On the Epidemiological Microfoundations of Sticky Information.[*]

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Abstract

The sticky information setup assumes that information disseminates slowly throughout the population, inducing interesting dynamics in macroeconomic models. Carroll (2003) estimates an epidemiological model of expectations, providing a microfoundation for the sticky information model of Mankiw and Reis (2002). We show that this microfoundation is rather weak. Firstly, it is hard to argue that professional forecasters formed expectations rationally. Second, if we estimate an equation where expectations of households are updated towards rational expectations then the results differ dramatically. Third, by examining the time series of the median household forecaster we manage to invalidate the epidemiological microfoundation of sticky information models.

JEL *classification*: D84, E31

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1 Introduction

Macroeconomics has recently started to pose alternatives to Rational Expectations (henceforth, RE). Estrella and Fuhrer (2002) show that a general class of macroeconomic models exhibit inconsistencies under RE. Some departures from RE that enhance the fit of macroeconomic models have been proposed. This paper will focus on the departures from traditional RE proposed in Mankiw and Reis (2002) (henceforth MR) and Carroll (2003, 2004) (henceforth, Carroll). MR

suggested a sticky information approach, where households form expectations rationally but only revise them periodically. MR and Reis (2004) justify such an approach on the grounds that it is costly to obtain and process information. Carroll argues that a more appealing microfoundation of sticky information is related to the slow dissemination of information. The author argues that households' expectations are derived from news reports, which in turn reflect the views of professional forecasters. The author compares the dissemination of information to the dissemination of a disease considered in epidemiological studies. Carroll finds that households only occasionally pay attention to the expectations of professional forecasters, and this inattention generates stickyness in aggregate expectations. Both in Carroll and MR this result is presented as a microfoundation to the sticky information model. Moreover, MR calibrate the *information absorption* parameter using the estimates of Carroll. Their model is sensitive to the calibration of this specific parameter.

MR assume that when agents revise expectations they do it rationally. Carroll assumes that households revise expectations towards the reported expectations of the Survey of Professional Forecasters (henceforth, SPF), which as he claims may be rational. We show, however, that it is hard to argue that professional forecasters form expectations rationally.[1] This observation breaks the link between Carroll and MR setup. It is possible to check Carroll's results assuming that households revise expectations towards RE instead of the SPF mean. Carroll argues that if one would do so it is unlikely that his results would change. Roberts (1998) had already provided an empirical framework where households are assumed to update their expectations towards RE. We reexamine Roberts (1998) work and we provide further empirical evidence. We find that Carroll's results change dramatically. This evidence allows us to affirm that Carroll's results are hardly related to the MR setup.

Finally, one could still say that the epidemiological approach of Carroll is an important finding in itself. It is interesting to know that households' expectations move towards the expectations of professional forecasters. In fact, Carroll argues that his main finding is exactly that households expectations follow the SPF. However, we examine the households' median forecast and find a basic and severe inconsistency with the epidemiological approach. Overall, our results are quite discomforting for Carroll and the link that Carroll and MR draw between their approaches. We caution the reader that our results are significantly less discomforting for the MR sticky information setup. MR framework can be motivated under a different microfoundation and has been estimated with different techniques.[2]

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[1]The observation that the SPF and other surveys are not rational led many researchers to question the validity of these surveys.

[2]For a microfoundation of sticky information appealing to costs to obtain and process information see Reis (2004). For an estimation of sticky information models see Khan and Zhenhua

The paper is organized as follows: section 2 analyzes the rationality of professional forecasters, section 3 estimates the model when households update towards RE, section 4 shows that the epidemiological view of expectations is hard to reconcile with the data, section 5 concludes.

2 Is the SPF inflation forecast rational?

Carroll and MR do connect their frameworks and MR use Carroll's estimates in their calibration. As we described in the introduction, if the expectations reported in the SPF are not rational then Carroll and MR frameworks are not directly related.

The Survey Research Center at the University of Michigan conducts a monthly survey intended to be representative of the USA population. Carroll uses the mean inflation forecast of inflation for the next year as a proxy for households' expectations. The Federal Reserve Bank of Philadelphia conducts a quarterly survey targeted at professional forecasters. Carroll uses the mean inflation expectations of the SPF for the next year as a proxy for RE or newspaper forecasts. The mean Michigan and mean SPF forecast are shown in figure 1. Figure 2 shows the SPF forecast and core inflation and figure 3 shows the SPF forecast and CPI inflation. The Mean Square Error of the mean and median forecasts are computed in table 1.[3] The mean forecast is usually used to assess the overall forecasters' opinion, however the mean is sensitive to outliers that may report bad forecasts for several reasons. Some authors argue that the median forecast is more accurate since it is less sensitive to outliers. The first column considers the forecast error relative to core inflation and the second column considers CPI inflation. While core inflation may relate more directly to the foreseeable component of inflation, the CPI inflation may reflect more accurately households relevant measure of inflation. For core inflation the SPF mean performs the best but for CPI inflation the Michigan median has the lowest mean squared error. Overall, table 1 suggest that the relative forecast accuracy of the two surveys depends on the measure of inflation considered.

Table 1

	MSE	
	CORE	CPI
SPF MEAN	0.56	1.49
SPF MEDIAN	0.57	1.55
MIC MEAN	1.09	2.19
MIC MEDIAN	0.63	0.87

(2002).

[3]We used as closely as possible the original data of Carroll available at http://www.econ.jhu.edu/people/carroll. We are grateful to Cristopher Carroll for making his data and codes publicly available.

Quarterly Data From 1981:03 To 2000:02

Even if the SPF would undoubtedly forecast better than the Michigan it would not imply that the SPF inflation forecast is rational. Carroll brings evidence from Croushore (1998) to argue that the SPF is indeed rational. However, in addition to arguments that Carroll invokes, Croushore (1998) also argues that it is possible to improve inflation forecasts and that the forecasts do not pass all tests of rationality. Adam and Padula (2003) and Nunes (2006) also analyze the SPF forecast concluding that the forecasts are not entirely rational. In any case, neither Croushore nor Adam and Padula used the same measure of inflation forecast as that used by Carroll. While Carroll considers the inflation forecast, the previous authors consider the GDP deflator forecast.

Since previous work did not examine the SPF inflation forecast rationality we will proceed with such examination. We will apply two basic tests of rationality to the SPF inflation forecast for the sample period considered by Carroll. If the SPF mean inflation forecast is rational then the average prediction error should be zero. The average prediction error relative to core inflation is -0.271. The null that this value is zero has a p-value of 0.001. The average prediction error relative to CPI inflation is -1.075. The null that this value is zero has a p-value of 0.000. This first test does not suggest that the SPF forecast is rational in the sense that MR employ.
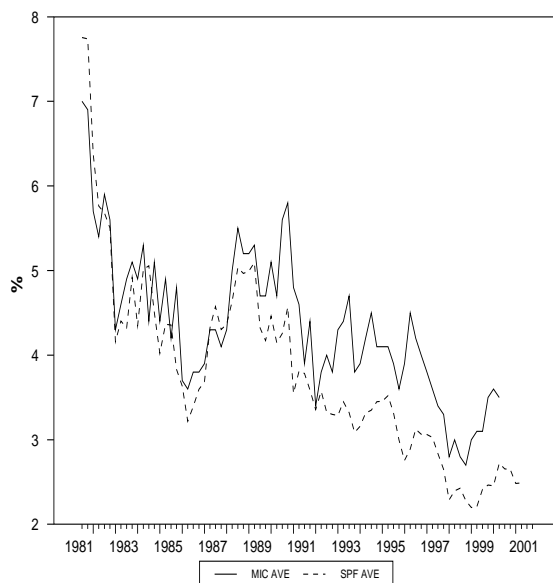

Figure 1:

Another basic test that a rational forecast must pass is an unbiasedness test. This test is computed by regressing actual inflation rates on a constant and on

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Figure 2:

expected inflation rates. If the constant is equal to zero and the coefficient on the expectation term equals one then we accept unbiasedness. For core inflation we obtain[4]

$$\pi_{t,t+4} = 0.770 + 0.730 S_t \pi_{t,t+4} \tag{1}$$
$$(0.488) \quad (0.133)$$

where $\pi_{t,t+4}$ is inflation in the following four quarters and $S_t[\pi_{t,t+4}]$ is the SPF forecast for $\pi_{t,t+4}$. For CPI inflation we obtain

$$\pi_{t,t+4} = 1.385 + 0.489 S_t \pi_{t,t+4} \tag{2}$$
$$(0.548) \quad (0.143)$$

The significance level of the bias test for the first regression is 0.043 and 0 for the second one. So we soundly reject no bias. Even if a forecast passes the previous tests, we would still have to check if all information is used efficiently efficient. Since it hardly arguable that the SPF is rational we do not provide such analysis here. Adam and Padula (2003) provide such analysis and conclude that not all information is used efficiently. It has been argued in the literature that in

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[4]The values in parentheses are asymptotic Newey-West 4 lags standard errors. Considering further lags in the Newey-West correction does not change the results.

Figure 3:

the presence of partial information the previous tests could falsely reject rationality. Nevertheless, MR or Carroll do not assume partial information environments. For further details see Andolfatto and Moran (2005)

2.1 Should we consider Rational Expectations?

Carroll claims to have found a microfoundation of the sticky information model of MR. Since MR assume that when households update expectations they form RE, the previous section shows that there is a big gap between both approaches. Based on the results of Roberts (1998), Carroll argues that if one would assume that households' expectations move towards rational expectations the results do not change. However, this conjecture does not hold, Branch (2004) in a heterogeneous expectations framework obtains quite different results if he replaces VAR generated expectations by RE.

As a first step let's review Carroll's results presented in table 2. The first row estimates the equation

$$M_t[\pi_{t,t+4}] = \alpha_0 + \alpha_1 S_t[\pi_{t,t+4}] + \alpha_2 M_{t-1}[\pi_{t-1,t+3}] + \nu_t, \qquad (3)$$

where $S_t[\pi_{t,t+4}]$ and $M_t[\pi_{t,t+4}]$ are the SPF and Michigan mean forecast respectively. The results are not extremely encouraging. We can not accept that the model does not have a constant and neither can we accept that $\alpha_1 + \alpha_2 = 1$. Despite these evidence, Carroll imposes these restrictions. He finds that $\alpha_1 = 0.27$

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as can be seen in table 2. If we allow for the presence of lagged inflation we estimate

$$M_t[\pi_{t,t+4}] = \alpha_0 + \alpha_1 S_t[\pi_{t,t+4}] + \alpha_2 M_{t-1}[\pi_{t-1,t+3}] + \alpha_3 P_t[\pi_{t-5,t-1}] + \nu_t, \quad (4)$$

where $P_t[\pi_{t-5,t-1}]$ represents the most recently published annual inflation rate as of time t. Again table 2 shows that the results are not better. We reject that the constant is zero and that $\alpha_1 + \alpha_2 + \alpha_3 = 1$. If we impose these restrictions the results are still disappointing, since the implied α_3 is negative.[5] In spite of the obvious limitations of these estimations both Carroll and MR argue that the the second estimation in table 2 provides evidence in favor of sticky information. MR calibrate the *information absorption* parameter with the value of $\alpha_1 = 0.25$, which is statistically equal to 0.27.

We will now estimate an equation where households' expectations move towards the rational expectations, which is the assumption that MR employ. We will estimate

$$M_t[\pi_{t,t+4}] = \alpha_0 + \alpha_1 E_t[\pi_{t,t+4}] + \alpha_2 M_{t-1}[\pi_{t-1,t+3}] + \nu_t \quad (5)$$

where $E_t[\pi_{t,t+4}]$ is the RE term. The previous equation can not be estimated with OLS and we have to employ GMM instead. [6] We are considering CPI inflation, the results do not change if we consider core inflation. The hypothesis that the constant is zero and the weights sum to 1 is rejected. The J-test shows that the instruments are valid. Proceeding as Carroll and imposing the restrictions we now find that $\alpha_1 = 0.097$, a value dramatically below 0.27. This result is hardly surprising, looking at figure 2 or 3 we see that the SPF overpredicts inflation, while both variables are decreasing. Therefore, it must be that if households move towards RE they must do it slower than towards the SPF. Table 3 also shows that including lagged inflation does not help. Our results show that there is a considerable difference between considering that households move towards the SPF forecast or the RE as considered in MR. We find that the rationality content of surveys is much lower than that shown by Roberts.[9] We conjecture that Roberts results are simply not robust to different orthogonalizations and must be taken with caution.

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[5]Note that if one just uses OLS the specification where $P_t[\pi_{t-5,t-1}]$ may be preferable. The reason is that if both households and professional forecasters use lagged inflation to form expectations equation 3 has an endogeneity problem while equation 4 does not.

[6]We use a four lag Newey-West covariance matrix, the results are robust to the inclusion of additional lags. We used different sets of instruments to check for robustness.[7] The instruments used in the computations of table 3 include two lags of the Michigan Survey forecast and four lags of quarterly unemployment and federal funds interest rate. We are not considering current period variables to allow for publication and information delays as is standard to assume in the literature.[8]

[9]For the Michigan survey Roberts estimate α_1 to be 0.61 using two different sets of instruments for the sample 1966:2-1995:4. Roberts (1998) uses a different orthogonalization but nevertheless his results are quite different from 0.25.

Table 2

	α_0	α_1	α_2	α_3	$\bar{R}^2$	P-value	P-value
(1)	1.219	0.510	0.263		0.838	$\alpha1+\alpha2=1$	$\alpha1+\alpha2=1,\alpha0=0$
	(0.204)	(0.078)	(0.094)			0.000	0.000
(2)		0.273			0.76		
		(0.066)					
(3)	1.259	0.504	0.249	0.013	0.837	$\alpha1+\alpha2+\alpha3=1$	$\alpha1+\alpha2+\alpha3=1,\alpha0=0$
	(0.268)	(0.083)	(0.112)	(0.054)		0.000	0.000
(4)		0.439	0.719	-0.157	0.789		
		(0.079)	(0.062)	(0.047)			

Table 3

	α_0	α_1	α_2	α_3	J-test	P-value	P-value
(1)	0.548	0.197	0.713		0.368	$\alpha1+\alpha2=1$	$\alpha1+\alpha2=1,\alpha0=0$
	(0.170)	(0.095)	(0.070)			0.074	0.001
(2)		0.097			0.338		
		(0.027)					
(3)	0.464	0.179	0.766	-0.025	0.404	$\alpha1+\alpha2+\alpha3=1$	$\alpha1+\alpha2+\alpha3=1,\alpha0=0$
	(0.314)	(0.097)	(0.125)	(0.065)		0.275	0.263
(4)		0.151	0.975	-0.126	0.723		
		(0.029)	(0.031)	(0.033)			

3 Do households' expectations follow Professional Forecasters' expectations?

This section shows that the epidemiological view seems to be flawed altogether. Carroll's estimations only use the mean forecasts because his model is only valid for the mean. Nevertheless, one can examine the time series behaviour of the median to check the model's consistency. The epidemiological approach says that a proportion (α_1) of households update their expectations towards the SPF mean. By examining figure 1 we can understand the results of Carroll's estimations. In the first half of the sample, households and SPF forecasts move quite closely. In the second half of the subsample, the SPF forecast moves down and the households forecasts move down with some delay. It is therefore not surprising that Carroll finds that the Michigan mean follows the SPF mean. Figure 4 plots the Michigan median forecast and the SPF mean forecast. Figure 4 is quite surprising. It does seem strange that while the Michigan mean is above the SPF mean, the Michigan median is below. Given Carroll's story, it appears odd that the SPF mean follows the Michigan median.

In addition, we also observe some basic inconsistencies in figure 4. We observe, quite frequently, in this sample that the Michigan median is falling, given that the Michigan median is below the SPF mean. If Carroll's model were true this behaviour should not happen. According to Carroll, nearly 25 per cent of

households update their beliefs towards the SPF mean; given a distribution for the Michigan forecasts, if the SPF mean is higher than the Michigan median, then it can not be that the Michigan median falls. We observe that in figure 4 this inconsistency arises quite often.[10] A symmetric inconsistency emerges at the end of the sample as the Michigan median rises while it is above the SPF mean. Another more subtle inconsistency also arises in this sample. The Michigan median increases/decreases towards the SPF mean but it becomes higher/lower than the SPF mean (we denote this fact as inconsistency 2). In order to spot more easily the inconsistencies mentioned, Figure 5 plots the Michigan median and the next period SPF mean forecast. In the bottom of the graph, we plot two series labelled *inconsistency 1* and *inconsistency 2*, when these series are 1 it means that an inconsistency is present and when they are 0 there is no inconsistency. The first inconsistency arises in 48,75% of the data (80 data points) and the second arises 10%, overall 58,75% of the data is against the epidemiological model of Carroll.

4 Conclusion

The sticky information framework has been shown to improve the implications of macroeconomic models. Carroll presents an epidemiological microfoundation for sticky information models. We find that such microfoundation is flawed. We first bring evidence to the fact that the SPF inflation mean forecast is biased and, therefore, can not be rational in the usual sense. We also estimated an equation where households' expectations move towards the RE as MR argue. We find that the results differ dramatically from those of Carroll. In addition, by inspecting the households' median forecast and the SPF mean forecast we manage to invalidate the epidemiological microfoundation of sticky information models.

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[10]One can still argue, that households update expectations towards a distribution of forecasts of the SPF. In this case, it is not impossible to see falling median while the SPF average is higher since some forecasts of the SPF may be lower than the Michigan median. Our response to this reasoning, is that it is not impossible but it is extremely unlikely to observe that this phenomena is observed so often in the data.
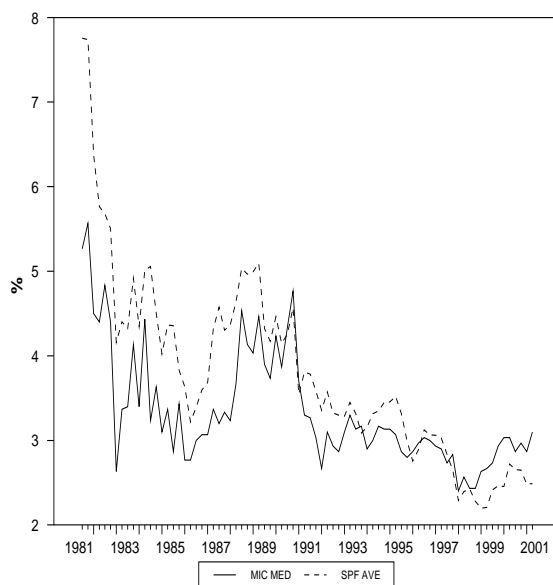
Figure 4:

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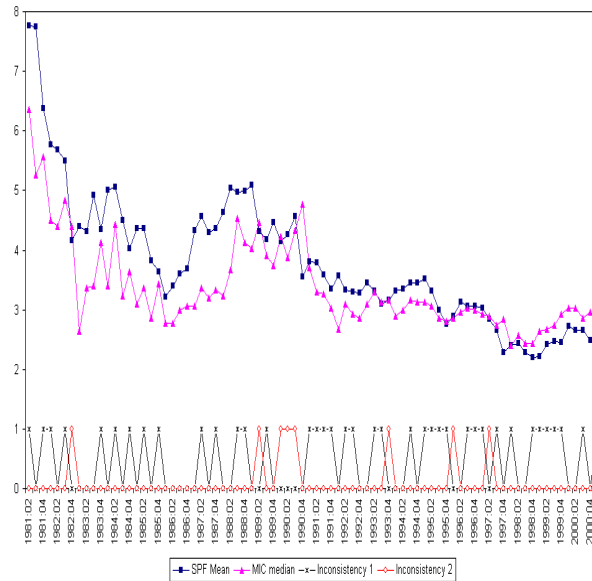
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