Has Fed Policy Mattered for Inflation? Evidence from a Structural Monetary Model

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Evidence from a Structural Monetary Model

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Introduction

Following the severe bout of post-Covid inflation, a renewed debate around Fed policy and its efficacy has emerged. While several critics have long questioned (and should continue to question) the need for a central bank that actively manages the economy,[2] a more fundamental question remains unanswered: *can* the Fed manage inflation, even if U.S. citizens agree that it should?

A CMFA working paper from May 2023 (henceforth "CMFA VAR study") utilized a structural monetary VAR and suggests that the Fed has a minimal effect on inflation. Most of the inflation over all future horizons and across sectors is determined primarily by supply shocks with monetary policy usually accounting for around 5% of inflation. At its peak – during the post-financial crisis period and only looking at longer term horizons – monetary policy accounts for roughly 10% of inflation. In short, the VAR evidence did not suggest that the Fed has much ability to manipulate inflation.

It is important to note that VARs are useful but ultimately simple tools to analyze macroeconomic relationships. Like with most empirical techniques, they come with their own set of pros and cons.[3] In this manner, the simplicity of VARs is both pro and con. One benefit of this approach is that VAR coefficients are unrestricted since they are purely estimated from data and do not rely on any background micro-based model. As such, many academics use the VAR as the "true" model by which the economy operates and judge the success or failure of their fully specified model by how closely it matches the results from a VAR. Indeed, several empirical macroeconomists estimate the parameters from their structural models by a technique known as "impulse response matching": In this method, the parameters of the structural model are set to match the business cycle predicted by a VAR.[4]

However, the simplicity of the VARs does not allow for a detailed analysis of policy. A researcher must simply accept parameter estimates as a description of the data – there is no way to understand *why* a parameter is estimated to be a specific number. Given the simple nature of the variable relationships, even under structural identification methods such as those used in the CMFA VAR study, the link between economic theory and coefficients is weak. An additional concern, noted in the CMFA VAR study itself, is that it is impossible to

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[2] See Selgin, Lastrapes, and White (2012) for a full academic critique of the Fed's historical policymaking.

[3] See Stock and Watson (2001) for a detailed explanation of the benefits or limitations as applied to macroeconomic analysis.

[4] See Chapter 9 of the *Handbook of Macroeconomics* written by J. Fernandez-Villaverde, et. al., for more details on IRF matching.

disentangle the sources of demand and supply shocks since the VAR specification only includes 3 equations with corresponding exogenous error terms. It is understood that the output equation contains the demand shock, the inflation equation the supply shock, and the interest rate equation the monetary policy surprise, but no further breakdown is possible. This shortcoming makes it difficult to tell, for example, whether the supply shock comes from the labor market or the goods market? Such questions cannot be answered using the VAR method.

To address these (and other) concerns, empirical macroeconomists usually rely on estimating a fully specified dynamic stochastic general equilibrium (DSGE) model with Bayesian methods. This paper uses this method to further investigate the Fed's inability to significantly control inflation. Smets and Wouters (2007) – considered to be a true benchmark model for the U.S. economy with nearly 7,000 citations – is chosen to fit U.S. macro data. Quarterly macro time series data from 1960 to 2019 is collected from the FRED database on 7 key U.S. economic indicators – output, consumption, investment, labor hours, wages, inflation, and interest rates. The analysis is conducted for the full data sample as well as time periods between significant structural breaks such as the pre-Volcker era, the post-Volcker Great Moderation era, and the post-financial crisis zero lower bound era.

The results corroborate all the key findings from the CMFA VAR study. A forecast error variance decomposition of inflation into its constituent shocks once again shows that supply factors dominate at all horizons from immediate quarters to long-term outcomes. The source of the variation shifts from supply shocks in the goods market to labor supply shocks as the horizon increases. For the full period, monetary policy accounts for almost none of the variation in inflation with its effect increasing at longer horizons but never exceeding 5%. The maximum effect of monetary policy is in the ZLB period but it only reaches around 10% at the 100-quarter horizon. In fact, monetary policy accounts for a much larger share of output – determining over 20% of its variation in the ZLB period – suggesting that the Fed would cause larger recessions even as its fight to bring down inflation would have only minimal effects. Finally, a breakdown of historic inflation in the U.S. into its constituent shocks from 1960 to 2019 largely corroborates the accepted accounts of modern U.S. history. However, this breakdown shows that monetary policy has had a minimal effect. Despite the Fed getting much of the credit from the public, supply factors largely dominate the story of inflation.

1. Model

For simplicity, the full derivation of the Smets and Wouters (2007) (henceforth "SW2007") model is omitted from this article. Only the summarized equilibrium equations for the model are presented below so that the relations between key macro variables are clear. For full details on the derivation of the model or the exact parameter meanings and specifications, please refer directly to SW2007 and its extensive appendices.

The model structurally relates the following 14 macro variables presented as log deviations from their respective steady states: output (y_t), consumption (c_t), investment (i_t), capital utilization (z_t), labor hours supplied (l_t), interest rate (r_t), inflation (π_t), value of capital stock (q_t), rental rate of capital (r_t^k), capital services (k_t^s), aggregate capital stock (k_t), price markup (μ_t^p), wages (w_t), and the wage markup (μ_t^w). Additionally, the economy is subject to 7 per-period disturbances: exogenous spending (ε_t^g), risk-premium (ε_t^b), investment-specific technology (ε_t^i), productivity (ε_t^a), price markup (ε_t^p), wage markup (ε_t^w), and monetary policy (ε_t^r).

The equilibrium equations of the model are as follows:

Aggregate resource constraint:

$$y_t = c_y c_t + i_y i_t + z_y z_t + \varepsilon_t^g \qquad (1)$$

Consumption Euler equation:

$$c_t = c_1 c_{t-1} + (1 - c_1)\mathbb{E}_t c_{t+1} + c_2(l_t - \mathbb{E}_t l_{t+1}) - c_3\left(r_t - \mathbb{E}_t \pi_{t+1} + \varepsilon_t^b\right) \qquad (2)$$

Investment Euler equation:

$$i_t = i_1 i_{t-1} + (1 - i_1)\mathbb{E}_t i_{t+1} + i_2 q_t + \varepsilon_t^i \qquad (3)$$

Arbitrage equation for value of capital:

$$q_t = q_1 \mathbb{E}_t q_{t+1} + (1 - q_1)\mathbb{E}_t r_{t+1}^k - \left(r_t - \mathbb{E}_t \pi_{t+1} + \varepsilon_t^b\right) \qquad (4)$$

Aggregate production function:

$$y_t = \Phi(\alpha k_t^s + (1 - \alpha) l_t + \varepsilon_t^a) \qquad (5)$$

Evolution of capital services:

$$k_t^s = k_{t-1} + z_t \qquad (6)$$

Degree of capital utilization:

$$z_t = z_1 r_t^k \qquad (7)$$

Capital accumulation:

$$k_t = k_1 k_{t-1} + (1 - k_1) i_t + k_2 \varepsilon_t^i \qquad (8)$$

Goods market price markup:

$$\mu_t^p = \alpha(k_t^s - l_t) + \varepsilon_t^a - w_t \qquad (9)$$

New-Keynesian Phillips curve:

$$\pi_t = \pi_1 \pi_{t-1} + \pi_2 \mathbb{E}_t \pi_{t+1} - \pi_3 \mu_t^p + \varepsilon_t^p \qquad (10)$$

Rental rate of capital:

$$r_t^k = -(k_t - l_t) + w_t \qquad (11)$$

Labor market wage markup:

$$\mu_t^w = w_t - \left(\sigma_l l_t + \frac{1}{1 - \lambda/\gamma}\left(c_t - {}^{\lambda}\!/_{\gamma}\, c_{t-1}\right)\right) \qquad (12)$$

Wage relation:

$$w_t = w_1 w_{t-1} + (1 - w_1)(\mathbb{E}_t w_{t+1} + \mathbb{E}_t \pi_{t+1}) - w_2 \pi_t + w_3 \pi_{t-1} - w_4 \mu_t^w + \varepsilon_t^w \qquad (13)$$

Taylor rule[5]:

$$r_t = \rho r_{t-1} + (1 - \rho)\begin{bmatrix} r_\pi \pi_t \\ + r_y\left(y_t - y_t^p\right) \end{bmatrix} + r_{\Delta y}\begin{bmatrix} \left(y_t - y_t^p\right) \\ -\left(y_{t-1} - y_{t-1}^p\right) \end{bmatrix} + \varepsilon_t^r \qquad (14)$$

The evolution of the disturbances is also taken directly from SW2007. Again, a detailed explanation of these equations is beyond the purview of this paper and can be found by reading SW2007. All disturbances have corresponding per-period i.i.d. shocks

[5] This generalized Taylor rule responds to inflation and output deviations from potential (y_t^p). In the context of this model, potential output is the output that would have been achieved in an alternate economy that had flexible prices instead of sticky prices.

(η_t). The processes for the 7 model disturbances are presented below:

Exogenous spending:

$$\varepsilon_t^g = \rho_g \varepsilon_{t-1}^g + \eta_t^g + \rho_{ga}\eta_t^a \tag{15}$$

Risk-premium:

$$\varepsilon_t^b = \rho_b \varepsilon_{t-1}^b + \eta_t^b \tag{16}$$

Investment-specific technology:

$$\varepsilon_t^i = \rho_i \varepsilon_{t-1}^i + \eta_t^i \tag{17}$$

Productivity:

$$\varepsilon_t^a = \rho_a \varepsilon_{t-1}^a + \eta_t^a \tag{18}$$

Price markup:

$$\varepsilon_t^p = \rho_p \varepsilon_{t-1}^p + \eta_t^p - \mu_p \eta_{t-1}^p \tag{19}$$

Wage markup:

$$\varepsilon_t^w = \rho_w \varepsilon_{t-1}^w + \eta_t^w - \mu_w \eta_{t-1}^w \tag{20}$$

Monetary policy:

$$\varepsilon_t^r = \rho_r \varepsilon_{t-1}^r + \eta_t^r \tag{21}$$

2. Data and Methodology

The estimation process requires as many data series as there are exogenous shocks in the model. In the case of SW2007, there are 7 exogenous shocks so 7 macro time series are chosen to estimate model parameters – real GDP, real consumption, real investment, real wages, log hours worked, log difference of the core PCE price index (PCE inflation)[6], and the federal funds rate. Like the CMFA VAR study, data is collected quarterly from Q1 1960 through Q4 2019, stopping just before the onset of the Covid-19 pandemic. To analyze the varying effects of policy in differing U.S. macro regimes, the model is estimated for 4 differing time periods as follows:

Era Label	*Date Range*
Full Period	Q1 1960 to Q4 2019
Pre-Volcker	Q1 1960 to Q4 1983
Post-Volcker	Q1 1984 to Q4 2007
ZLB Regime	Q1 2008 to Q4 2019

Table 1: Data Periods for DSGE Analysis

Macro time series data are collected from the FRED database. For the ZLB Regime period, the federal funds rate is replaced by the Wu and Xia (2016) shadow rate to accurately account for the stance of monetary policy when the nominal rate is stuck at the zero lower bound. The measurement equation for the estimation is as follows:

$$Y_t = \begin{bmatrix} dlRGDP_t \\ dlRCONS_t \\ dlRINV_t \\ dlRWAGE_t \\ lHOURS_t \\ dlPCE_t \\ FFR_t \end{bmatrix} = \begin{bmatrix} \gamma \\ \gamma \\ \gamma \\ \gamma \\ \bar{l} \\ \bar{\pi} \\ \bar{r} \end{bmatrix} + \begin{bmatrix} y_t - y_{t-1} \\ c_t - c_{t-1} \\ i_t - i_{t-1} \\ w_t - w_{t-1} \\ l_t \\ \pi_t \\ r_t \end{bmatrix} \tag{22}$$

where dl and l represent 100 times the log difference and the log value respectively, γ is the common economy-wide trend growth rate, $\bar{l}$ is the steady-state hours of labor supplied (normalized to zero), $\bar{\pi}$ is the steady

[6] SW2007 follows standard academic procedure and computes inflation as the log difference of the quarterly GDP deflator series. This is a rare instance where this paper deviates from SW2007 by choosing the core PCE index as the measure for the price level. Since the goal of this paper is to measure how effective the Fed has been in controlling prices, it is better to look at the Fed's preferred price level measure – core PCE (Yellen, 2015).

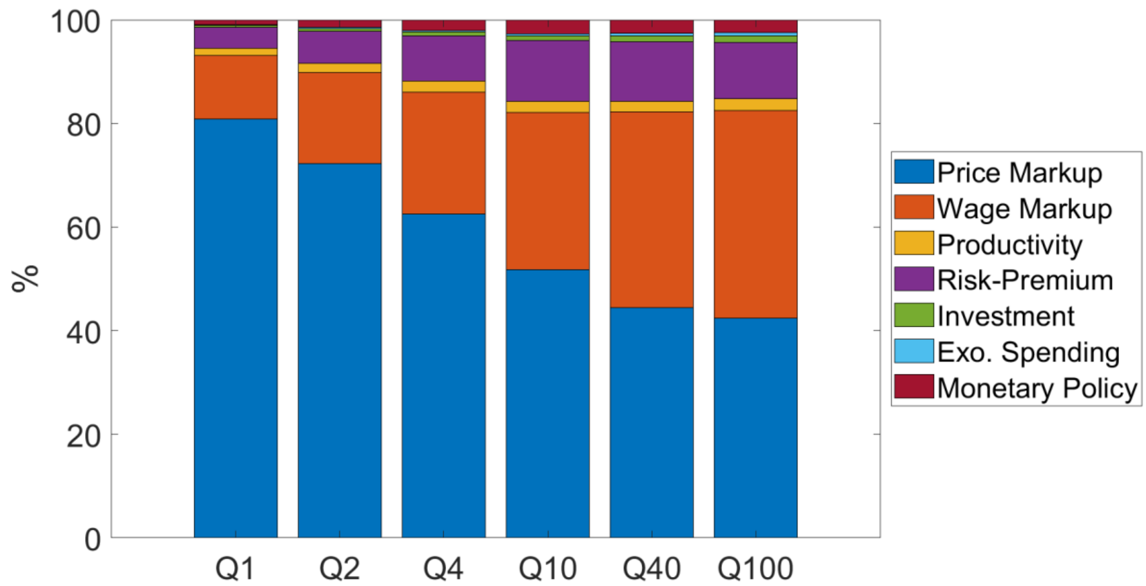

Figure 1: FEVD of Core PCE Inflation, Full Period (Q1 1960 to Q4 2019)

state quarterly rate of inflation, and $\bar{r}$ is the steady state quarterly nominal interest rate.

The models are estimated for the various time periods listed in Table 1 using a standard Bayesian Markov chain Monte Carlo algorithm[7] with a single chain of 500,000 draws and a 40% burn-in. All priors for the analysis are identical to SW2007. The posterior distributions – including means, modes, and 90% credible intervals – for all structural parameters, shock processes, and data periods, are reported in the Appendix of this paper. A detailed discussion of the parameter estimates is omitted here since the primary focus is on the contribution of monetary policy to inflation.

Similar to SW2007, forecast error variance decompositions (FEVD) at horizons of 1, 2, 4, 10, 40, and 100 quarters ahead are used to analyze the contribution of various structural shocks to model variables like π_t and y_t. Additionally, again in a similar manner to SW2007, the historical breakdown of inflation into its constituent shocks is also computed for the Full Period. Both the FEVDs and historical shock decomposition are computed at the estimated posterior means for each data period, as shown in the Appendix.

3. Results

3.1 Forecast error variance decompositions

As discussed in SW2007 as well as the CMFA VAR study, a FEVD shows what the "main driving forces" are for any of the macro variables in the model. While the CMFA VAR study could only disaggregate variables into demand, supply, and monetary policy shocks, this paper can further disaggregate the sources of variation. Demand shocks, defined as shocks that make

[7] See An and Schorfheide (2007), Fernandez-Villaverde (2010), and Herbst and Schorfheide (2015) for an overview of Bayesian MCMC estimation methods pertaining to DSGE models.

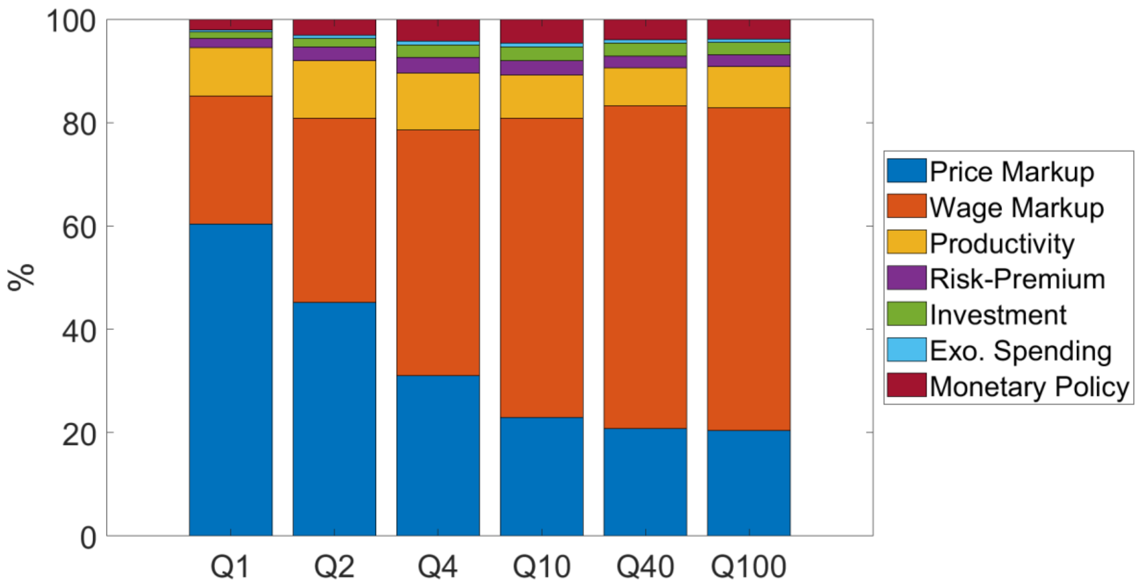

Figure 2: FEVD of Core PCE Inflation, Pre-Volcker Period (Q1 1960 to Q4 1983)

output and inflation fluctuate in the same direction, can be further decomposed into risk-premium, investment, and exogenous spending. Supply shocks, defined as shocks that make output and inflation fluctuate in opposite directions, may be decomposed into price markup (goods supply), wage markup (labor supply), and productivity.

Figure 1 shows the FEVD of inflation into its constituent shocks for the Full Period at various forecast horizons. The graph corroborates the findings from the CMFA VAR study – most inflation is driven by supply factors at all horizons. Supply factors determine around 90% of inflation in the short run (1-qtr, 2-qtr, and 1-yr) and around 84% in the long run (>1-yr). Over all periods demand factors are second in importance (ranging between 5% and 13%); demand increases in importance as the horizon stretches to the long run. Monetary policy never exceeds 2% in the short run and contributes only between 2% and 3% to inflation in the long run.

Within the supply side, price markup shocks in the goods market via exogenous changes in firms' bargaining power are the primary determinant of inflation.[8] As the horizon increases, price markups reduce in importance and are replaced by wage markups – exogenous shocks to workers' bargaining power. Productivity does not play a significant role in determining inflation. Within the demand side, only risk-premium shocks affect inflation suggesting that changes in consumers' preferences and attitudes toward risk are the primary demand determinant of price fluctuations.

[8] Note that this does not lend support to the "greedflation" theory – the notion that greedy corporations are to blame for inflation. Firms cannot arbitrarily raise prices without consideration for market conditions. These shocks are exogenous and firms as well as the rest of the economic agents are simply responding to them. For more on why "greedflation" does not serve as an economic explanation of inflation please refer to Kedia (2023c).

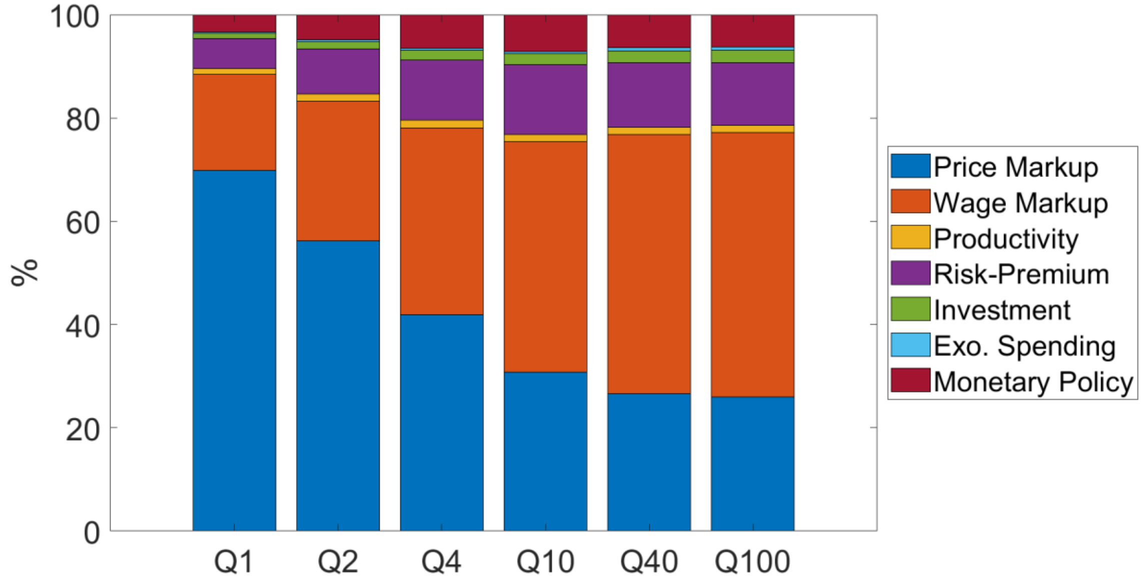

Figure 3: FEVD of Core PCE Inflation, Post-Volcker Period (Q1 1984 to Q4 2007)

It is interesting to note that these results largely corroborate the FEVD from SW2007 itself – despite the use of a significantly extended dataset. SW2007 only uses data ranging from Q1 1966 to Q4 2004; consequently, their results do not capture the effects of monetary policy interactions during and after the financial crisis. This analysis uses data ranging from Q1 1960 to Q4 2019. Despite this inclusion, monetary policy still plays only a minor role. SW2007 finds monetary policy contributes less than 5% across horizons to inflation. They also find that supply factors predominantly drive inflation with price and labor markups accounting for over 90% in the short run to around 85% in the long run, with price markups ceding importance to wage markups as the horizon increases. This analysis corroborates all these findings from SW2007.

A concern with using the full dataset for analysis is that such an estimation procedure is not robust to structural breaks in the economy. The key structural break in the 1980s was the nomination of Paul Volcker to Fed chairmanship – ushering in the era of "active" monetary policy (see Clarida, Gali, and Gertler, 2000). SW2007 also tests for robustness by comparing parameter estimates between the pre- and post-Volcker eras (but do not compare FEVDs between these eras). However, their analysis only extends through 2004. Since then, following the Great Recession, the U.S. economy arguably encountered another structural break with interest rates entering a zero lower bound regime.[9]

Figure 2 shows the FEVD of core PCE inflation during the pre-Volcker period. The broad results are still the same – supply

[9] As Kedia (2023b) shows, Fed policymaking in this period is drastically different compared with the pre-financial crisis periods. This era is characterized by increased Fed discretion and a departure from rules-based governance.

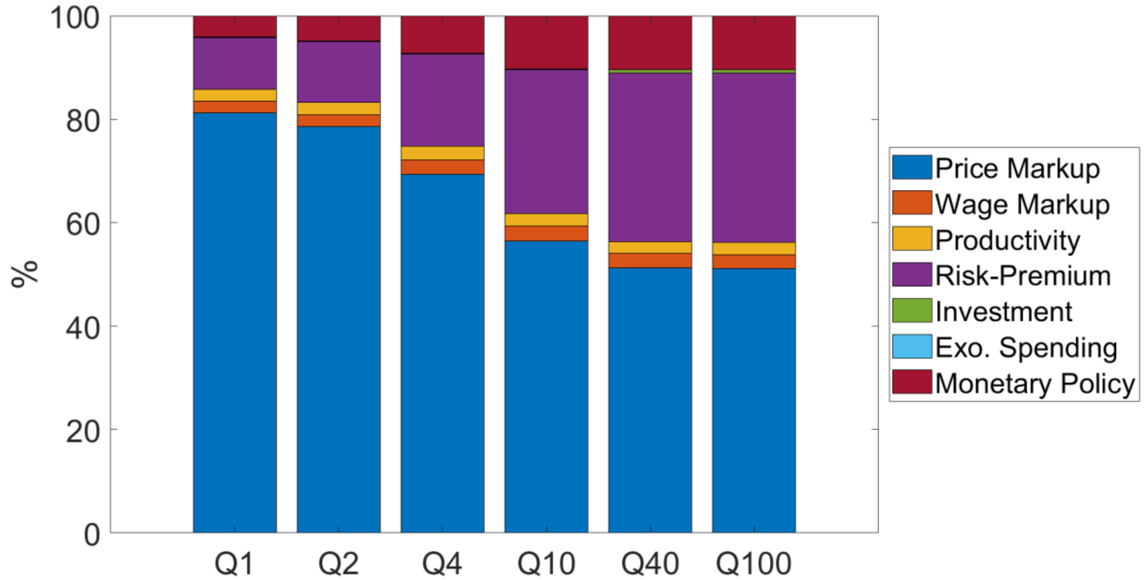

Figure 4: FEVD of Core PCE Inflation, ZLB Regime Period (Q1 2008 to Q4 2019)

factors dominate while demand and monetary policy play minor roles. Supply shocks account for even more inflation in this period with their FEVD share being close to or above 90% across all horizons. Demand is second in importance and is between 5 to 6% at long term horizons. Monetary policy plays the smallest role – only exceeding 4% at the Q4 and Q10 horizons.

Interesting differences only arise within the breakdown of supply factors. While price markups are still the primary driver in the short-run and cede importance to wage markups, this effect is much stronger in the pre-Volcker period. Given that the 1970s are particularly noted for having very tight labor markets and inflated wages it is unsurprising to see their outsized effect on inflation. Over 60% of inflation is driven by the labor market at longer horizons. In contrast to all other periods, productivity also plays a sizable role in the pre-Volcker era and fluctuates between 8 to 10% depending on the horizon. Given that the 1970s is known to be a decade of low TFP growth (Shackleton, 2013), this result again confirms lessons from economic history.

Figure 3 shows the same FEVD of inflation but for the post-Volcker period. The results look broadly similar to the Full Period except that monetary policy plays a larger role – but is still significantly behind supply and demand factors in driving inflation. Supply factors again dominate but fall in importance from around 90% at Q1 to around 78% at Q40 and Q100. Demand factors – almost entirely through preference shocks that affect the risk-premium – are also important. Aggregate demand shocks contribute between 7 to 10% in the short run but contribute around 14-16% in the long run. Monetary policy plays its largest role yet but never exceeds 10%. It contributes 3.4% at Q1, peaks at 7% at Q10 and settles at around 6% at the longest horizons.

The ZLB period offers the sharpest contrast to the prior results – both demand and monetary policy increase in importance

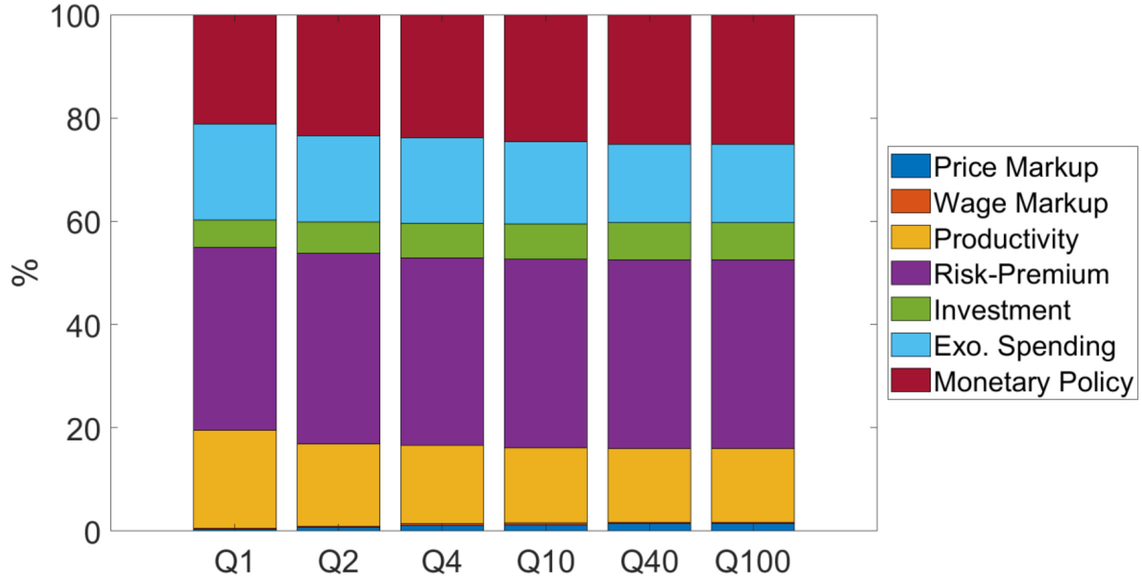

Figure 5: FEVD of Real GDP Growth, ZLB Regime Period (Q1 2008 to Q4 2019)

but the Fed is still dwarfed by the other determinants. Figure 4 shows the FEVD of inflation for this period. It is immediately clear that supply factors – while still the primary determinant of inflation – are a significantly reduced driver of inflation in this period. They account for 86% of inflation in the short run but only 56% in the long run. The source of supply shocks is also significantly altered. Only price markups play a role with productivity and wage markups only totaling around 5% of inflation variation at all horizons.

However, the reduction in the importance of supply is mostly accounted for by the increased importance of demand, not monetary policy. Demand (again exclusively in the form of risk-premium shocks) now drives 10-11% of short-term inflation and increases to 33% at long run horizons of Q40 and Q100. While wage markups usually take over importance from price markups in the long run, in the ZLB period risk-premium shocks play the same role as wage markups in the other periods. Monetary policy, while more important than before, still only accounts for 4-5% of short run inflation and just marginally over 10% of long run inflation.

As part of its dual mandate, the Fed is also responsible for stabilizing output (or its economic equivalent – employment). The empirical results suggest that it is unsuccessful at that too in comparison to demand shocks but has a greater effect on output than on inflation. Figure 5 shows the FEVD decomposition of real output growth into its constituent shocks for the ZLB period – the era during which monetary policy has the largest effect on the economy. As the figure indicates, the Fed plays a much larger role in output than inflation. Contributions from all shocks remain stable at all horizons. Supply shocks are now the least important, contributing only around 16% to output growth at most quarters primarily through productivity shocks. Demand shocks are the largest determinant of output growth with a close to 60% share. Risk-premium, exogenous spending, and investment shocks all play a role and their contributions to output are ranked in that order. Monetary policy accounts for over 20% of output growth – 25% at long term horizons.

These results suggest that monetary policy is far more effective at causing output fluctuations than inflation. This is important to note as in its fight against inflation, the Fed seems to exert much more control over the GDP than prices. Consequently, to dramatically reduce inflation – as it is presently trying to do – the Fed is more likely to negatively affect output (and thereby employment) than bring inflation back to its target.

3.2 Historical shock decomposition

The FEVDs presented above are forward looking – they explain how forecast errors going into the future are affected by the various shocks. A similar exercise with a different interpretation is to look at the history of inflation and decompose it into its constituent shocks. Such an analysis is conducted here. The model assumes inflation to be at its steady state (say 2% annualized); the fact that it is never at this state is due to a combination of shocks affecting inflation in any given period. This "historical shock decomposition," presented in Figure 6, allows a researcher to measure which shocks have historically been important in determining the actual values of inflation.

As the figure shows, monetary policy plays a minor role in the history of inflation just as it plays a minor role in its forecast errors. The only period where monetary policy has a sustained contribution is the early-1980s when the Fed, under the chairmanship of newly elected Paul Volcker, undertook a severe rate hiking campaign to bring inflation down to its steady state. There are a few interspersed periods of monetary policy effects, but they are neither large nor sustained. As with the FEVDs, the story of inflation is primarily told through supply shocks – especially goods market price markups and labor market wage markups as well as productivity to a smaller extent.

The figure accurately captures several facets of modern U.S. economic history. The 1970s, categorized by drastic supply shocks that led to stagflation, are likewise a period where inflation is very high (almost 10% higher than trend at its peak). Most of this inflation is driven by price markups reflecting things like oil price shocks which were known to be high in this era. The 1970s was also marked by an exogenous increase in workers' bargaining power – causing a sudden but unsustainable increase in real wages. These two supply factors combined to cause the highest recorded inflation in this data sample.

Another interesting observation is from the post-financial crisis period. While the SW2007 model does not explicitly include a financial sector, it does model private investment. Both private investment (through capital stock prices) and private consumption are affected by risk-premium shocks that reflect changes in consumers' preferences and attitudes toward risk (see equations 2 and 4). As SW2007 states, these shocks are similar to "net worth" shocks that are usually included in financial frictions models such as Bernanke, Gertler, and Gilchrist (1999)'s financial accelerator framework. It is likely that this shock was an important contributor to economic fluctuations during and after the Great Recession owing to the tumult in the financial sector which would affect investments and thereby macro aggregates such as GDP and inflation. The historical decomposition shows exactly this result. Risk-premium shocks, which had until this point been relatively unimportant, now become a significant contributor to inflation (in this case exerting a downward effect). The effect of these shocks is even stronger than price markups and similar in magnitude to labor supply factors.

In summary, the analysis documents the following key results: (a) the SW2007 offers a robust framework to study macro aggregates and leads to realistic historical interpretations of the U.S. economy, (b) monetary policy plays a minor role in determining inflation with most effects occurring at long run horizons and primarily during the ZLB period, (c) the vast majority of inflation is driven by supply factors – especially price and wage markups, (d) similar results hold when looking *back* at the history of U.S. inflation – supply not monetary policy primarily determines inflation.

Conclusion

This paper analyzes the main factors that drive inflation in the U.S. To this end, it utilizes a benchmark medium-scale model that is commonly used for such analyses, the Smets and Wouters (2007) framework. This model is fit to 7 quarterly U.S. macro time series: output, consumption, investment, wages, labor hours, inflation, and interest rates for 4 time periods – a full period from 1960 to 2019 as well as sub-periods that capture various structural breaks in the economy. The fitted model parameters are then used to compute forecast error variance decompositions to capture the drivers of inflation. Goods and labor supply factors are the primary determinants of inflation. Monetary policy is the least important driver – almost always behind supply and often behind demand. A historical breakdown of inflation into its constituent shocks paints a realistic picture of modern U.S. economic history. The 1970s are characterized by massive supply disruptions and the period during and after the financial crisis by risk-premium shocks. The historical view is like the variance decomposition – monetary policy plays a minor role. It is clear from this analysis that the outsized role the Fed plays in public perception as well as in the media's coverage of inflation is unwarranted.

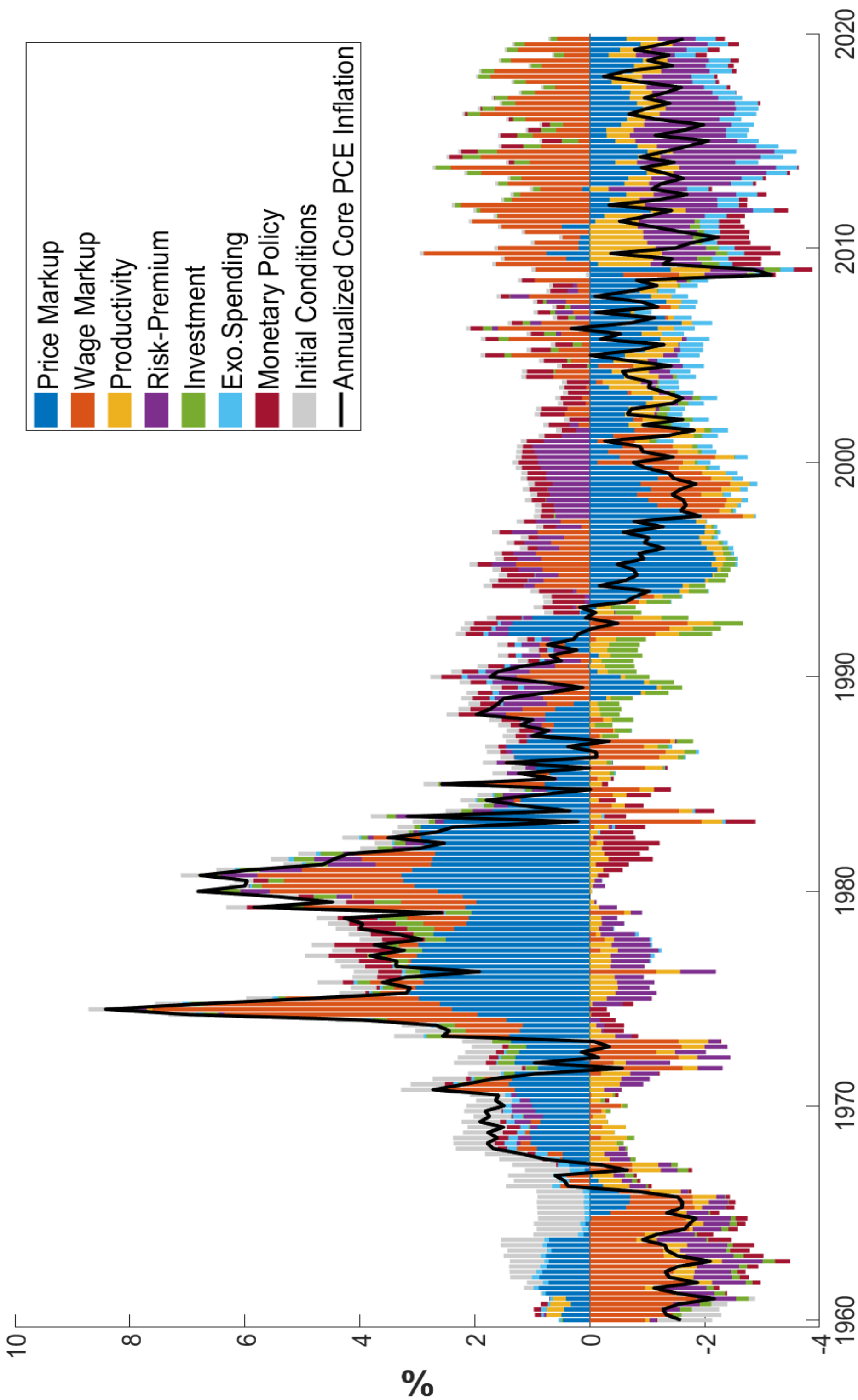

Figure 6: Historical Shock Decomposition of Core PCE Inflation, Q1 1960 to Q4 2019

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Appendix

Table A1: Posterior Distribution of Model Parameters, Full Period

	Prior			Posterior			
	Distribution	**Mean**	**Std. Dev.**	**Mode**	**Mean**	**10%**	**90%**
φ	Normal	4	1.5	4.6415	5.0922	3.2210	6.9173
σ_c	Normal	1.5	0.375	1.4405	1.4024	1.1431	1.6682
h	Beta	0.7	0.1	0.5082	0.5317	0.4447	0.6170
ξ_w	Beta	0.5	0.1	0.8321	0.8130	0.7484	0.8799
σ_l	Normal	2	0.75	2.1040	2.0881	1.2622	2.9174
ξ_p	Beta	0.5	0.1	0.8103	0.8039	0.7474	0.8597
ι_w	Beta	0.5	0.15	0.5853	0.5610	0.3470	0.7804
ι_p	Beta	0.5	0.15	0.2386	0.2596	0.1102	0.4006
ψ	Beta	0.5	0.15	0.7377	0.7357	0.6042	0.8725
Φ	Normal	1.25	0.125	1.5125	1.5255	1.4056	1.6437
r_π	Normal	1.5	0.25	1.9715	2.0077	1.7671	2.2668
ρ	Beta	0.75	0.1	0.8335	0.8323	0.7986	0.8689
r_y	Normal	0.125	0.05	0.1020	0.1025	0.0691	0.1343
$r_{\Delta y}$	Normal	0.125	0.05	0.2213	0.2250	0.1839	0.2650
$\bar{\pi}$	Gamma	0.625	0.1	0.6875	0.7122	0.5598	0.8608
$100(\beta^{-1}-1)$	Gamma	0.25	0.1	0.1198	0.1414	0.0544	0.2232
$\bar{l}$	Normal	0	2	1.2684	1.0990	-0.3989	2.6439
$\bar{\gamma}$	Normal	0.4	0.1	0.3497	0.3411	0.2920	0.6630
α	Normal	0.3	0.05	0.1892	0.1905	0.1650	0.2160
σ_a	$Gamma^{-1}$	0.1	2	0.4796	0.4829	0.4414	0.5243
σ_b	$Gamma^{-1}$	0.1	2	0.0861	0.0910	0.0737	0.1076
σ_g	$Gamma^{-1}$	0.1	2	0.4634	0.4680	0.4313	0.5034
σ_i	$Gamma^{-1}$	0.1	2	0.3315	0.3357	0.2811	0.3862
σ_r	$Gamma^{-1}$	0.1	2	0.2113	0.2162	0.1961	0.2348
σ_p	$Gamma^{-1}$	0.1	2	0.0844	0.0843	0.0668	0.1013
σ_w	$Gamma^{-1}$	0.1	2	0.3594	0.3570	0.3231	0.3909
ρ_a	Beta	0.5	0.2	0.9867	0.9871	0.9789	0.9956
ρ_b	Beta	0.5	0.2	0.8753	0.8628	0.8126	0.9170
ρ_g	Beta	0.5	0.2	0.9803	0.9773	0.9638	0.9911
ρ_i	Beta	0.5	0.2	0.8032	0.8004	0.7051	0.8973
ρ_r	Beta	0.5	0.2	0.1651	0.1879	0.0873	0.2817
ρ_p	Beta	0.5	0.2	0.9408	0.9295	0.8874	0.9762
ρ_w	Beta	0.5	0.2	0.9779	0.9646	0.9345	0.9950
μ_p	Beta	0.5	0.2	0.8223	0.7887	0.6774	0.9024
μ_w	Beta	0.5	0.2	0.9648	0.9417	0.9002	0.9807
ρ_{ga}	Beta	0.5	0.2	0.5603	0.5617	0.4554	0.6630

Table A2: Posterior Distribution of Model Parameters, Pre-Volcker Period

	Prior			**Posterior**			
	Distribution	**Mean**	**Std. Dev.**	**Mode**	**Mean**	**10%**	**90%**
φ	Normal	4	1.5	4.1765	4.4953	3.0373	5.9067
σ_c	Normal	1.5	0.375	1.3570	1.4000	1.1138	1.6756
h	Beta	0.7	0.1	0.7125	0.6997	0.6090	0.7972
ξ_w	Beta	0.5	0.1	0.7307	0.7113	0.6317	0.7946
σ_l	Normal	2	0.75	1.8932	1.6425	0.5907	2.6641
ξ_p	Beta	0.5	0.1	0.5541	0.5622	0.5000	0.6129
ι_w	Beta	0.5	0.15	0.5840	0.5783	0.3614	0.7994
ι_p	Beta	0.5	0.15	0.4932	0.5003	0.2747	0.7297
ψ	Beta	0.5	0.15	0.2826	0.3359	0.1523	0.5018
Φ	Normal	1.25	0.125	1.5872	1.5814	1.4640	1.6995
r_π	Normal	1.5	0.25	1.7160	1.7369	1.4773	2.0037
ρ	Beta	0.75	0.1	0.7543	0.7332	0.6569	0.8132
r_y	Normal	0.125	0.05	0.1645	0.1634	0.1045	0.2225
$r_{\Delta y}$	Normal	0.125	0.05	0.1689	0.1712	0.1192	0.2229
$\bar{\pi}$	Gamma	0.625	0.1	0.6423	0.6784	0.5095	0.8534
$100(\beta^{-1}-1)$	Gamma	0.25	0.1	0.2088	0.2180	0.0924	0.3345
$\bar{l}$	Normal	0	2	0.2515	0.2621	-1.5949	2.1764
$\bar{\gamma}$	Normal	0.4	0.1	0.2595	0.2836	0.2110	0.3737
α	Normal	0.3	0.05	0.2309	0.2323	0.1933	0.2716
σ_a	Gamma^{-1}	0.1	2	0.5769	0.5828	0.5049	0.6577
σ_b	Gamma^{-1}	0.1	2	0.2638	0.2704	0.2055	0.3342
σ_g	Gamma^{-1}	0.1	2	0.5423	0.5574	0.4920	0.6250
σ_i	Gamma^{-1}	0.1	2	0.5325	0.5327	0.4036	0.6600
σ_r	Gamma^{-1}	0.1	2	0.2800	0.2929	0.2542	0.3307
σ_p	Gamma^{-1}	0.1	2	0.1191	0.1151	0.0822	0.1490
σ_w	Gamma^{-1}	0.1	2	0.2053	0.2035	0.1643	0.2405
ρ_a	Beta	0.5	0.2	0.9885	0.9872	0.9804	0.9940
ρ_b	Beta	0.5	0.2	0.3953	0.3820	0.1815	0.5819
ρ_g	Beta	0.5	0.2	0.9042	0.9022	0.8487	0.9585
ρ_i	Beta	0.5	0.2	0.5746	0.6007	0.4517	0.7536
ρ_r	Beta	0.5	0.2	0.2470	0.2938	0.1150	0.4644
ρ_p	Beta	0.5	0.2	0.7342	0.7523	0.5263	0.9897
ρ_w	Beta	0.5	0.2	0.9623	0.9223	0.8598	0.9888
μ_p	Beta	0.5	0.2	0.5845	0.5655	0.3082	0.8341
μ_w	Beta	0.5	0.2	0.8845	0.8007	0.6631	0.9416
ρ_{ga}	Beta	0.5	0.2	0.6585	0.6606	0.5041	0.8128

Table A3: Posterior Distribution of Model Parameters, Post-Volcker Period

	Prior			Posterior			
	Distribution	**Mean**	**Std. Dev.**	**Mode**	**Mean**	**10%**	**90%**
φ	Normal	4	1.5	5.6933	6.0446	4.0429	7.8829
σ_c	Normal	1.5	0.375	1.0871	1.1191	0.8781	1.3525
h	Beta	0.7	0.1	0.4845	0.5086	0.4137	0.6088
ξ_w	Beta	0.5	0.1	0.5354	0.5379	0.4006	0.6677
σ_l	Normal	2	0.75	2.1750	2.2820	1.3749	3.1944
ξ_p	Beta	0.5	0.1	0.8179	0.8053	0.7418	0.8704
ι_w	Beta	0.5	0.15	0.4664	0.4577	0.2122	0.6915
ι_p	Beta	0.5	0.15	0.2238	0.2631	0.0978	0.4170
ψ	Beta	0.5	0.15	0.7299	0.7253	0.5794	0.8741
Φ	Normal	1.25	0.125	1.4789	1.4857	1.3332	1.6311
r_π	Normal	1.5	0.25	1.9833	1.9961	1.6796	2.3053
ρ	Beta	0.75	0.1	0.8208	0.8142	0.7680	0.8595
r_y	Normal	0.125	0.05	0.0830	0.0913	0.0359	0.1422
$r_{\Delta y}$	Normal	0.125	0.05	0.1709	0.1633	0.1119	0.2174
$\bar{\pi}$	Gamma	0.625	0.1	0.6783	0.6824	0.5402	0.8216
$100(\beta^{-1}-1)$	Gamma	0.25	0.1	0.1676	0.1890	0.0794	0.2871
$\bar{l}$	Normal	0	2	-0.5201	-0.4841	-1.8538	0.9178
$\bar{\gamma}$	Normal	0.4	0.1	0.4601	0.4578	0.4164	0.5013
α	Normal	0.3	0.05	0.1965	0.2003	0.1590	0.2412
σ_a	Gamma^{-1}	0.1	2	0.3535	0.3600	0.3145	0.4069
σ_b	Gamma^{-1}	0.1	2	0.0630	0.0709	0.0509	0.0907
σ_g	Gamma^{-1}	0.1	2	0.3850	0.3957	0.3463	0.4404
σ_i	Gamma^{-1}	0.1	2	0.3007	0.3157	0.2391	0.3893
σ_r	Gamma^{-1}	0.1	2	0.1348	0.1396	0.1193	0.1598
σ_p	Gamma^{-1}	0.1	2	0.0810	0.0814	0.0628	0.1001
σ_w	Gamma^{-1}	0.1	2	0.3115	0.3170	0.2431	0.3896
ρ_a	Beta	0.5	0.2	0.9213	0.9194	0.8778	0.9628
ρ_b	Beta	0.5	0.2	0.8726	0.8406	0.7527	0.9338
ρ_g	Beta	0.5	0.2	0.9707	0.9672	0.9474	0.9880
ρ_i	Beta	0.5	0.2	0.6840	0.6766	0.5494	0.8014
ρ_r	Beta	0.5	0.2	0.2941	0.3400	0.1869	0.4967
ρ_p	Beta	0.5	0.2	0.8294	0.7946	0.6584	0.9422
ρ_w	Beta	0.5	0.2	0.9517	0.9430	0.9021	0.9864
μ_p	Beta	0.5	0.2	0.6952	0.6201	0.3921	0.8425
μ_w	Beta	0.5	0.2	0.6947	0.6411	0.4597	0.8266
ρ_{ga}	Beta	0.5	0.2	0.4655	0.4522	0.2792	0.6393

Table A4: Posterior Distribution of Model Parameters, ZLB Regime

	Prior			Posterior			
	Distribution	**Mean**	**Std. Dev.**	**Mode**	**Mean**	**10%**	**90%**
φ	Normal	4	1.5	5.2484	5.4076	3.4853	7.3018
σ_c	Normal	1.5	0.375	1.1386	1.1826	0.9201	1.4303
h	Beta	0.7	0.1	0.6014	0.6013	0.4932	0.7076
ξ_w	Beta	0.5	0.1	0.8060	0.7604	0.6544	0.8621
σ_l	Normal	2	0.75	1.0456	1.1226	0.2500	2.0746
ξ_p	Beta	0.5	0.1	0.8403	0.8334	0.7607	0.9083
ι_w	Beta	0.5	0.15	0.3566	0.4214	0.1861	0.6612
ι_p	Beta	0.5	0.15	0.2572	0.3072	0.1172	0.4927
ψ	Beta	0.5	0.15	0.7279	0.7047	0.5156	0.8905
Φ	Normal	1.25	0.125	1.3153	1.3335	1.1786	1.4934
r_π	Normal	1.5	0.25	1.5272	1.5697	1.1737	1.9647
ρ	Beta	0.75	0.1	0.8886	0.8725	0.8135	0.9342
r_y	Normal	0.125	0.05	0.1813	0.1811	0.1191	0.2438
$r_{\Delta y}$	Normal	0.125	0.05	0.0995	0.0938	0.0399	0.1493
$\bar{\pi}$	Gamma	0.625	0.1	0.6019	0.5883	0.4457	0.7212
$100(\beta^{-1}-1)$	Gamma	0.25	0.1	0.1534	0.1725	0.0668	0.2749
$\bar{l}$	Normal	0	2	1.7156	1.6405	0.3017	3.0341
$\bar{\gamma}$	Normal	0.4	0.1	0.2405	0.2333	0.1830	0.2867
α	Normal	0.3	0.05	0.1344	0.1353	0.0963	0.1722
σ_a	Gamma^{-1}	0.1	2	0.4668	0.4883	0.4018	0.5728
σ_b	Gamma^{-1}	0.1	2	0.0430	0.0487	0.0345	0.0627
σ_g	Gamma^{-1}	0.1	2	0.2620	0.2762	0.2249	0.3237
σ_i	Gamma^{-1}	0.1	2	0.2633	0.2856	0.1803	0.3906
σ_r	Gamma^{-1}	0.1	2	0.1006	0.1060	0.0809	0.1302
σ_p	Gamma^{-1}	0.1	2	0.0792	0.0906	0.0534	0.1324
σ_w	Gamma^{-1}	0.1	2	0.6509	0.6602	0.5271	0.7884
ρ_a	Beta	0.5	0.2	0.8577	0.8531	0.7685	0.9397
ρ_b	Beta	0.5	0.2	0.9385	0.9261	0.8903	0.9616
ρ_g	Beta	0.5	0.2	0.7735	0.7474	0.5935	0.9087
ρ_i	Beta	0.5	0.2	0.7590	0.7489	0.5950	0.9125
ρ_r	Beta	0.5	0.2	0.5623	0.5688	0.3848	0.7678
ρ_p	Beta	0.5	0.2	0.6593	0.6411	0.4079	0.8830
ρ_w	Beta	0.5	0.2	0.2801	0.2832	0.0631	0.4921
μ_p	Beta	0.5	0.2	0.4550	0.5324	0.2328	0.9606
μ_w	Beta	0.5	0.2	0.5662	0.5484	0.3631	0.7457
ρ_{ga}	Beta	0.5	0.2	0.4601	0.4532	0.2827	0.6091