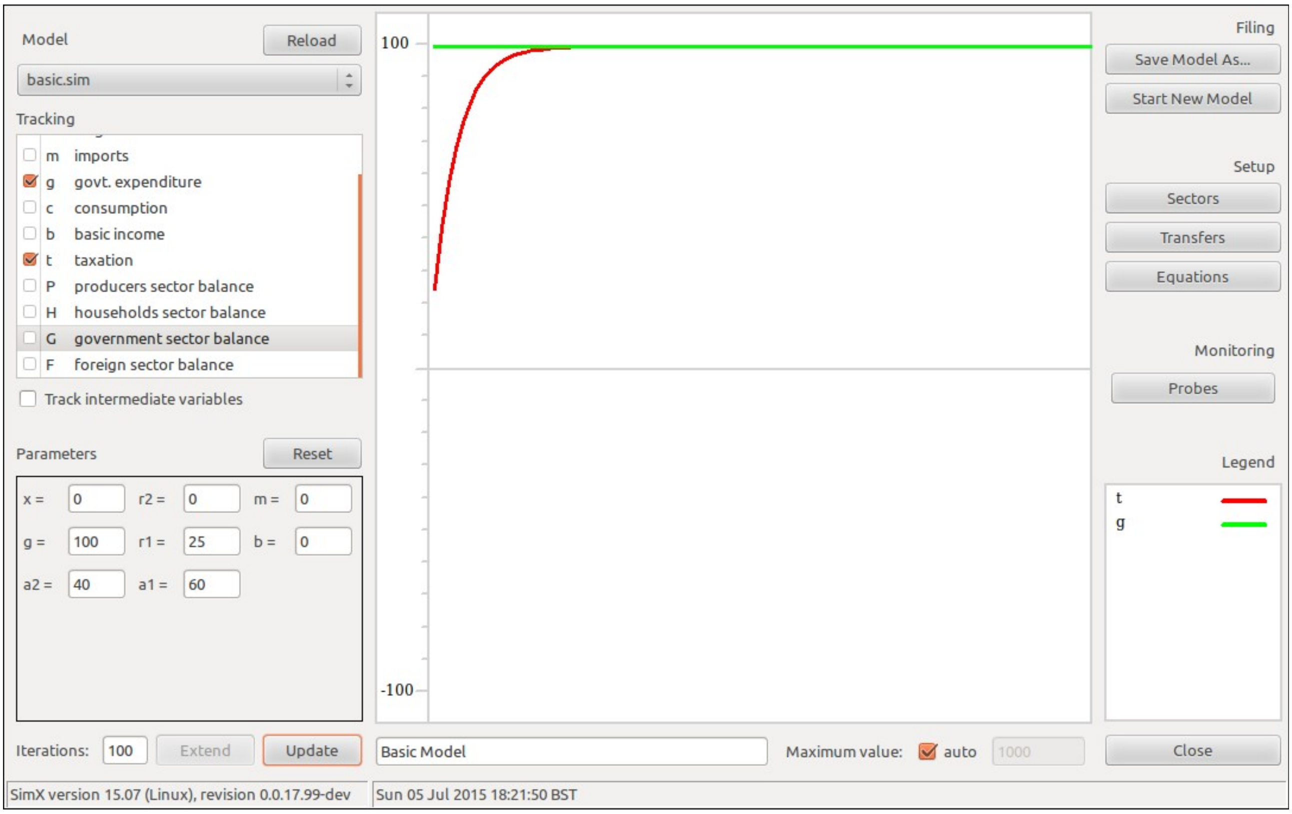

Illustration 4: Changing the Tax Rate

Oops!

Having asserted that tax will always track government spending I now have to backtrack a little. I having problems proving this theoretically, so I consulted [Godley & Lavoie, 2007], and found that they related what classical economists call the multiplier effect (not the same thing, by any means, but connected) to the fact that households use some of their 'savings' (H', in our system) as part of their payment for consumption.

The default parameters of our Basic Model do indeed stipulate that as well as 60% of their disposable income (d) households will spend 40% of their accumulated wealth (H') on consumption.. To see whether, as G&L seemed to suggest, this could have a bearing on the question whether tax follows government spending, I changed parameter a_2, the fraction of H' that is employed, to zero. The immediate consequence was that tax no longer followed government expenditure, whatever the value of a_1 . It continued to reach a 'steady state' but at a fraction of g that was much smaller than a_1.

The proportion (a_2) of H' that was employed was more-or-less immaterial: t reliably tracked g for all values of a_2 greater than zero, though as with the tax rate itself the speed of adjustment was higher for higher values. In fact for values close to 100% it would very slightly overshoot the target and then drop back down.

This weakens my assertion that tax follows follows government expenditure (i.e. that $t \rightarrow g$) but not that it is endogenous. The extent to which it follows expenditure will depend to the extend to which households spend either (a) 100% of their income or (b) at least some of their accumulated wealth, on consumption. But where neither of these conditions apply we can still say that t*axation never exceeds expenditure*, and is generally much less. Further, that an attempt to 'remedy' this by increasing the tax rate will always be unsuccessful.

And in practice, the assumption that part of the households sector's spending will be a fairly consistent proportion of its accumulated wealth, still seems reasonable.

Digression 1: Steady States

All the experiments so far have given rise to what we call a 'steady state'. The rough meaning of this term is fairly obvious, but it will be helpful to pin it down it bit more firmly. First, let's look at a situation than doesn't reach a steady state. Suppose we reduce tax to zero. We have seen what happens when either r_1 or r_2 (or both) is non-zero; now we will see (Illustration 5) what happens to domestic wealth (H) if government expenditure (g) is non zero but no tax is recovered.

Unsurprisingly, the graph shows the households sector's balance (the green line) increasing without limit. This is hardly surprising – the government is spending money into the economy at a constant rate (100 units per period) but it's a closed system and the money is never taken out again, so it

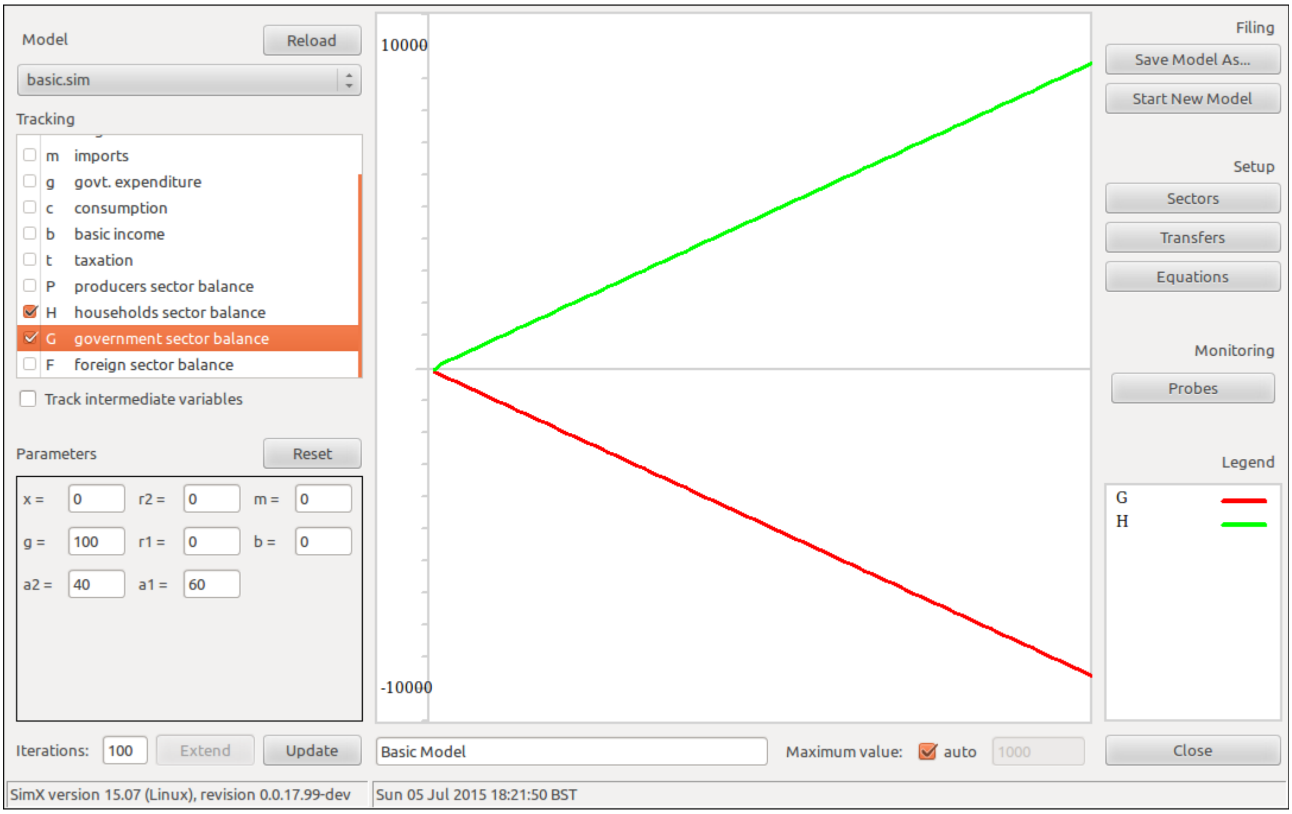

Illustration 5: Household sector balance increases without limit if tax is zero

simply accumulates as the household sector's balance.

I have also included the government sector's balance (the red line) as a reminder that a positive domestic balance inevitably requires an equal but negative balance in the government sector. This isn't, of itself, a problem but it is an inevitable fact – unavoidable and non-negotiable, despite the fact that the policy of the present government, most previous governments, and the vast majority of the media has been to try to 'fix' it.

But all we are really concerned about here is to note that in no sense is this a steady state, because something (lots of things, in fact) is changing. At any point in time we would find that $H > H'$ and $G > G'$. Similar things would also be happening to the variables we have not plotted. If we compare this with, say, Illustration 4 and previous examples, we can see that when the steady state has been reached everything remains the same. In particular, in Illustration 4 it is clear the after the initial rise all subsequent values of t satisfy the equation $t = t'$. If the whole system is in a steady state (which it usually is, if any part of it it is) then for any variable β of the system,

$$\beta = \beta' \tag{15}$$

This means that we will sometimes be able to write down simultaneous equations that we can solve to find the values variables must have in a steady state. It is important to recognise however that solving such equations does not on its own prove that a steady state exists.

Equipped with equation (14) we could rewrite our four Basic Model equations as

$$w = c + g \tag{1a}$$

(we have dropped the x as we're assuming no exports)

$$c = a_1 d + a_2 H \tag{2d}$$

(substituting H for H')

$$d = w - t \tag{5a}$$

(substituting w for w' and t for t'), and

$$t = r_1 w + r_2 c \tag{7a}$$

We could then supplement the list with equation (13) or (14) to enable us to get rid of the H term in equation (2d) and solve the equations simultaneously to obtain t, w and c in terms of g. We could, but it's far easier just to run the model and see what comes out.

Referring back now to Illustration 5, a question that comes to mind concerns the slope, or 'rate of change' of the sector balances. Clearly it has to be $(t - g)$ for sector G, and therefore $(g - t)$ for sector H.. Each period the government sector reduces its balance by g units and recovers t units, and produces the opposite effect in the households sector.

Another, more mathematical, way of stating this is to say that:

$$\frac{\delta H}{\delta T} = H - H' = g - t \tag{16}$$

where T represents time, counted in periods.

Now in a steady state the line representing H, or any other sectoral balance, is flat: there is no change. In other words $H = H'$ (and $G = G'$ and $P = P'$), so $(g - t)$ must be zero – i.e. $g = t$, or in other words *tax must equal government expenditure*.

More generally the relationship between H and H' is

$$\begin{aligned} H &= H'(1-a_2) + d(1-a_1) \\ &= H'(1-a_2) + (w'-t')(1-a_1) \end{aligned} \tag{17}$$

from the definitions of a_1, a_2, and d. For a steady state to be achieved this expression must converge, which the model clearly shows is the case for the situations we have examined. For a more thorough treatment we would have to show algebraically what were the limits of this convergence. Illustration 5 Is an obvious example.

A non-zero value for g tends to be viewed with concern by government. The cry goes up, 'Balance the books!' and there are calls, if $g > t$, to increase taxation or to reduce expenditure in order to bring them into line. But, as we have seen, in a closed economy, at least one of the simple kind we are considering, this will not work. The tax take is endogenous. More than that it will automatically track government expenditure without any intervention from the government.

If it fails to do this there are essentially two possible explanations. Either (somewhat improbably) the household sector is spending less than 100% of it income and none of its accumulated wealth, or (much more realistically) the economy is not closed and exports and imports do not match. Increasing taxes and reducing expenditure will not affect this in any direct way.

However, we have not yet included imports and exports so I'll say no more about it for now.

Experiment 4: Tax and Wealth

Wealth is a tricky concept. We tend to see it as obvious that someone who has more money is necessarily wealthier than someone who has less. We get a different perspective however if we ask ourselves the following question. If Fred has £10,000 in the bank, and leaves it there, while his friend Jim has nothing in the bank because he has just spent it on something he has always wanted, who is the richer of the two?

Money in the bank is potential wealth; money spent is realised wealth – always assuming, of course that it was spent on something worthwhile. Economists sometimes make a similar distinction by referring to financial assets (money in the bank) and real assets (stuff that the money was spent on). The notion of real assets as real wealth is difficult to quantify, unfortunately, because we still tend to set its value according to what it cost or what we could sell it for. In the end we always invoke 'the market' to decide, for example, whether a Monet is more valuable than a Degas, with the consequence that the work of artists who themselves lived lives of penury, can only be afforded by the super-rich.

This question is relevant if we want to examine the effect of tax on wealth. Would we consider a tax rate optimal if it maximized the money that households held in reserve, or their wages, or their consumption? Perhaps we would look at none of these but instead try to maximise government spending on public services as the best way to ensure a good quality of life for everyone.

These are of course political and moral rather than economic questions, but they suggest that to make such decisions we, and our politicians, need to be aware of the effect tax has on all these factors.

To my mind Illustration 6 is the most interesting graph so far. It clearly illustrates two points we have already made in a different context: (1) changing the tax rate does not, apart from an initial blip, change the amount of tax recovered, but (2) it very clearly does drastically affect wealth (here

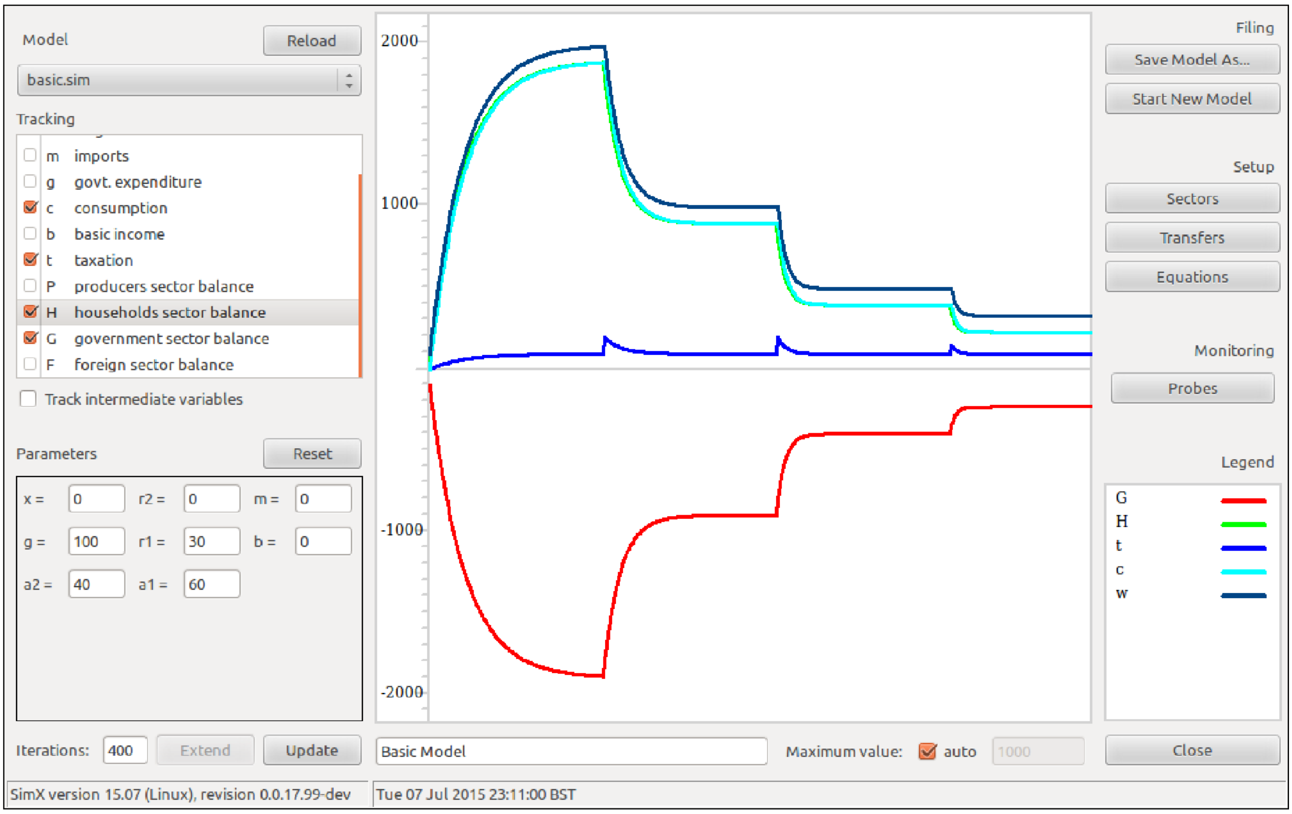

Illustration 6: Effect on Wealth of Changing Tax Rate

considered to be a product of consumption or wages).

Cyan represents consumption and blue represents income tax. Wages are the top, blue-grey line. In the first section of the graph, before the blip, I set the tax rate (r_1) to 5%. The corresponding steady state wage level (w) was 2000, i.e. government expenditure ($g = 100$) divided by tax rate ($r_1 = 1/20$). Consumption (c) is always going to be $w - g$, which here is 1900. Next I extended the graph by another 100 iterations at 10% tax, which reduced wages to 1000 (and consumption to 900). Essentially by doubling the tax rate we have halved the wage level. The pattern continues, wages and consumption plummeting as taxation is increased to 20% and then to 30%.

Although we should expect it by now, I think it's quite striking to see the consistency of the blue line representing taxation (t). Whatever we do to the tax rate the tax take remains doggedly the same – apart from the blips, which are caused by the fact that it takes a while to establish the new steady state after each change.

The red curve is the government sector balance (G). I've included it not because it is interesting itself, but because it is the mirror image the household sector balance (H) – households' 'money in the bank', which we might want to use as an indicator of wealth but is concealed by the cyan curve. As you may be able to see (try imagining the red curve the other way up), it's more-or less identical to the consumption curve, not the wages curve. It adjusts at a slight different rate (consumption lags by one period) but apart from that it's the same.

It's worth reminding ourselves that these results are all built on the default parameters of the basic model, and could be significantly different if we changed them. To be completely rigorous we should try every combination of parameters, but given that we have limited time and space we must be content to trade some rigour for comprehensibility.

On the question of which indicator of wealth to base policy on we see that wages, consumption and money stock all move together. At least until the tax rate is high enough to bring them all down to a level close to that of government expenditure (significantly affecting their relative values), it makes little difference which we choose. And since government expenditure equals tax take, which doesn't vary tax rate has no direct bearing on the question at all. If we want to increase government expenditure the only way to do it is to increase government expenditure – not mess about with tax rates!

On the other hand if we want to increase economic activity because it will *indirectly* help to pay for things of public value, the way to do it is to *reduce* tax rates. Counter-intuitive, perhaps, but you can't argue with the numbers (unless I've got them wrong, of course!).

One further point worth mentioning: I noted that doubling the tax rate halves wages – that is,

$$r_2 = 0 \Rightarrow w \propto \frac{1}{r_1} \qquad (18)$$

but remember that this refers to gross wages. The effect on net wages is much greater, because tax is subsequently deducted from the already reduced figure. On reflection it is evident that equation (18) holds *by definition*. What is unexpected about it though is the fact that wages are determined by taxation (which is equal to government expenditure), not the other way around!

Experiment 5: Government Expenditure and Wealth

We are beginning to see that there is a clear symmetry between taxation and government expenditure, and this is confirmed in the next experiment (Illustration 7). It would probably be perfectly accurate to define taxation as negative government expenditure and vice versa: one or other of the concepts is logically redundant. So just as taxation is inversely proportional to wealth, as in equation (18), so government expenditure is directly proportional to wealth, giving us:

$$r_2 = 0 \Rightarrow w \propto g \qquad (19)$$

Illustration 7: Effect on Wealth of Changing Government Expenditure

The constant of proportionality would be different, of course, because tax is defined relative to wages (as it has to be, being endogenous), while government expenditure is given as an absolute value. No surprises then, in Illustration 7, which simply confirms what we already know. The first section of the graph shows wages increasing from zero to to ten times the default government expenditure (tax rate $r_1 = 0.1$) of 100. In the second section g is suddenly increased to 200, and wages double to a new steady state value of 2000. Consumption remains at 90% of wages throughout, reflecting the fact that households' consumption is only 90% of the total, the other 10% being absorbed by government expenditure, which, like taxation, remains at 10% of wages.

Experiment 6: Welfare and Taxation

Our default value for welfare benefits (or basic income), b, is zero – in other words everything we have examined so far has assumed that there are no unemployment benefits, tax credits, disability benefits or basic income payments. Whenever 'benefits' are discussed one of the first issues raised is inevitably how to pay for them, which generally means whether taxes will need to be raised. The next question is likely to be whether they are affordable, the assumption being that there will be a significant cost to taxpayers. This experiment addresses the first of these questions and the next experiment addresses the second.

In Illustration 8 we start off with the usual default values: 100 for government expenditure, 10% for income tax rate, and zero welfare benefits. We plot total government expenditure (the red line), which now includes both primary expenditure and welfare costs, the tax take (the green line), and the level of benefits payments (the blue line). As we have already seen, the tax take rises from zero and levels off at 100, equal to government expenditure.

After 100 iterations we suddenly increase welfare spending to 50 – half of primary government expenditure. The effect on the tax take is exactly the same as if we had just increased primary expenditure by the same amount. Total government expenditure ($g + b$) is now 150, and the tax take increases to exactly 150. But is is important to note that we did not have to adjust the tax rate at all. The mere fact that 50% more money is being injected into the economy causes the tax take to rise by 50% automatically. Contrary to what many people would expect, the affordability of welfare payments is not limited by taxation.

It should also be clear that since the same proportion of taxes is being taken but taxes have increased, it must be the case that wages have increased in the same proportion. How can this happen? If nothing else changes (which, of course, it might) as a result of the welfare payments,

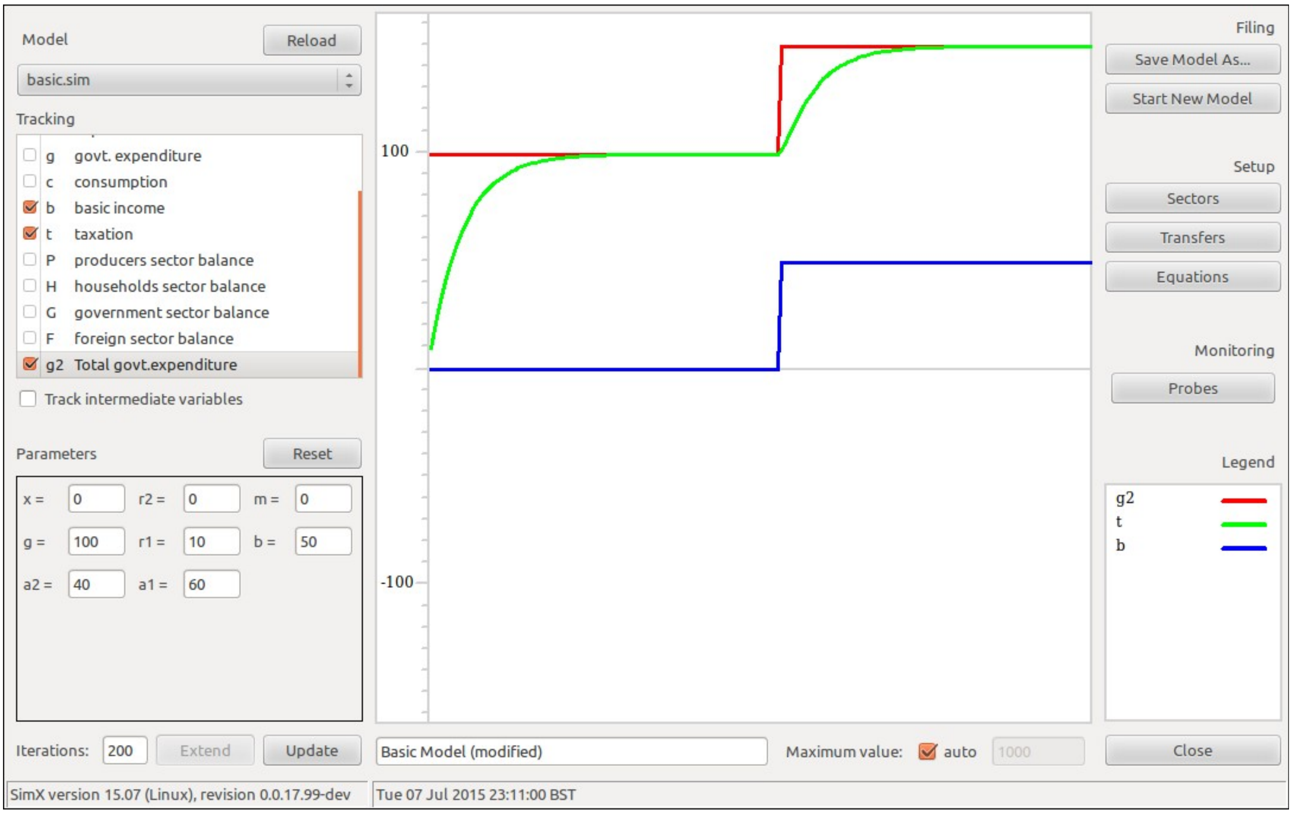

Illustration 8: Effect of Welfare Payments on Taxation

there will inevitably be an increase in economic activity arising from the spending of the benefits, and this, on the assumption that all the money is transferred by producers to households will cause an exactly equal increase in wages.

Where this system can break down, of course, is in the distribution of wages. If they are retained by the owners of the businesses where the benefits are spent, then although aggregate wages will be increased by 50% those at the lower end of the pay scales may see little of the additional money. In a very real sense, without fair distribution mechanisms the moderately poor will find themselves paying for the very poor, while at the same the same time subsidising the rich. But this is not an argument against welfare – it is an argument for fairer distribution or greater equality.

Experiment 7: Welfare and Aggregate Wealth

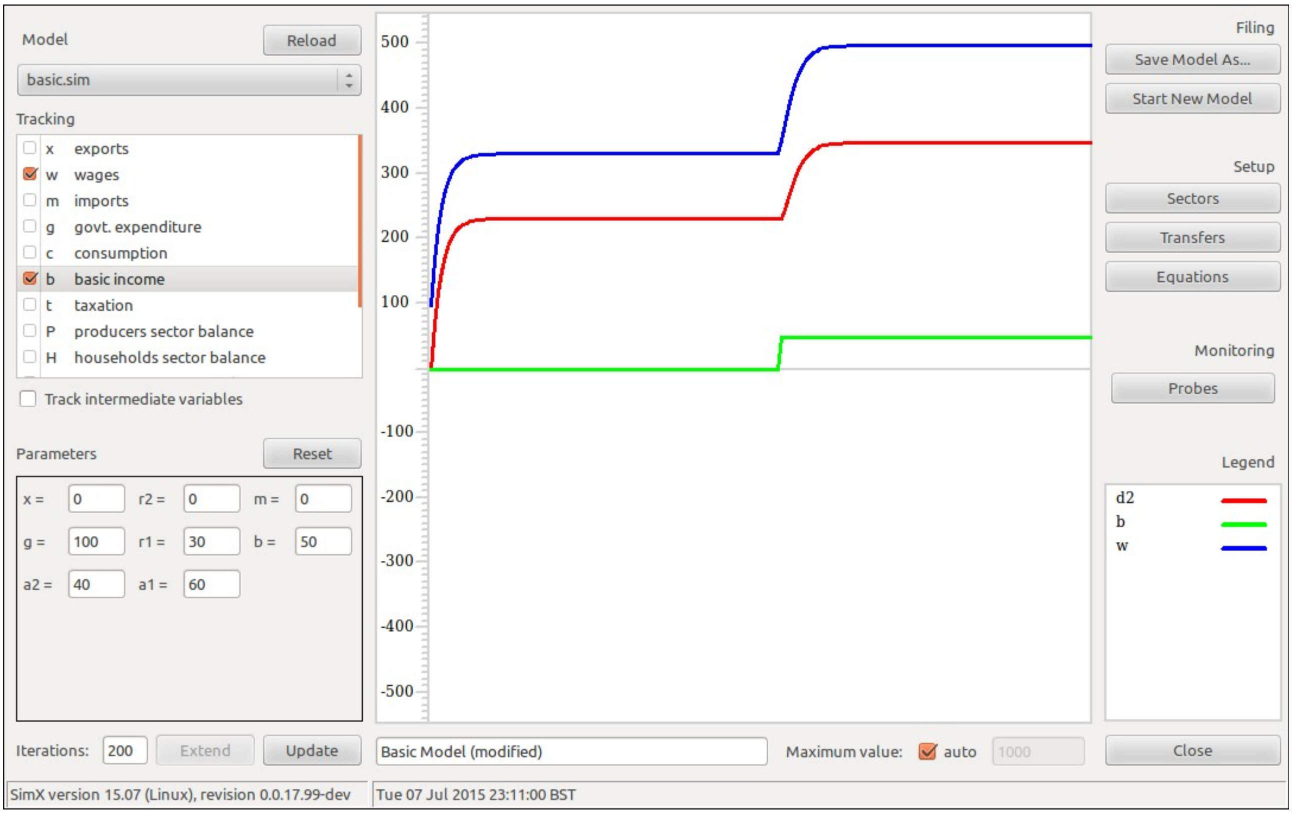

Illustration 9: Effect of Benefits on Aggregate Wealth

In Illustration 9. I have plotted gross wages and disposable income (aggregated, of course, for the whole of the households sector). The plot is a bit different from all the previous ones, in that I have pushed tax up, from the outset, from 10% to 30%. The only reason for doing this is to make the graph clearer: by reducing the level of wages (which increasing tax does, as we have already shown) it's possible to get benefits and wages on the same graph without wages completely overwhelming benefits. It makes it easier to see what's going on, that's all.

Gross wages are shown by the blue line, net (after tax) by the red line, and benefits payments by the green line. If we spend more on benefits there will be less left for everyone else, right? Wrong! What the graph shows is that is that both gross and net wages are dramatically increased by increasing benefits, which I increased from zero to 50 against the default primary government expenditure of 100. Of course, one would expect there to be some increase, because those on benefits are now receiving, and spending, money, and they weren't before. But compare the height of the step in the green line, 50 units, with the corresponding increase in the height of the red line, 267 units. Subtract 50 from 267 and you still have an additional increase, beyond the extra funds injected, of 217 units. And this would have been very much more if we had held tax at its default level of 10%.

Evidently benefits, far from being a cost to the household sector result in a major overall benefit. But I'm going to leave the maths as an exercise to the reader this time. It's not very complicated if you keep all the relationships clearly in focus!

Experiment 8: Varying Propensity to Consume

Throughout this series of experiments the parameters a_1 and a_2 have been kept at their default values of 60% and 40%. Together they define 'propensity to consume' The first indicates the proportion of the household sector's disposable income (i.e. after tax) that is assumed to be spent on consumption, and the second is the proportion of the sectors balance that is assumed to be used. To avoid computational circularity – and to reflect the real world a little more accurately – the figures from the previous period are used (see equations 2c and 5). This conveniently provides an approximating mechanism and allows the system to adjust asymptotically to changes.

For completeness I ran a couple of tests to get some sense of the kind of effect that varying a_1 and a_2 is likely to have. The results were complex but for the most part unsurprising.

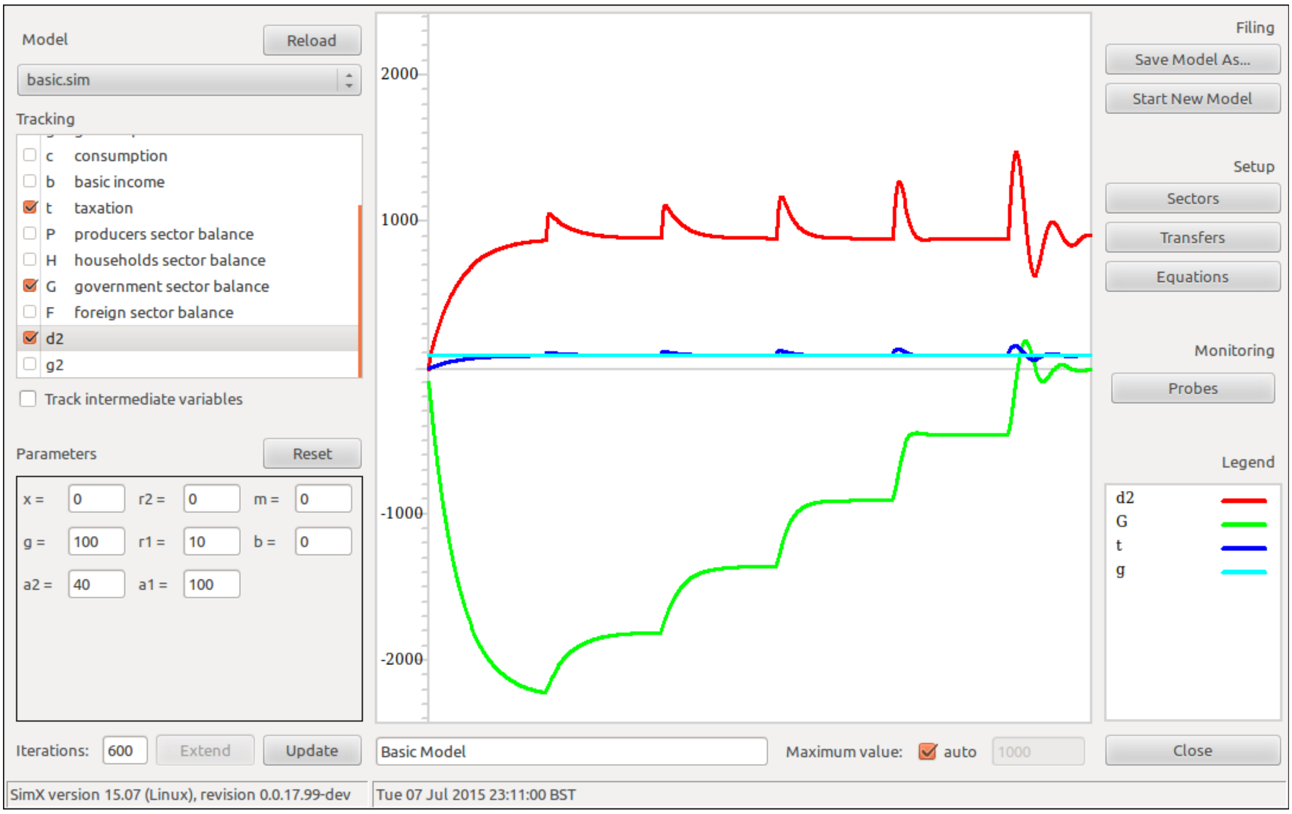

Illustration 10: Varying Propensity to Consume out of Income

In Illustration 10 I kept a_2 at 40% and varied a_1 in steps, from zero to 100%. The red line representing disposable income remained constant throughout, apart from increasingly wild blips at change-over points. Similarly for tax, the dark-blue line largely obscured by the cyan line representing government expenditure. The green line representing government sector balance and therefore the negative of the household sector balance diminished at each step as income was increasingly used for consumption rather than being saved. This all seems intuitively predictable, though the constancy of everything apart from government and household sector balances is notable.

I then varied a_2 keeping a_1 constant at 60% The results were very similar, except that the sector balances did not reduce to zero as they were always topped up by the 40% remaining from disposable income after spending on consumption. The system broke down if a_2 was zero (as discussed earlier) only in the sense that the *H* and *G* balances increased without limit (H negatively), but everything else continued as normal. In the real world of course a steadily increasing sectoral balance would not be acceptable

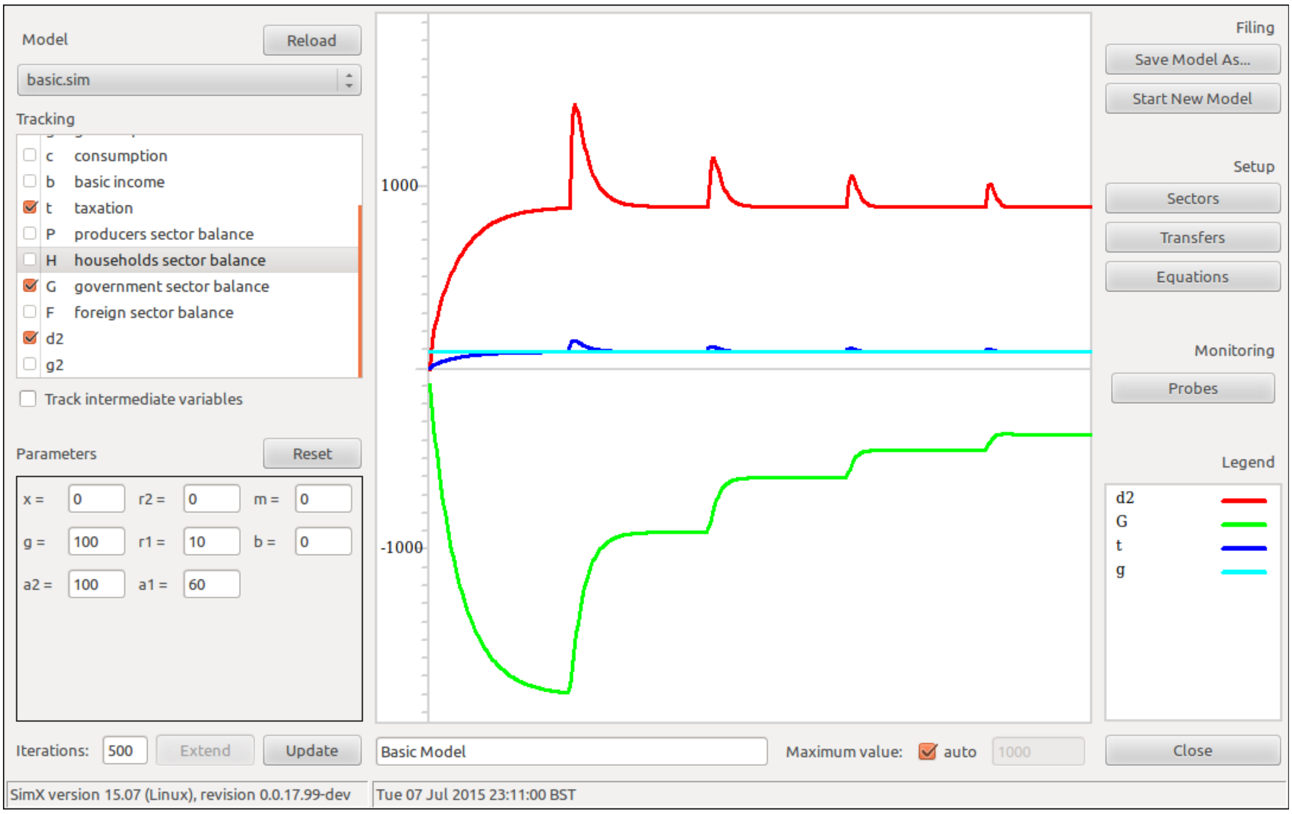

Illustration 11: Varying Propensity to Consume out of Savings

Experiment 9: Imports and Exports

The defining characteristic of a closed economy is that it does not involve imports or exports, so strictly speaking this experiment is outside our remit. However, a few preliminary results will enable us to see the kinds of effects that opening the economy up might have.

The important feature of imports and exports that distinguishes them from transactions within the economy is that they require transactions in a different currency. Imports, for example, cannot, by definition, be paid for using the home currency, so we first have to obtain the necessary funds in the foreign currency. If we do not already hold any we must find someone – in principle an agent within the external economy – who is willing to exchange some of our currency for the required amount of theirs, which we can then use to make the purchase. We end up with a real asset; they end up with a holding in what, to them, is a foreign currency. They can use this to pay for imports (exports, from our point of view), or they can hold them in anticipation of someone else being willing to exchange them for, possibly, yet another currency. A person who exchanges currencies in this way is a currency trader, and will endeavour to make a profit on each trade. However this is organised it results in the holding of our currency by an agent of an economy that trades in a different currency.

A foreign importer (someone to whom we export) will have to obtain funds in our currency. In principle this will result in an agent of our economy holding funds in a foreign currency.

Clearly these shenanigans are liable to be a complicating factor in our hitherto simple and smooth-running system. What happens if we wish to import something but cannot find anyone who wants our currency enough to be willing to exchange it for the currency we need? Conversely, what happens if we have goods to export but the only people who wish to import them use a currency that is of no use either to us or to anyone who wishes to trade in our currency?

This is new territory and well beyond the scope of this note, but it will be the subject of Part Two. However, we will have a preliminary look at the effect of imports and exports on our sector balances and aggregate disposable income, ignoring the complications implicit in the need to exchange one currency for another in order to carry out the transactions.

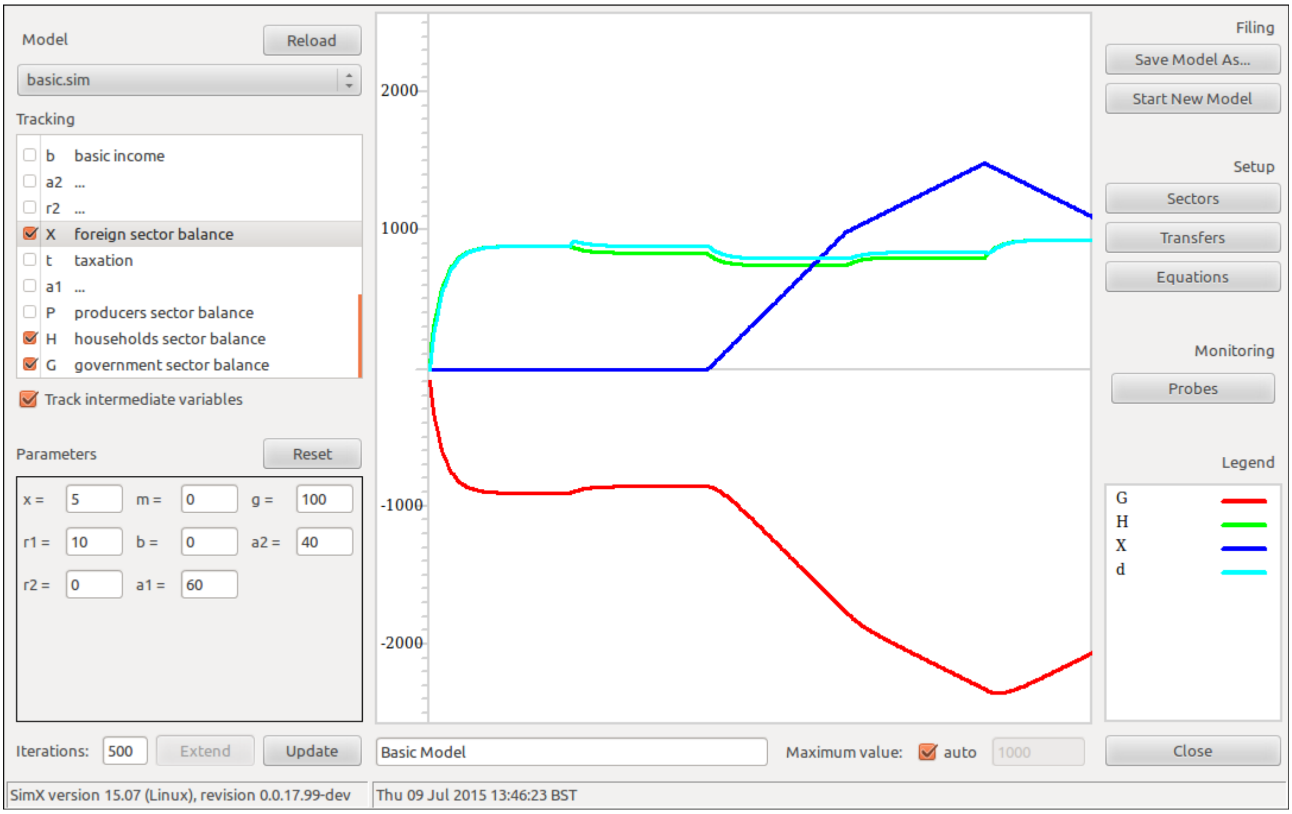

Illustration 12:Unbalanced Trade without Exchange Rate Adjustment

In Illustration 12 we start with the closed economy of our Basic Model. The cyan line indicates aggregate disposable income, the green line the households sector balance (in case it's not clear, it's the lower of the two more-or-less parallel curves); the red line shows the government sector balance, and the blue line indicates the foreign sector balance. It's important to note that the blue line only accounts for that part of the foreign economy that is actively engaged in trade with us – it is not their government sector balance, although it contributes to it. It is what the government refers to (I think) as our 'current account' – with the proviso that where we show a positive amount (i.e. from the foreign sector's viewpoint), our government would register a negative amount and call it a 'trade deficit'.

The second section of the graph introduces balanced imports and exports of 20 units each. This doesn't make a lot of difference to anything. The government sector balance is slightly increased and the household sector balance reduced by the same amount. Aggregate disposable income is also slightly reduced (from 927 to 900).

For the third section we keep imports at 20 and reduce exports to 10. This reduces the households sector balance still further, though not dramatically, and reduces aggregate disposable income to about 810. The most important changes though are the steep rise in foreign sector balance (due to the increased trade deficit) and the correspondingly steep fall in government sector balance. The latter is slightly less steep than the former to start with, as some of the change is absorbed by the household sector, but essentially both of these changes are 'straight line' effects and will continue as long as the imbalance continues.

For the next section I reduced the trade imbalance by increasing exports to 15, halving the trade deficit and (equivalently) the (negative) rate of increase in the account. And lastly I reversed the situation by changing imports from 20 to 15 and exports from 15 to 20.

Clearly these straight line sections are not sustainable and something must happen to level them off. What actually happens is that exchange rates change. Ideally they will change in such a way as to bring the values of imports and exports into line, but this is often impossible. A country may have so much of an exportable commodity (such as oil) that it can attract vast quantities of foreign currencies which it can use for imports without having to worry about the value of its domestic currency. Or it may have nothing to export so its domestic currency is worthless to the outside world. If it has no domestic economy to speak of (think Zimbabwe) it will be dependent on imports that it has no means to obtain.

Deep waters! Hopefully I'll have some answers for Part Two.

Conclusions and Caveats

I have to acknowledge that I am neither a mathematician nor an economist, and can claim no great expertise in either area. My objective has simply been to try to pin down the key logical features of any economy that is based on money created by a sovereign currency-issuer – of which the UK is one – and by means of a computer model incorporating those features to draw some conclusions about the way it will behave. To the best of my knowledge and belief, the model works and the principles are valid, from which it follows that the conclusions should be sound. But I could be wrong on any of these points!

The principle conclusions *for a closed economy* are these:

1. An economy automatically adjusts, after changes, to a steady state in which tax recovered is equal to government expenditure.
2. Tax rates determine the relationship between government expenditure and aggregate income:
3. Aggregate income is inversely proportional to tax rate
4. Aggregate income is directly proportional to government expenditure.
5. It follows that an attempt to increase tax receipts by increasing tax rates will merely have the effect of depressing economic activity and reducing aggregate wealth. A persistent deficit or surplus probably has more to do with foreign trade than with domestic issues.
6. Household and government sector balances are accumulated (and dissipated) during the periods of adjustment from one set of conditions (principally tax regimes and government expenditure) to another. When no change is taking place net government expenditure is zero

and the balances remain unchanged.

7 The only exogenous variables (within the limits of the repertoire we have investigated) are tax rates and government expenditure. Subject to the limits imposed by the economy's productive capacity (see discussion below) the former should be kept as low as possible and the latter as high as possible.

I am aware that these conclusions ignore other candidates for exogenous parameters that could be used in regulating the behaviour of the economy – notably interest rates. These cannot be modelled without an explicit financial or banking sector. I hope to include them in subsequent investigations.

A further possible weakness of the model adopted is that lack of any empirical or statistical basis for the 'propensity to consume' functions. I have endeavoured to minimise the effect of this problem by experimenting with different values of the a_1 and a_2 parameters, but the approach is still open to the criticism that real-world propensities to consume may well not be linear or even consistent. Further research on this topic would be helpful.

A critic will also draw attention to the assumption throughout that economic activity will always expand and contract in response to demand. Clearly this is an approximation. In particular an economy can only expand within the limits of its productive capacity. At the same time it needs to be recognised that the UK, or any economy with moderate to high levels of unemployment, is nowhere these limits.

A more serious issue is our implicit assumption that increasing aggregate wealth is necessarily good for everyone. Clearly this is untrue. Our socio-economic structures are organised so as to ensure that the principal beneficiaries of increased wealth are the already wealthy, and the principal sufferers from reduced aggregate wealth are the already poor. It is also true that capitalism is inherently conservative, in that it confers most power on the rich. These are serious issues that need to be recognised, but they can only be dealt with politically.

National Debt

One more observation that is not strictly drawn from this investigation: we have consistently shown a substantial level of government 'debt' in every case we have considered. It is commonplace to argue that this is a bad thing and should be avoided, that the 'debt' should be 'paid down'. I mention this in case it is an issue that concerns the reader. This is one of the commonest and most pernicious of mainstream misrepresentations of economic fact. Government 'debt' (so-called, rather misleadingly) is the precise counterpart of domestic wealth. Get rid of one and you get rid of the other – it's as simple as that. Our grandchildren will not 'inherit' it, in the sense of a liability that they will somehow have to pay off out of their hard-earned wages. This whole scenario is nonsense. It's not what it means, or how it works. For more information on this you are recommended to look up Modern Money Theory, as there is insufficient space here.

Reflection on Government Economic Policy

The principal, and obvious implication is summed up by the adage 'When you are in a hole, stop digging'. More specifically that you cannot fix a recession through austerity, since austerity tends inevitably to worsen and prolong the recession. The fact that this has been known since Keynes' work in the 1920s cannot but throw serious doubt over the motives, good-will, economic literacy and competence of the present government – or over at least one of those factors.

Bibliography

Godley & Lavoie, 2007: Godley, W and Lavoie, M, Monetary Economics: An Integrated Approach to Credit,Money, Income, Production and Wealth, 2007

Other Resources

The program (SimX) used to create the graphs shown here is written in C++ using the wxWidgets framework and is available from the author both as source code and as a Linux executable. For more information please email david.peaceparty@gmail.com.