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Comments on:

"Michelson-Morley, Fisher and Occam: The Radical Implications of Stable Quiet Inflation at the Zero Bound"

by John Cochrane, NBER Macroeconomics Annual 2017*

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1 Introduction

This is an unusual paper to discuss in a few ways (and I mean this as a compliment) because it leaves my job as a discussant with unusual tasks to perform. Typically, discussants suggest that the authors apply their model to some related question to assess how relevant are the points being made, or they argue that the authors should relax some assumptions to understand the generality of the conclusions, or they point to different data or empirical tests of the validity of the findings. As a result, discussant's suggestions, if followed, would lead to longer papers. This paper is so unusually long however, more than twice as long as the papers published in the recent past in this publication, that taking on the usual discussant role would do everyone a disservice. The partial derivative of the social welfare function with respect to length here is probably negative.

Moreover, usually discussants take advantage of the fact that fewer people read the discussion than the actual paper to risk being provocative and less guarded than the author. This paper is also unusual in this regard because it makes many bold claims that, purposely or not, try to ruffle feathers and provoke counter-arguments. Trying to add more fuel to the fire in my discussion would again probably move us away from the social optimum. The role of this discussion will be instead to be more guarded and tell the reader to seriously consider, but not outright embrace, the stark conclusions that Cochrane reaches.

Because of these two features, this discussion will first try to subtract rather than add to the topics on the table. Because the paper tries to provide an exhaustive and comprehensive review of the theory behind inflation control, it makes many arguments that were already made elsewhere. Much of sections 2 and 5 are spent discussing theoretical points about price-level determinacy when central banks set interest rates. There are by now many useful summaries of this literature, from Woodford (2003) to Cochrane (2011). Throughout the paper, and especially in sections 2 and 6, there is a spirited defense of the fiscal theory of the price level, with arguments similar to those in Sims (2013) and many others. The discussion of how quantitative easing had no impact on inflation because reserves are special provides a compressed version of the points in Reis (2016), and the discussion of the VAR evidence on the effect of monetary shocks summarizes points in Ramey (2017). Finally, the conclusion that including currency in the utility function both has little quantitative effects for realistic parameter values, and is not a promising way to understand monetary non-neutralities, was already in Woodford (2003) or Reis (2007). All of these are useful and important points in the literature, and I understand why the author would like to include them in order to provide readers from outside this literature with a full discussion of all the issues. For those who have seen the topics above before, or who have trouble digesting more than what is in a regular-length paper, then my suggestion is to read sections 1, 2.1, 3, 4, and 8.

Given this, admittedly narrow, perspective on the content of this paper, this discussion is split into three points organized around sections. First, I discuss the empirical puzzle on inflation that this paper starts from, and the author's answer to it. I will argue that his approach has virtues and promise beyond the application in this paper. Second, I reexamine a central point that the author tries to make: that the response of inflation to interest rates shows a depp problem in current standard macroeconomic models. This paper opened my mind to some issues, but I am left not convinced that there is such a deep flaw that must be fixed. My reading of the match between theory and facts is more mixed. Third and finally, I will argue against the rhetorical approach of this paper of interpreting the recent evidence as either "Michelson-Morley" or "Occam" moments that discredit some theories and support others.

2 Inflation 2010-16

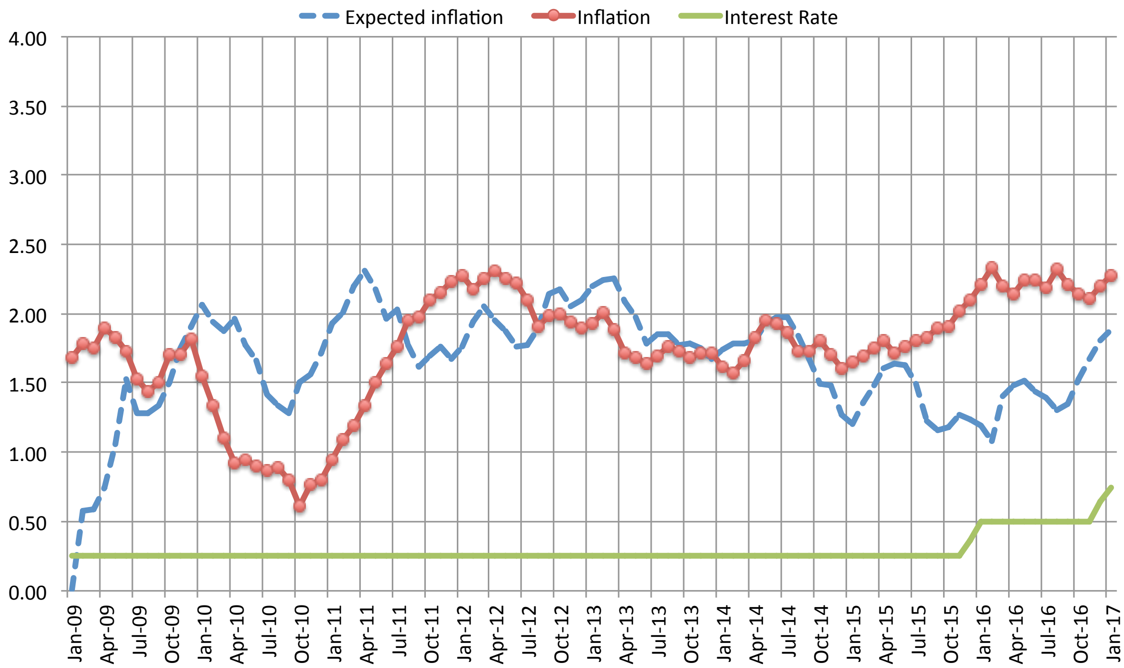
Miles et al. (2017) provide a comprehensive review of the developments on inflation across the world so far in the XXIst century. Figure 1 plots the data series for 2010-16 U.S. inflation (the percentage annual change in the core CPI), expected inflation (the 5-year breakeven from indexed Treasuries) and the nominal interest rate (the interest on excess reserves). For the purposes of this paper, five facts are worth highlighting:

1. Nominal interest rates were held by the central bank at a constant level.
2. Expected inflation was quite stable.
3. Forward guidance was heavily used through announcements about future nominal interest rates.
4. Inflation has no clear trend nor any apparent permanent shocks.
5. The variance of inflation has been small.

Why are these five facts interesting from a perspective of monetary theory? The Fisher equation states that:

$$i_t = r_t + \mathbb{E}_t(\pi_{t+1})$$

Figure 1: Annual U.S. inflation (%) at monthly frequency 2009-17



where i_t is the nominal interest rate, r_t is the real interest rate, and π_t is the inflation rate. If the left-hand side is constant, then expected inflation should move around with shocks to the real interest rate. The period 2010-2016 has seen plenty of signs of changes in productivity, in financial conditions, and in marginal tax rates that should be expected to move real interest rates. There is even some evidence that real interest rates have trended down. That, in spite of these, expected inflation is so constant and inflation shows no trend is quite interesting.

Second, as emphasized by Miles et al. (2017), this was a time of unconventional, and in many cases, unprecedented monetary policies. Focusing solely on interest rates, central banks experimented with different types of forward guidance, different forms of communicating it, and different ways of implementation, all of which likely resulted in different interpretations by the public about the stance of monetary policy. Yet, in spite of all this experimenting, and the many errors that surely came with it, inflation was as stable as it had been in decades. From a practical perspective, one can tally this as a success for central bankers. From an academic perspective, it seems too good to be true, and raises questions instead about whether our theories of inflation are right.

This paper provides a novel explanation for this set of facts. Cochrane starts by assuming an approximately constant safe real interest rate equal to $-\log(\beta)$. As I noted above, this is perhaps not the best assumption for this period, but the main point that follows would remain unchanged, and it simplifies the exposition. It implies that the expected present value of fiscal surpluses, on the right-hand side of the next expression, is independent of monetary policy as long as fiscal surpluses (s_{t+j}) are likewise independent of monetary policy:

$$\frac{\sum_{j=0}^{\infty} Q_t^j B_{t-1}^j}{P_t} = \sum_{j=0}^{\infty} \beta^j \mathbb{E}_t(s_{t+j})$$

This is the government debt valuation equation. On the left is the market value of debt. It is the sum of the price at date t of a zero-coupon bond that pays off in j periods (Q_t^j) times the amount outstanding of this bond issued in past periods (B_{t-1}^j). Since these are nominal bonds, the sum must be divided by the price level P_t in order to express it in real units.

Changes in interest rates, which change the nominal yields given by the inverse of Q_t^j, must lead to no changes on the left-hand side since the right-hand side is fixed. But, since the bonds outstanding were set last period, it follows that unexpected changes in monetary policy lead to changes in the price level.

This equation provides a fiscal theory of the price level, but not in the traditional sense according to which exogenous changes in fiscal policy (s_t) affect the price level. Rather, here the focus is on changes in nominal interest rates and their effect on unexpected inflation, following the work of Cochrane (2001). To see this link, one can use the main proposition in Hilscher, Raviv and Reis (2014) to re-write:

$$\sum_{j=0}^{\infty} \beta^j \left(\frac{B_{t-1}^j}{P_t}\right) \hat{\mathbb{E}}_t \left(\frac{P_t}{P_{t+j}}\right) = \sum_{j=0}^{\infty} \beta^j \hat{\mathbb{E}}_t(s_{t+j}).$$

The new operator $\hat{\mathbb{E}}_t$, is the risk-neutral expectation, which tilts probabilities across states by their relative value as captured by a stochastic discount factor. The exogenous fiscal policy together with the pre-exiting debt obligations pin down the sum of the expected path for inflation, leaving changes in nominal interest rates to be reflected right away into different paths for actual inflation. This expression makes clear that this is true whether the changes are in current nominal interest rates or in future ones, as in forward guidance. When the news is realized about nominal interest rates in the present or the future, this has an impact on the value of the debt, which must be offset by changes in the path of inflation to keep the real value unchanged.

How does this theory account for the last decade? First, as the amount of outstanding debt is nowadays larger (so a larger B_t^j) then the effect of any change in interest rates is smaller on the price level. Second, the maturity of the U.S. public debt has changed significantly over the last few decades. With a shorter maturity of privately-held debt, then a shock to future interest rates will have a smaller impact on the current price level. This theory promises to explain the stability of inflation by the combination of higher and shorter public debt, together with shocks to future nominal interest rates.

To gauge the size of both of these effects requires a series for public debt at different maturities (B_t^j). Cochrane does very well in avoiding the use of the series that one can download from the Treasury website: as Hall and Sargent (2011) document they do not match the economic definition of B_t^j. However, the Hall-Sargent series is also not the right one to plug into these calculations, since it includes all publicly issued debt, whether it is privately or publicly held. Holdings of public debt by social security or local and state pension funds have to be netted out to match the government debt constraint. Moreover, the Federal Reserve during this time period bought a large amount of long-term government debt in exchange for short-term central bank reserves. While these quantitative easing operations do not reduce the total amount of government debt (reserves are a government debt), they dramatically reduce the maturity held by the public.

Figure 2 shows the actual public debt that is privately held, as constructed by Hilscher, Raviv and Reis (2014) and compares it to the Hall-Sargent series. The maturity of debt is considerably shorter as the combination of quantitative easing and the policy of debt issuance over the last 10 years gave significantly lowered the duration of the debt, as described and emphasized by Hilscher, Raviv and Reis (2014).

Figure 3 plots the impulse responses of inflation to a change in nominal interest rates announced three periods ahead of time in the models discussed in the paper, but using the different calibration for the debt. The top-left panel shows the result of a permanent increase in rates in the flexible price model, while the top-right panel simulates instead a new Keynesian sticky-price model. The bottom-left panel considers instead a 3-year increase in nominal interest rates, and the bottom-right panel shows the result of a positive impulse to the AR(1) process for nominal interest rates with serial correlation 0.7.

The effects of the changes in forward guidance about interest rates on inflation are significantly smaller with the right measure of debt. Therefore, the Cochrane explanation is even more credible. In short, perhaps the stability of inflation in response to forward-guidance interest-rate shocks has been due to the large and short maturity of the privately-held government debt.

A related point made in the paper is worth a detour. No matter what the model of the

Figure 2: U.S. public debt in 2015 by maturity

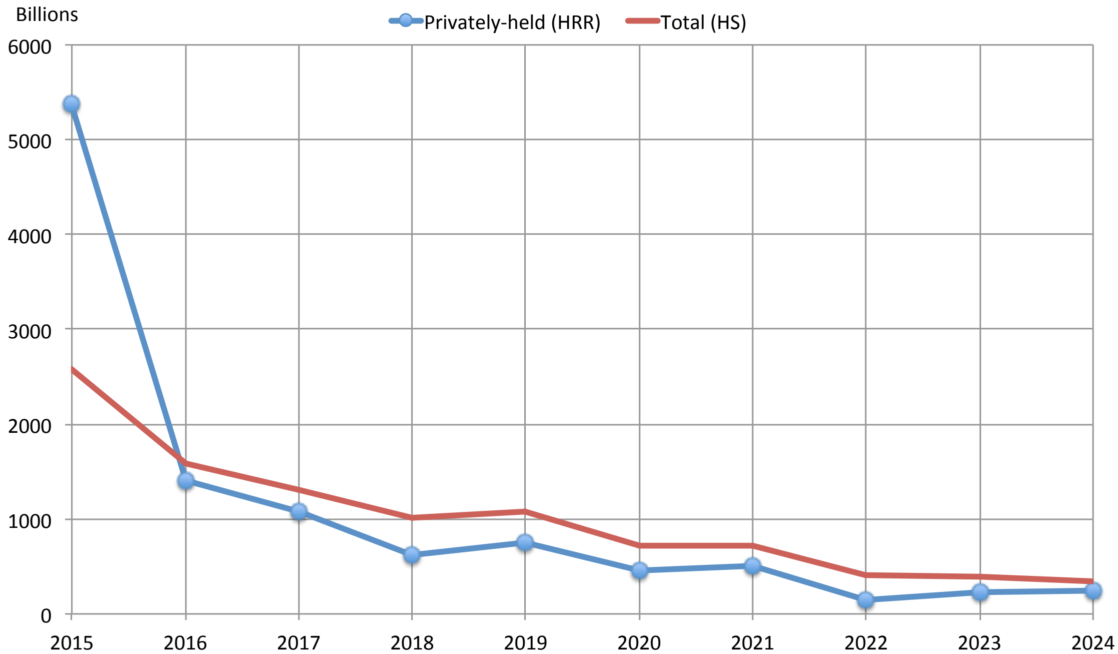
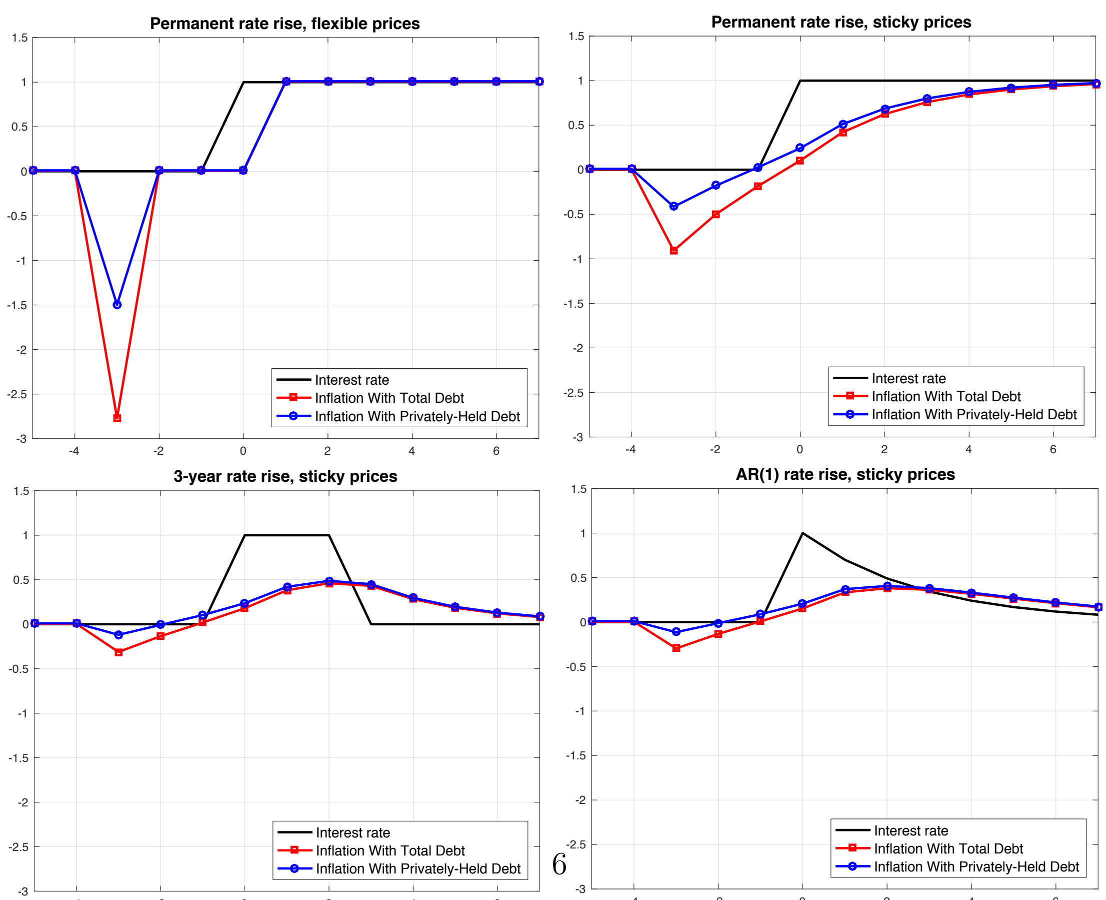


Figure 3: Impulse response of inflation to interest-rate shocks: the role of debt maturity



price level is, the government debt valuation equation will hold:

$$\frac{B_{t-1}}{P_t} = \sum_{j=0}^{\infty} \mathbb{E}_t \left[\frac{\beta^j u'(C_{t+j}) s_{t+j}}{u'(c_t)} \right]$$

This makes the very unrealistic assumption that all debt is of one-period maturity, while allowing for future fiscal surpluses to be discounted by the marginal utility of consumption. As section 9.5 of the paper shows, log-linearizing this around a point where surpluses and consumption are fixed, and letting x denote the log-deviation of consumption while $\Delta\,\mathbb{E}_t = \mathbb{E}_t - \mathbb{E}_{t-1}$, then:

$$\Delta s \approx -\Delta\,\mathbb{E}_t(\pi_t) + \frac{1-\beta}{\sigma} \sum_{j=0}^{\infty} \beta^j \Delta\,\mathbb{E}_t(x_{t+j} - x_t)$$

This equation does not get as much attention in the paper or in the literature as it deserves. It links the equivalent change in the fiscal surplus with the surprises to inflation and real interest rates. This equation must hold in any well specified monetary model with a government. Therefore, evaluating the right-hand side after a response to a monetary shock (or any other shock) will give the required change in fiscal surpluses that the government must undertake in order to validate this response in equilibrium. This fiscal index, has Cochrane calls it, can be a very useful object to understand how much fiscal accommodation is needed in monetary models. Moreover, one can potentially construct empirical estimates of each of these variables to shocks, to assess whether they are consistent with the government budget constraint. More generally, evaluating the impulse response of this fiscal index to monetary shocks is an unexplored research area that Cochrane insightfully highlights in section 3.4.4 of the paper.

3 The nominal interest rate puzzle

A large part of the paper is devoted to the claim that conventional models are unable to generate the result that higher nominal interest rates lower inflation. While it is true that sometimes higher interest rates do lead to higher inflation in simple new Keynesian models, this is far from a universal property of this class of models.

To see this, consider the simplest 3-equation New Keynesian model:

$$
\begin{aligned}
\pi_t &= \mathbb{E}_t\{\pi_{t+1}\} + \kappa y_t \\
y_t &= -\frac{1}{\sigma}(i_t - \mathbb{E}_t\{\pi_{t+1}\}) + \mathbb{E}_t\{y_{t+1}\} \\
i_t &= \phi_\pi \pi_t + v_t
\end{aligned}
$$

All variables are written as log-linear deviations from a steady state and stand for: π_t is inflation, y_t is output, and i_t is the nominal interest rate. There is a single shock v_t to interest rates. Finally, κ and σ are both positive parameters, while $\mathbb{E}_t$ is the rational-expectations operator.

Take the simplest possible version of this model, which can be solved with pencil and paper. That comes from assuming that v_t is iid. In that case, all expectations are zero in the fundamental solution of the linear expectational system of difference equations. Thus, it follows that inflation and interest rates are equal to:

$$
\begin{aligned}
\pi_t &= -\left(\frac{\kappa\sigma}{1+\kappa\sigma\phi}\right) v_t \\
i_t &= \left(\frac{1}{1+\kappa\sigma\phi}\right) v_t
\end{aligned}
$$

Clearly, a positive monetary policy shock raises nominal interest rates and lowers inflation. The intuition is simply that a positive shock leads to higher nominal interest rates, which raise real interest rates, lower current real activity, and so brings down inflation through the Phillips curve. The lower inflation leads to an offsetting falls in the nominal interest rate, but this is smaller than the initial increase, so this second round effect does not change the prediction that inflation falls and nominal interest rates rise. There is nothing puzzling here.

In the textbook model, the interest rate rule is instead:

$$
\begin{aligned}
i_t &= \rho + \phi_\pi \pi_t + \phi_y y_t + v_t \\
v_t &= \phi v_{t-1} + \xi_t
\end{aligned}
$$

It is true that with this rule and a persistent process for shocks, it is possible for a positive monetary policy shocks to lower inflation but also lower nominal interest rates. This happens because the lower inflation and recession both lower interest rates in the policy rule, see for instance Sims, Garin and Lester (2017). Cochrane emphasizes this, and shows that this is true for the paths of interest rates that he feeds into his model, as well as for the parameter values that he chooses. But this model is very standard, and has been calibrated numerous times always generating the conventional result. A standard reference (Gali, 2008) has no puzzle: a positive ξ_t shocks both raises nominal interest rates and lowers inflation.

These are textbook examples, but one may worry that perhaps the puzzle comes whenever the models are made more complicated by fitting the data. The canonical new Keynesian model of this category is the Smets and Wouters (2007). Figure 6 of that paper shows the response to a typical monetary policy shock. Inflation falls, and the nominal interest rates rises for the first 6 quarters, even if then it becomes slightly negative and converges back to steady date from below the horizontal axis. This is as conventional as it gets for the new Keynesian model, and Cochrane's puzzle is simply not there.

Part of the reason for this puzzling difference on the supposed puzzle comes because Cochrane focuses on what is closer to permanent changes in the inflation target. Now replace the interest rate rule with instead:

$$i_t = \rho + \pi^* + \phi_\pi(\pi_t - \pi^*) + \phi_y y_t$$

Now imagine that the inflation target π^* increases unexpectedly and permanently. In this case, the nominal interest rate rises, and so does inflation. This is not puzzling and, I think, is well understood by the economists who use these models. Announcing a permanently higher inflation target will both raise inflation and nominal interest rates. It makes quite a difference whether the reasons for higher nominal interest rates is a transitory shock (v_t) or a permanent increase in the target (π^*). These are the conventional cases considered, and there is not much to puzzle about.

Continuing the search for the puzzle, combine the joint assumption that interest rates are zero (or any constant) now and for the next T periods, together with the assumption that afterwards they will follow an interest-rate rule like the ones above. Here, yes, one gets the strange result that increasing T, which amounts to keeping interest rates lower for longer, will lead to lower inflation today. This is a reflection of the forward guidance puzzle of Del Negro, Giannoni and Patterson (2012): announcements of future policy at zero interest rates leads to several peculiar conclusions in the new Keynesian model. While this is certainly a problem for the sticky price model, there are already many solutions. One of the first was put forward by Carlstrom, Fuerst and Paustian (2015) who showed that replacing the assumption of sticky prices with sticky information, the forward guidance puzzle disappears. They show that while an announcement of raising interest rates in T periods leads to a positive response of inflation today with sticky prices, it leads to a fall in inflation with sticky information.

In sum, it is only if one considers the interaction of sticky prices with either persistent target-like changes in nominal interest rates, or announcements of future changes in interest rates starting from a peg, that the new Keynesian model leads to higher inflation with higher nominal rates. With regular transitory shocks and standard parameters this does not happen. With forward guidance and sticky information, it does not happen either.

4 Experiments and models on inflation

Cochrane makes strong conclusions from the results of his analysis. Right in the first page of the paper he writes that: “This is a Michelson-Morley moment for monetary policy. We observe a decisive experiment, in which previously hard-to-distinguish theories clearly predict large outcomes. That experiment yields a null result, which invalidates those theories.” In his view: “The observed inflation stability is thus a big feather in the new-Keynesian cap.” The concluding comments are that: “The observation that inflation has been stable or gently declining and quiet at the zero bound is important evidence against the classical view that an inflation is unstable at the zero bound, and by implication at an interest rate peg, and the new-Keynesian view that these lead to sunspot volatility.”

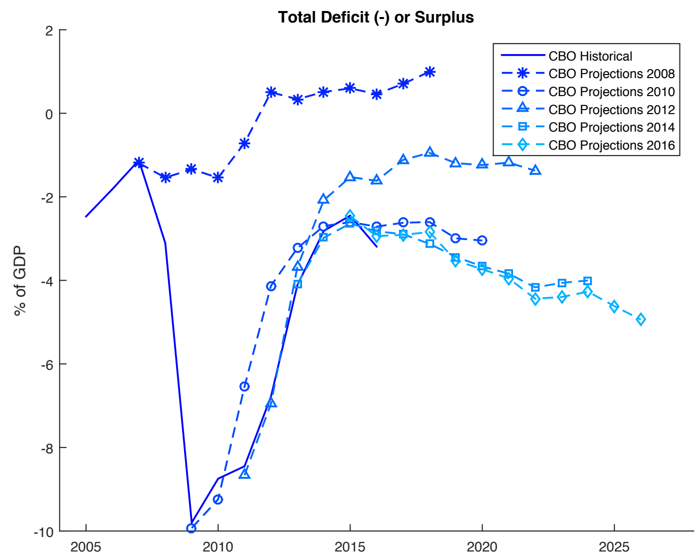
While the stability of inflation since 2010 is noteworthy and poses interesting challenges to our models of inflation, I do not agree that it is a Michelson-Morley moment. This is not a decisive experiment; rather, it is far from satisfying the requisites for being valid. An experiment requires not just a treatment (here zero interest rates) but also a control, a way to separate the treatment from the reason why it was implemented in the first place, and a way to control for confounding variables that may cause differences between treatment and control. In this case, there is no clear control (other countries, the United State before 2010?), the treatment clearly came in response to the financial crisis and the recession which surely have an independent direct effect on inflation, and there are many confounding variable as productivity, fiscal policy, and financial conditions all changed during 2010-26. Staring at the time series in figure 1 alone is not decisive in any direction.

Moreover, I also was not convinced by the appeals to Occam’s razor to rule out interest-rate rules and the new Keynesian model. Cochrane writes that: “You cannot truthfully explain, say, to an undergraduate or policy maker, that higher interest rates produce lower inflation because prices are sticky...” But, I just did so, at the start of section 3 of this discussion. Cochrane argues that “The qualifiers simple and economic are important.” for any explanation of the behavior of inflation since 2010. Like beauty, these features are in the eye of the beholder, but the model in Del Negro, Giannoni and Schorfheide (2015) is, to my eyes, not terribly complicated or uneconomic and it can fit reasonably well the behavior of inflation. Finally, Cochrane writes that “Now, any theory, especially in economics, invites rescue by epicycles.” acknowledging that there are ways to reverse puzzling predictions but criticizing them for coming after the fact. However, the ones he discusses in the paper all came *before* the fact, before the 2010-16 period. This paper together with Miles et al. (2017) are the first to emphasize the stability of inflation in this period. There are no theoretical epicycles, at least yet, because as far I know no one had the time between reading section 2 of this paper and getting to section 5 to perform such trickery.

Finally, in section 6, Cochrane concludes that the fiscal theory of the price level can account for this and other movements in inflation. I am certainly open to the possibility, and find the fiscal theory relevant to discuss the behavior of inflation. But looking at the last ten years, and at the U.S. inflation stability, I do not come out thinking this was a success for the fiscal theory. For starters, from 2008 to 2016, almost every annual number for the deficit came out below what the CBO expected, as seen in figure 4. This was a time of negative fiscal shocks, anda naive FTPL would predict rising, not stable inflation. Second, this was a time of higher fiscal uncertainty, as reflected in figure 5. Again a naive FTPL would say that higher uncertainty by rational agents would usually come with more volatile fiscal shocks, and this would lead to volatile inflation.

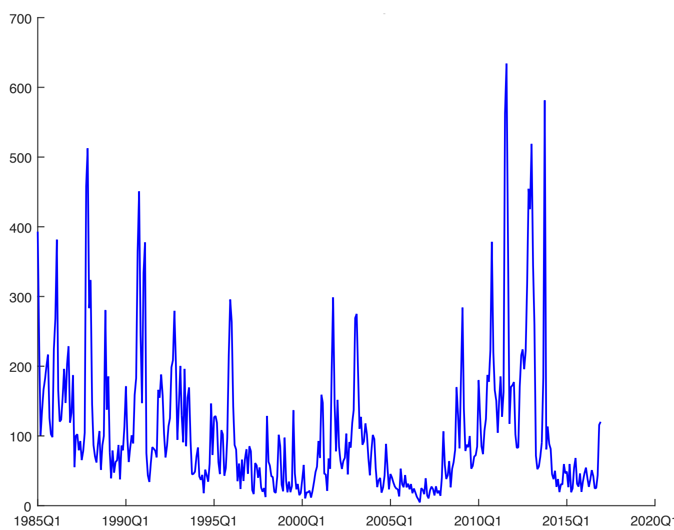
I have emphasized that these would be, at best, tests of a naive FTPL. As section 6 of this paper rightly notes, one can rebate them and, in my view, convincingly argue that they are consistent with the FTPL. It does not seem far fetched to me to argue that the unexpected deficits of the last few years came with improvements in expected future surpluses, or that there have been large changes in the real interest rates at which future surpluses are discounted helping to stabilize inflation. But, I can see how these explanations could be called epicycles, and some may want to reject the FTPL by applying to Michelson-Morley or Occam. If I raise these points in this discussion is to emphasize why, in my view, the episode of the last few years is not a Michelson-Morley or Occam moment for most theories of inflation, including interest feedback rules or the FTPL. Ultimately, this rhethorical approach does not lead me to strong conclusions.

Figure 4: CBO projections and actual fiscal supluses



Source: Congressional Budget Office, Historical data and 10-yrs Projections

Figure 5: Fiscal policy uncertainty Index



Source: EPU Index - Baker, Bloom and Davis (QJE, 2016)

5 Conclusion

Because inflation has been low and stable, it does not pose a problem. Thus, it has not drawn too much attention form commentators or policymakers. From the perspective of researchers though, this stability is surprising, interesting, and worthy of study. Given the shocks, policies, and other circumstances around it, this episode may well be as interesting as the high inflation of the late 1970s. Cochrane provides an important service in this paper in putting a bright light over the behavior of US inflation 2010-17.

Moreover, Cochrane puts forward a new explanation for this phenomenon that is both intriguing and promising. Privately-held U.S. public debt has both increased over the last 20 years, and has become much more concentrated at shorter maturities. These two facts imply that changes in future nominal interest rates now have a smaller impact on inflation because of the smaller debasement effect of inflation on the debt. This provides an intriguing explanation for why forward guidance shocks have had a moderate impact on inflation. Moreover, the suggestion to measure the fiscal impact of monetary policies deserves more attention from empirical researchers.

Too much of the paper though is spent arguing that conventional models of inflation are at odds with the data and that the fiscal theory of the price level is not. In my view, much more has to be put forward to convincingly show that there is indeed some puzzle in the relation between nominal interest rates and inflation, or to use the recent data to dismiss or confirm models in a sweeping way.

References

Carlstrom, Charles T., Timothy S. Fuerst, and Matthias Paustian. 2015. "Inflation and Output in New Keynesian Models with a Transient Interest Rate Peg." *Journal of Monetary Economics*, 76(C): 230–243.

Cochrane, John H. 2001. "Long-Term Debt and Optimal Policy in the Fiscal Theory of the Price Level." *Econometrica*, 69(1): 69–116.

Cochrane, John H. 2011. "Determinacy and Identification with Taylor Rules." *Journal of Political Economy*, 119(3): 565–615.

Del Negro, Marco, Marc Giannoni, and Christina Patterson. 2012. "The Forward Guidance Puzzle." *FRB New York Staff Paper 574*.

Del Negro, Marco, Marc P. Giannoni, and Frank Schorfheide. 2015. "Inflation in the Great Recession and New Keynesian Models." *American Economic Journal: Macroeconomics*, 7(1): 168–196.

Gali, Jordi. 2008. *Monetary Policy, Inflation, and the Business Cycle.* Cambridge, USA:MIT Press.

Hall, George J., and Thomas J. Sargent. 2011. "Interest Rate Risk and Other Determinants of Post-WWII US Government Debt/GDP Dynamics." *American Economic Journal: Macroeconomics*, 3(3): 192–214.

Hilscher, Jens, Alon Raviv, and Ricardo Reis. 2014. "Inflating Away the Public Debt? An Empirical Assessment." *NBER Working Paper 20339*.

Miles, David, Ugo Panizza, Ricardo Reis, and Angel Ubide. 2017. "And Yet it Moves. Inflation and the Great Recession: Good Luck or Good Policies?" *Geneva Reports on the World Economy 19*, IMCB and CEPR.

Ramey, Valerie A. 2017. "Macroeconomic Shocks and Their Propagation." In *Handbook of Macroeconomics.* , ed. John Taylor and Harald Uhlig, 71–162. Elsevier.

Reis, Ricardo. 2007. "The Analytics of Monetary Non-Neutrality in the Sidrauski Model." *Economics Letters*, 94(1): 129–135.

Reis, Ricardo. 2016. "Funding Quantitative Easing to Target Inflation." In *Designing Resilient Monetary Policy Frameworks for the Future.* Jackson Hole Symposium:Federal Reserve Bank of Kansas City.

Sims, Christopher A. 2013. "Paper Money." *American Economics Review Papers and Proceedings*, 103(3): 563–584.

Sims, Eric, Julio Garin, and Rob Lester. 2017. "Raise Rates to Raise Inflation? Neo-Fisherianism in the New Keynesian Model." *Journal of Money Credit and Banking*, forthcoming: forthcoming.

Smets, Frank, and Rafael Wouters. 2007. "Shocks and Frictions in U.S. Business Cycles: A Bayesian DSGE Approach." *American Economic Review*, 97(3): 586–606.

Woodford, Michael. 2003. *Interest and Prices.* Princeton, New Jersey:Princeton University Press.