“Learning and Time-Varying Macroeconomic Volatility”

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- The paper provides an interesting view on the Great Moderation: learning can endogenously generate changes in macroeconomic volatility that looks similar to changes in the volatility of the exogenous shocks.
- The mechanism is driven by time-variation in the gain coefficient: based on the forecast performance over the recent history, agents switch between constant-gain learning and decreasing gain learning. If the Mean Absolute Error over the recent past exceeds the long run MAE, agents revert to a high constant gain which causes more time-variation in the belief equations and therefore a higher macroeconomic volatility.
- If the time-variation in the observed volatility is endogenously generated through the learning dynamics, it is important to understand how this process depends on the monetary policy behaviour: a more aggressive reaction to inflation lowers the frequency of switches in the gain and as a result the average gain and therefore the volatility in beliefs. The contribution of “good policy” to the Great Moderation is probably underestimated by neglecting this mechanism.

Comments are organised around four points:

1. Does learning necessary lead to higher volatility ?
2. The relation between the gain and endogenous volatility.
3. The role of the underparameterized and initial beliefs.
4. Is the reaction of the gain to the forecast errors optimal ?

Does learning necessary lead to higher volatility ?

- Learning and imperfect information does not necessary lead to larger volatility: Bullard & Singh in “Learning and the Great Moderation” suggest that imperfect information about the stochastic regime leads to more moderate reactions/dynamics compared to a world of perfect information because agents will apply a kind of Bayesian model averaging;
- Higher volatility in that model provides more information to identify the underlying regime, which means that agents will behave as if they have perfect information, and the absence of learning will create more pronounced reactions to the shocks:

  => Role of learning in the highly volatile 70’s was low
- The opposite holds in this paper: bigger shocks or forecast errors imply more uncertainty, a return to higher gains, and more learning dynamics.

  => Role of learning in the highly volatile 70’s was high

Relation between gain and endogenous volatility

- Figure 2 in the paper suggests a simple relation between the gain in the updating equations and the volatility of endogenous variables:
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LEARNING AND TIME-VARYING MACROECONOMIC VOLATILITY

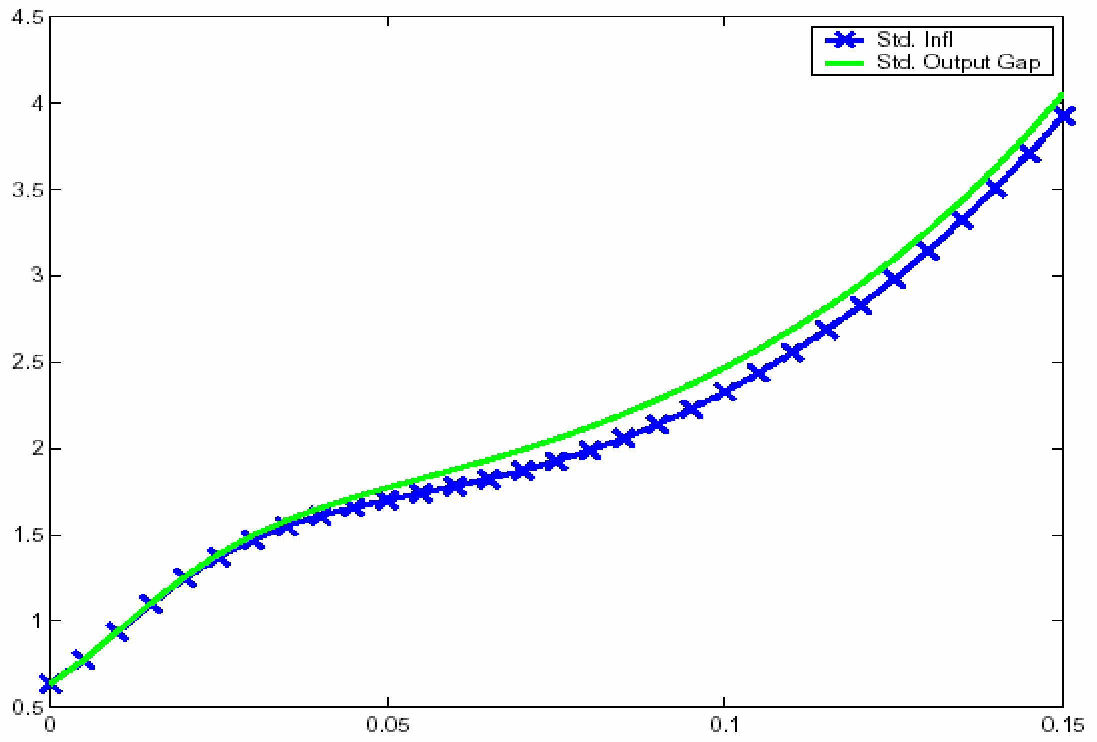


FIGURE 2. Volatility of simulated Inflation and Output Gap as a function of the constant gain coefficient.

Relation between gain and endogenous volatility

- Such a simple relation is found only for very special cases: Figure 2 applies for a model where monetary policy reacts only to the contemporaneous inflation and output gap, so that the model has only two exogenous states (g and u) which are not affected by the learning process. Therefore, this model is by definition stable for any gain coefficient.
- The relation between the gain and the volatility is much more complicated in more general models. To illustrate this point, we can simulate the model that is used in the rest of the paper (monetary policy reacts on the lagged inflation and output gap), with constant gain learning for different values of the gain (calibration corresponding with Figure 3).
- For gains > 0.01, the dynamics of the model often become unstable, so that the projection facility is needed to stabilize the model. In addition, the dynamics are typically characterised by "escape" dynamics.

Relation between gain and endogenous volatility

Volatility and Learning Gain: Model corresponding with Equations 2.1-2.3

belief equation = {cte,PIE,R,X} - Calibration as in Figure 3

gain	0,01	0,02	0,05	0,10	0,15
Std Inflation	0,76	0,93	1,31	5,53	7,11
Std Output Gap	1,12	1,39	2,61	12,81	21,15
% observations during which the projection facility is active					
	0,00%	0,10%	0,70%	13,00%	14,06%

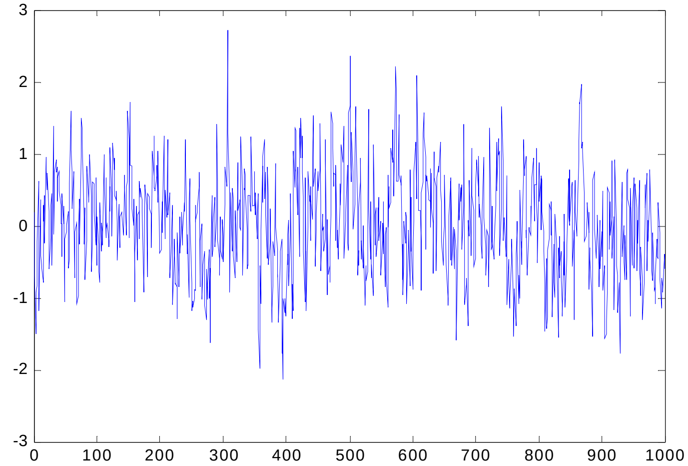
based on 10 simulations of 1000 observations

initial belief starts at the RE belief parameters

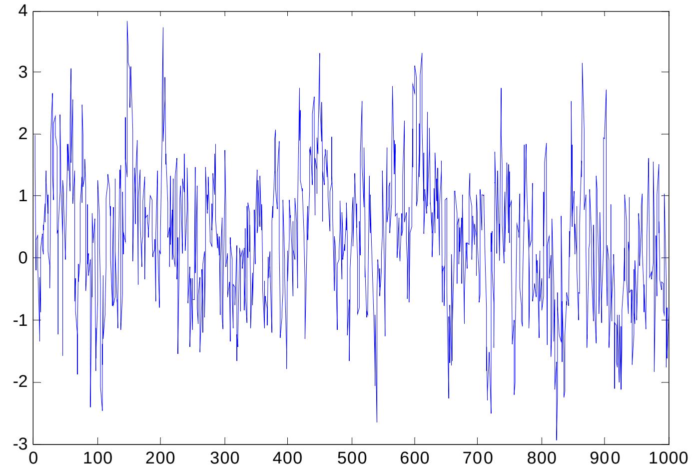
Relation between gain and endogenous volatility

gain = 0,01

inflation

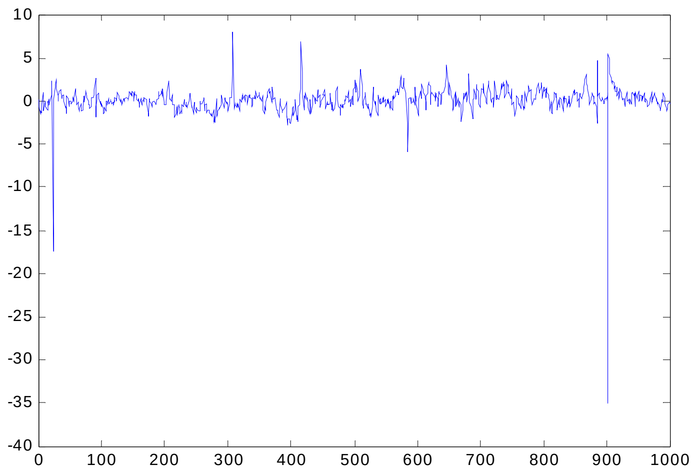


output gap

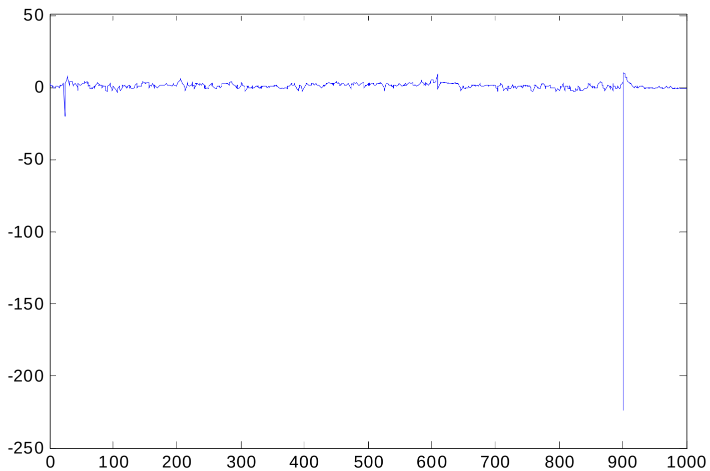


gain = 0.05

inflation



output gap



Relation between gain and endogenous volatility

- In general, constant gain learning with high gains generates complicated dynamics, and several practical issues have to be solved:

  - the projection facility will stabilize the model, but do we accept this mechanical procedure as a realistic description of actual learning behaviour? In addition, the discontinuity that follows from the projection facility complicates the likelihood evaluation in the estimation process (the continuous version in Adam et al. may reduce this problem).

  - do we accept the "escape dynamics" or the "large deviations" as part of the standard dynamics of the model? Papers like Marcet & Nicolini on Hyperinflation and Sargent on Escape Dynamics clearly calibrate the model to get recurrent escapes with an economic interpretation. Others (like Orphanides and Williams) exclude large deviations when studying standard dynamics of their model.

The role of underparameterised and initial beliefs

- The learning dynamics and the volatility that results from it, are influenced by two type of forces:

  - the stochastic dynamics in the beliefs around the equilibrium;

  - the transition dynamics from the initial beliefs towards these equilibrium beliefs.

- To fully understand the dynamics generated by the learning process, and to understand how general the results are, it is useful to distinguish between these two types processes.

The role of underparameterised beliefs

- In this paper, agents use a PLM that is a function of the observed endogenous variables (π,x,i) and a constant. This specification does not correspond with the MSV solution of the model which is also a function of the exogenous variables (g,u).
- Therefore, a first issue is whether learning with this underparameterized forecasting model converges to a "Restricted Expectations Equilibrium", and if so, how different is this fixed point and the stochastic dynamics around it from the Rational Expectations solution ?

  => simulating the model with LS learning converges to belief coefficients and a second moment matrix which are very similar to the ones implied by RE
- This result suggests that the role of the underparameterisation is not important in this application (as stated in Footnote 8)
- Branch and Evans (2006) show how different underparameterized beliefs can result in multiple equilibrium. In such a setup, agents solve a dual learning problem: LS parameter updating and forecasting model selection . This process can also result in switches between belief equations and endogenous volatility fluctuations.

The role of initial beliefs

- The initial beliefs in this application are derived from a pre-sample regression exercise. They might be especially important as they will also determine the type of learning that is selected in the beginning of the sample.
- Therefore, it would be useful to know how sensitive the results are to the specific pre-sample based initial beliefs.
- It would also be informative to know how different the initial beliefs are from the equilibrium beliefs ? What is the relative contribution in the overall dynamics of the transition dynamics from the initial beliefs towards the Equilibrium beliefs relative to the standard learning dynamics around the Equilibrium.

  => A plot of the evolution over time of the belief coefficients (2x4) and the second moments matrix could provide some evidence on these issues.

The optimal reaction of the gain to forecast errors

- In the learning process considered here, agents switch to a high constant-gain when the mean absolute forecast errors over the recent period (J) exceeds the long run average forecast errors. The motivation is that larger forecast errors are considered by the economic agents as evidence of a structural break in the data so that a high constant gain may be optimal for learning the new structure.
- However, in the model there are no structural breaks in the behavioural parameters or in the exogenous processes (except for the monetary policy switch in ‘79 but this event is not related to the switches in the learning process). Therefore, decreasing LS learning would have been the optimal learning process. Moreover, in that context the standard updating of the second moment matrixes would suggest that the most recent observations which create large forecast errors would receive less weight in the updating of the belief coefficients rather than a higher weight.

=> a generalisation of the approach that considers both changes in the exogenous volatility and in the learning process would provide a more consistent story.

The optimal reaction of the gain to forecast errors

- In addition, the threshold criteria implies that the learning process will not convergence: one or a few large shocks will always cause a return to the high constant gain. Is that a realistic hypothesis ?
- The switches in the updating mechanism and the selection criteria therefore appear as a relatively ad hoc process.
- One way to motivate this process would be to show that the empirical fit of the model with switches in the updating mechanism generate a higher marginal likelihood of the model compared to systematic LS or Constant gain learning. But this information is not provided ? Why not ? Are LS and constant gain learning special cases of the estimated model ?
- Alternatively, the process could be motivated by the quality of the two updating mechanisms in terms of forecasting performance: agents select the updating mechanism that generates the best forecasts over the recent history. Such an approach is followed for instance in Branch and Evans (2006).

The optimal reaction of the gain to forecast errors

- Finally, it is not clear to me whether it is optimal to switch towards a higher gain if there is a structural break in the underlying volatility, in contrast with a break in the structural relations. Does optimal filtering indeed suggest a higher gain in case of an increase in the underlying volatility ?
- Therefore, instead of formulating the selection criterium in terms of the relative mean absolute forecast error, one could detect structural breaks also by evaluating the systematic component in the forecast error. If the autocorrelation in the forecast errors exceeds some threshold, this would probably be stronger evidence of breaks in the underlying structural relations, for which the standard response is a switch to a higher gain in the learning process. Such an approach would perhaps better describe the actual updating practice of forecasters.

Concluding

- The paper does a nice job in illustrating the potentially important role of learning to explain the great moderation.
- By making the gain parameter, and therefore the role of learning, endogenous, the paper provides a simple framework to study the interaction between the volatility generated by the learning dynamics and the systematic behaviour of monetary policy.
- An interesting extensions would be to introduce time-variation in the model to motivate the constant gain learning. Switching the learning mechanism is a more natural behaviour in such a context. What is the relative contribution of the changes in the fundamental volatility versus the volatility generated by the learning ?