Abstract: If there are limits on the amount of debt which economic agents are allowed to bear, differences in beliefs affect average outcomes. Only in extremely special cases is the aggregate outcome a function only of the average forecast. A behavioral model with a credit constraint, in which different agents forecast using two different rules of thumb behaves fundamentally differently from an otherwise identical model in which all agents make the average forecast. There are occasional severe downturns roughly of the magnitude of the great depression, and the long term average of output depends on monetary policy.

Introduction and Literature review

The model

Our model is based on De Grauwe's model (agents forecast output and inflation according to one of two simple rules. Fundamentalists forecast future output and inflation to be constants. Extrapolators forecast output and inflation to be equal to their most recent lagged values. Agents choose forecasting rules partly based on past performance and partly based on an agent specific disturbance term. There is a simple aggregate demand equation in which agents' consumption is increasing in expected future income and decreasing in the real interest rate and a forward looking Phillips curve in which inflation is increasing in future expected inflation and in output. Monetary policy is a Taylor rule which gives the nominal interest rate as a coefficient (greater than one) times inflation plus a coefficient times output .

The innovation in this model is that, while price setting is modeled exactly as in DeGrauwe (200??) individual consumption is modeled so agents lend to each other at the safe nominal interest rate. The inclination to extrapolate is constant for each individual. In the model it takes one of N different values, so there are N classes of agents. The wealth of agents of each class varies over time.

Agents decide whether to extrapolate output and/or inflation based on the past performance of the extrapolative and fundamentalist forecasting rules as in De Grauwe in fact the variables

[here a long quotation from De Grauwe explaining how expectations are formed in his model the one point is that where he introduces the variable (you know the disturbance which isn’t evidence and effects beliefs so the fraction of extrapolators is a smooth function of past performance) we have to say that it is constant for each individual and takes one of N values. There is some need to translate

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nextp = 1+(floor((alfap-amin)/astep))*(alfap>amin); % the number of groups    who extrapolate inflation
        nextp = nextp + (nextp>(N-1))*(N-1-nextp); % alphap may have to be be rounded down to the allowed maximum alfam
        nexty = 1+floor((alfay-amin)/astep)*(alfay>amin); % the number of groups    who extrapolate output
        nexty = nexty + (nexty>(N-1))*(N-1-nexty); % alphap may have to be rounded down to the allowed maximum alfam

        extpv=zeros(N,1);
        extpv(1:(nextp)) = 1; % which groups extrapolate inflation
        extyv = zeros(N,1);
        extyv(1:(nexty)) = 1; % which groups extrapolate output

        alfap = amin+astep*(nextp-1); % round alfap to the minimum alfam plus an even number of allowed steps.a finite number of types
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alfay = amin+astep*(nexty-1);
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into English.

In general it is not obvious how the resulting financial position will affect agents' consumption choices, but this is very simple in the special case in which utility is additively separable in consumption and leisure and logarithmic in consumption. In this case, the consumption of a rational agent is simply the sum of what consumption would be if wealth were zero plus the rate of time preference times wealth. We assume that this is also true of our agents who are attempting to maximize subjective expected utility. So far this would mean that aggregates behave as in the De Grauwe model, that is they behave as they would if each agent made the average forecast.

However, there is an additional behavioral assumption that agents are not willing to lend to an agent whose debt is greater than a constant dl times one period's normal output. If a class of agents has borrowed to this limit, it is liquidity constrained.

In a (final?) behavioral assumption, agents are assumed to consider the risk that they will be liquidity constrained the next period to be negligible. This assumption is required for tractability and definitely very important. The justification is that agents borrow to the debt limit when they make optimistic forecast errors and we assume that agents have great, but unfounded, confidence in the forecast rule which they are currently using. The myopia and lack of concern about possible future liquidity constraints is one key difference between our behavioral model of boundedly rational agents and a model of fully rational agents who are learning about the data generating process.

The limit on borrowing fundamentally changes the behavior of the model. Consumption depends only on the forecasts of agents who are not liquidity constrained. Liquidity constrained agents consume less than they would if they could borrow reducing demand. The fact that agents are always free to save more but may not be able to borrow more introduces an asymmetry. This causes output to be lower on average than the level which would occur if all disturbance terms were set to zero (normal output). Our model in which agents differ only because they have different expectations is, in this way, an example illustrating the importance of financial frictions in models with heterogenous agents.

The liquidity constraint makes it slightly more difficult to calculate output and inflation given expectations. If one group of agents is liquidity constrained, output is reduced. This reduces income of the other agents, causing them to desire to borrow more. This can cause the debt of other groups to reach the limit dl. This is a minor computational difficulty given the finite number of agents. The solution procedure is first to solve assuming no agents are liquidity constrained, then to determine which classes of agents are attempting to borrow more than dl, then to reduce the consumption of liquidity constrained agents so that their debt is at the limit dl and recalculate output, then determine which agents are attempting to borrow more than dl and repeat until the process converges because exactly the same groups are liquidity constrained in two successive iterations. No more than N steps are required to find this solution.

This procedure automatically generates a variable Z equal to the sum over liquidity constrained agents of desired consumption minus actual consumption (expressed as a fraction of normal output). This is an interesting indicator of the effect of the borrowing limit out output. This effect can easily be very large causing output to be far below normal output.

The reduction of output due to liquidity constraints causes lower inflation and, therefore, lower expected inflation and, through the Taylor rule, lower interest rates. It also causes lower expected future output if any groups of agents are extrapolators. More importantly, the reduction in output causes fundamentalists to borrow more, or, at least, to save zero if they are liquidity constrained. They expect output to return to normal next period and attempt to smooth consumption. Thus output reductions due to the interaction of financial friction and diverse non fully rational expectations can be long lasting as well as large. Finally, the persistently low output can cause fundamentalists to become extrapolators, because output remains far from normal, so the extrapolative forecasts outperform the forecast that next period's output will be normal.

So far we have assumed that interest rates are given by the Taylor rule. It is also possible to impose a zero lower bound on the nominal interest rate, which implies a negative lower bound on the variable r which is the interest rate minus the normal interest rate. This causes periods with low output due to binding liquidity constraints to be more frequent, severe and long lasting. The zero lower bound is not essential for the qualitative results. Generally we allow negative nominal interest rates and only look at the effect of a zero lower bound to evaluate the robustness of the results.

Qualitative behavior of the model. A simulation. The story about what happens.

Now a graph of output vs debt – see Mian and Sufi stuff. Notice that depressions occur when debt levels are high, but not at the very highest debt levels.

Now output vs the effect of the liquidity constraint on demand. Notice two interesting subsets of points. There are great depression points when fundamentalists are liquidity constrained. Here output is low and the direct effect of the liquidity constraint is large. This occurs when the exogeneous output shock has been negative in recent periods. Fundamentalists borrow during these periods (extrapolators expect below normal output the next period and fundamentalists expect normal output so fundamentalists borrow from extrapolators). If the output shock happens negative for several periods in a row, the debt of some fundamentalist groups can reach the limit. This reduces output (which can be far below normal even if the output shock is zero that period). This causes fundamentalists to try to borrow more, driving the debt of other groups to the limit. The persistently extremely low output due to the liquidity constraint causes extrapolators to persistently predict extremely low output the next period, so they choose low consumption. Many fundamentalists (possibly all fundamentalists) also have low consumption, because they are liquidity constrained. A final effect of the depression is that it causes the extrapolative forecasting rule to perform much better than the fundamentalist rule. This fundamentalists to switch to using the extrapolative rule. Only the groups with the strongest tendency to use the fundamentalist rule remain convinced that prosperity is right around the corner. The depression only ends when a series of positive exogenous output shocks causes the consumption of the extrapolators to rise to normal consumption.

We stress that the preceding paragraph is describing the dynamics of variables in the simulated model. All the assertions, including those about beliefs and wishes, refer to numbers which are calculated by the computer. Any similarity with narratives of historical depressions is either a coincidence or evidence that our model is useful.

There are many fewer constraint constrains a boom points when extrapolators are liquidity constrained. Here output is slightly above normal. Fundamentalists are not liquidity constrained and have normal demand. Extrapolators expect higher than normal output next period so they wish to borrow. If they are liquidity constrained, then their consumption is equal to their labor income so they don't affect output. If they aren't liquidity constrained they consume more than normal output so they drive output up. The cloud of points slopes slightly up, as typically the groups with the strongest tendency to extrapolate are constrained, but some groups which are currently extrapolating but have often used the fundamentalist rule in the past are not constrained. The liquidity constraint keeps output from rising far above normal during periods when extrapolators forecast higher than normal output. This means that the effect of the liquidity constraint is to keep output close to normal, which means it keeps the forecasters of extrapolators close to those of fundamentalists. The limit on borrowing causes output to change in a direction which causes less disagreement, borrowing and lending. This means that these episodes are brief as well as mild.

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