Online Appendix for
Inflation in the Great Recession and New Keynesian Models
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A. Appendix

I. Data

Data on real GDP (GDPC), the GDP deflator (GDPDEF), nominal personal consumption expenditures (PCEC), and nominal fixed private investment (FPI) are produced at a quarterly frequency by the Bureau of Economic Analysis, and are included in the National Income and Product Accounts (NIPA). Average weekly hours of production and nonsupervisory employees for total private industries (AWHNONAG), civilian employment (CE16OV), and the civilian non-institutional population (LNSINDEX) are produced by the Bureau of Labor Statistics (BLS) at a monthly frequency. The first of these series is obtained from the Establishment Survey, and the remaining from the Household Survey. Both surveys are released in the BLS Employment Situation Summary. Since our models are estimated on quarterly data, we take averages of the monthly data. Compensation per hour for the non-farm business sector (COMPNFB) is obtained from the Labor Productvity and Costs release, and produced by the BLS at a quarterly frequency. All data are transformed following Smets and Wouters (2007). The federal funds rate is obtained from the Federal Reserve Board's H.15 release at a business day frequency. We take quarterly averages of the annualized daily data and divide by four. Let Δ denote the temporal difference operator. Then:

$$
\begin{array}{lcl}
\text{Output growth} & = & 100 * \Delta LN((GDPC)/LNSINDEX) \\
\text{Consumption growth} & = & 100 * \Delta LN((PCEC/GDPDEF)/LNSINDEX) \\
\text{Investment growth} & = & 100 * \Delta LN((FPI/GDPDEF)/LNSINDEX) \\
\text{Real wage growth} & = & 100 * \Delta LN(COMPNFB/GDPDEF) \\
\text{Hours worked} & = & 100 * LN((AWHNONAG * CE16OV/100)/LNSINDEX) \\
\text{Inflation} & = & 100 * \Delta LN(GDPDEF) \\
\text{FFR} & = & (1/4) * FEDERAL\ FUNDS\ RATE
\end{array}
$$

Long-run inflation expectations are obtained from the Blue Chip Economic Indicators survey and the Survey of Professional Forecasters available from the FRB Philadelphia's Real-Time Data Research Center. Long-run inflation expectations (average CPI inflation over the next 10 years) are available from 1991Q4 onward. Prior to 1991Q4, we use the 10-year expectations data from the Blue Chip survey to construct a long time series that begins in 1979Q4. Since the Blue Chip survey reports long-run inflation expectations only twice a year, we treat these expectations in the remaining quarters as missing observations and adjust the measurement equation of the Kalman filter accordingly. Long-run inflation expectations $\pi_t^{O,40}$ are therefore measured as

$$\text{10y Infl Exp} = (\text{10-YEAR AVERAGE CPI INFLATION FORECAST} - 0.50)/4.$$

where 0.50 is the average difference between CPI and GDP annualized inflation from the beginning of the sample to 1992. We divide by 4 to express the data in quarterly terms. Finally, we measure *Spread* as the annualized Moody's Seasoned Baa Corporate Bond Yield spread over the 10-Year Treasury Note Yield at Constant Maturity. Both series are available from the Federal Reserve Board's H.15 release. Like the federal funds rate, the spread data are also averaged over each quarter and measured at a quarterly frequency. This leads to:

$$\text{Spread} = (1/4) * (BaaCorporate\ -\ 10yearTreasury).$$

II. Prior and Posterior Distributions

Table A-1 summarizes the prior distribution.
Table A-2 summarizes the posterior mode for selected model parameters.

Table A-1—Priors

	Density	Mean	St. Dev.		Density	Mean	St. Dev.
Panel I: Smets-Wouters Model (SW)							
Policy Parameters							
ψ_1	Normal	1.50	0.25	ρ_R	Beta	0.75	0.10
ψ_2	Normal	0.12	0.05	ρ_{r^m}	Beta	0.50	0.20
ψ_3	Normal	0.12	0.05	σ_{r^m}	InvG	0.10	2.00
Nominal Rigidities Parameters							
ζ_p	Beta	0.50	0.10	ζ_w	Beta	0.50	0.10
Other "Endogenous Propagation and Steady State" Parameters							
α	Normal	0.30	0.05	π^*	Gamma	0.75	0.40
Φ	Normal	1.25	0.12	γ	Normal	0.40	0.10
h	Beta	0.70	0.10	S''	Normal	4.00	1.50
ν_l	Normal	2.00	0.75	σ_c	Normal	1.50	0.37
ι_p	Beta	0.50	0.15	ι_w	Beta	0.50	0.15
r_*	Gamma	0.25	0.10	ψ	Beta	0.50	0.15
(Note $\beta = (1/(1 + r_*/100))$)							
ρs, σs, and ηs							
ρ_z	Beta	0.50	0.20	σ_z	InvG	0.10	2.00
ρ_b	Beta	0.50	0.20	σ_b	InvG	0.10	2.00
ρ_{λ_f}	Beta	0.50	0.20	σ_{λ_f}	InvG	0.10	2.00
ρ_{λ_w}	Beta	0.50	0.20	σ_{λ_w}	InvG	0.10	2.00
ρ_μ	Beta	0.50	0.20	σ_μ	InvG	0.10	2.00
ρ_g	Beta	0.50	0.20	σ_g	InvG	0.10	2.00
η_{λ_f}	Beta	0.50	0.20	η_{λ_w}	Beta	0.50	0.20
η_{gz}	Beta	0.50	0.20				
Panel II: Long-Run Inflation Expectations							
ρ_{π^*}	Beta	0.50	0.20	σ_{π^*}	InvG	0.03	6.00
Panel III: Financial Frictions (SWFF)							
SP_*	Gamma	2.00	0.10	$\zeta_{sp,b}$	Beta	0.05	0.005
ρ_{σ_w}	Beta	0.75	0.15	σ_{σ_w}	InvG	0.05	4.00

Note: Smets and Wouters' (2007) original prior for π_* is Gamma(.62, .10). The following parameters are fixed in Smets and Wouters (2007): $\delta = 0.025$, $g_* = 0.18$, $\lambda_w = 1.50$, $\varepsilon_w = 10$, and $\varepsilon_p = 10$. In addition, for the model with financial frictions we fix the entrepreneurs' steady-state default probability $\bar{F}_* = 0.03$ and their survival rate $\gamma_* = 0.99$. The columns "Mean" and "St. Dev." list the means and the standard deviations for Beta, Gamma, and Normal distributions, and the values s and ν for the Inverse Gamma (InvG) distribution, where $p_{\mathcal{IG}}(\sigma|\nu, s) \propto \sigma^{-\nu-1}e^{-\nu s^2/2\sigma^2}$. The effective prior is truncated at the boundary of the determinacy region. The prior for $\bar{l}$ is $\mathcal{N}(-45, 5^2)$.

Table A-2—Posterior Mode for DSGE Parameters

Parameter	Posterior Mode				
	SWFF	SWπ	SW+Sp	SW	SW[07]
α	0.179	0.155	0.214	0.161	0.19
ζ_p	0.868	0.654	0.806	0.708	0.65
ι_p	0.226	0.209	0.772	0.291	0.22
Φ	1.526	1.709	1.642	1.728	1.61
S''	3.044	5.615	5.233	6.112	5.48
h	0.244	0.709	0.251	0.709	0.71
ψ	0.188	0.726	0.734	0.702	0.54
ν_l	2.673	2.080	2.165	2.510	1.92
ζ_w	0.888	0.787	0.859	0.804	0.73
ι_w	0.419	0.558	0.477	0.571	0.59
r_*	0.133	0.193	0.137	0.148	0.16
ψ_1	1.374	1.969	1.263	2.048	2.03
ψ_2	0.018	-0.005	0.057	0.087	0.08
ψ_3	0.240	0.218	0.246	0.236	0.22
π^*	0.766	0.687	0.627	0.693	0.81
σ_c	1.316	1.328	1.663	1.452	1.39
ρ	0.675	0.791	0.763	0.831	0.81
SP_*	1.908	.	1.524	.	.
$\zeta_{sp,b}$	0.044	.	0.050	.	.
γ	0.401	0.336	0.337	0.374	0.43
$\bar{l}$	-45.48	-45.44	-43.75	-42.52	-42.5

Note: See description of labels at the end of table below.

Table A-2: Posterior Mode for DSGE Parameters (cont.)

Parameter	Posterior Mode				
	SWFF	SWπ	SW+Sp	SW	SW[07]
ρ_g	0.979	0.999	0.976	0.999	0.97
ρ_b	0.944	0.249	0.993	0.305	0.18
ρ_μ	0.644	0.688	0.670	0.739	0.71
ρ_z	0.956	0.983	0.976	0.969	0.95
ρ_{λ_f}	0.794	0.867	0.260	0.872	0.90
ρ_{λ_w}	0.661	0.994	0.977	0.978	0.97
ρ_{r^m}	0.067	0.206	0.041	0.119	0.12
ρ_{σ_w}	0.990	.	0.990	.	.
ρ_{π^*}	0.990	0.990	.	.	.
σ_g	2.908	2.921	2.920	2.929	0.52
σ_b	0.038	0.224	0.026	0.217	0.24
σ_μ	0.503	0.430	0.428	0.418	0.45
σ_z	0.496	0.463	0.465	0.458	0.45
σ_{λ_f}	0.154	0.149	0.185	0.142	0.14
σ_{λ_w}	0.257	0.300	0.275	0.271	0.24
σ_{r^m}	0.292	0.240	0.244	0.222	0.24
σ_{σ_w}	0.057	.	0.053	.	.
σ_{π^*}	0.030	0.035	.	.	.
η_{gz}	0.874	0.835	0.844	0.832	0.52
η_{λ_f}	0.714	0.725	0.404	0.746	0.74
η_{λ_w}	0.572	0.967	0.963	0.942	0.88

Note: SWFF refers to the baseline model, i.e., Smets and Wouters' (2007) model with financial frictions and a time-varying inflation target. SWπ is the SW model with a time-varying inflation target but no financial frictions. SW+Sp represents the SW model estimated with the same observables as Smets and Wouters plus credit spread data. SW refers to the SW model estimated using the same observables as Smets and Wouters but with the 2012Q3 vintage of data. SW[07] indicates the parameter estimates reported in Smets and Wouters (2007).

III. *Additional Figures*

III.1. Additional Figures for Section II. — Figure A-1 depicts cumulative output growth and inflation forecasts.

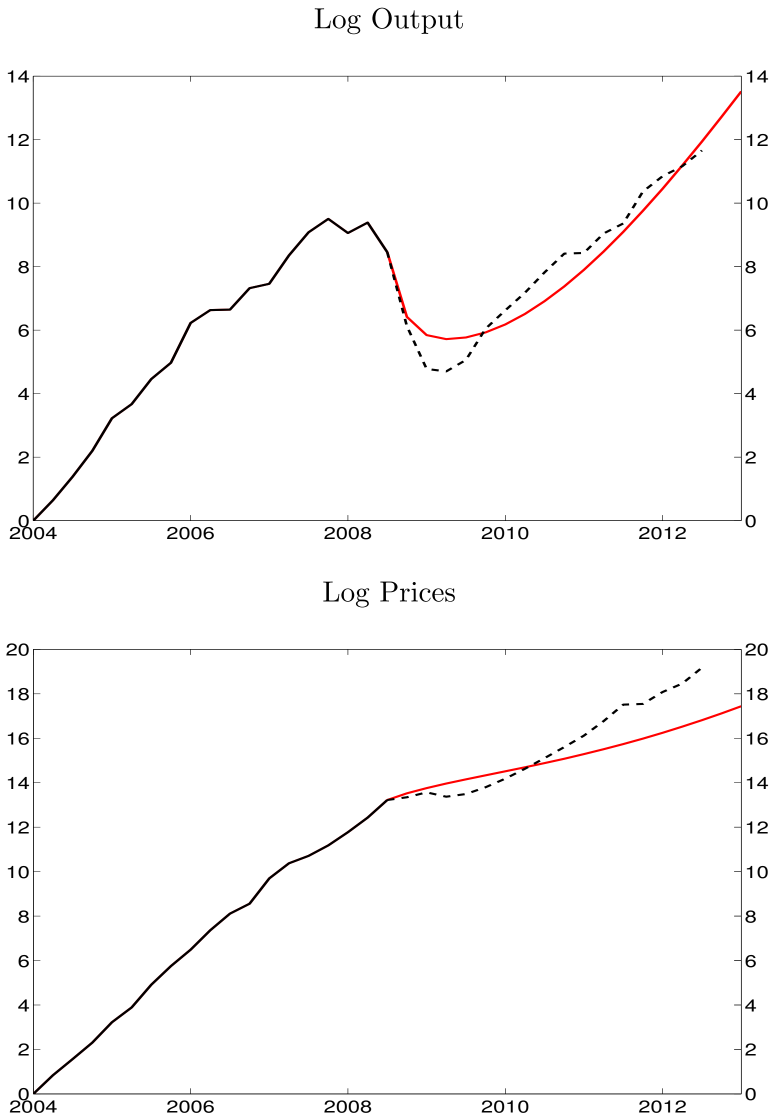

Figure A-1. Cumulative Forecasts of Output Growth and Inflation

Note: Log levels for 2004Q1 are normalized to zero. Actual data (solid black); Forecast paths (solid red); actual data (dashed black).

III.2. Additional Figures for Section IV.C. — Figure A-2 shows SWFF fundamental inflation $\tilde{\pi}_t$, core PCE inflation (since a core measure for the GDP deflator is not available), as well as a measure of fundamental inflation stripped of the indirect effect that arises from the impact of markup shocks on the evolution of marginal costs ($\pi_t^{no\ mkup}$). $\tilde{\pi}_t$ and $\pi_t^{no\ mkup}$ are close to one another and track core inflation even better than they track the GDP deflator inflation. The comparison between core and actual inflation is also revealing: differences between core and headline inflation usually reflect abrupt changes in commodity prices, as in the latest period or in the mid-2000s, and these changes are captured by markup shocks in the model. But markup shocks also have an effect on marginal costs: positive markup shocks depress economic activity and make fundamental inflation lower, opening a gap between $\tilde{\pi}_t$ and $\pi_t^{no\ mkup}$.

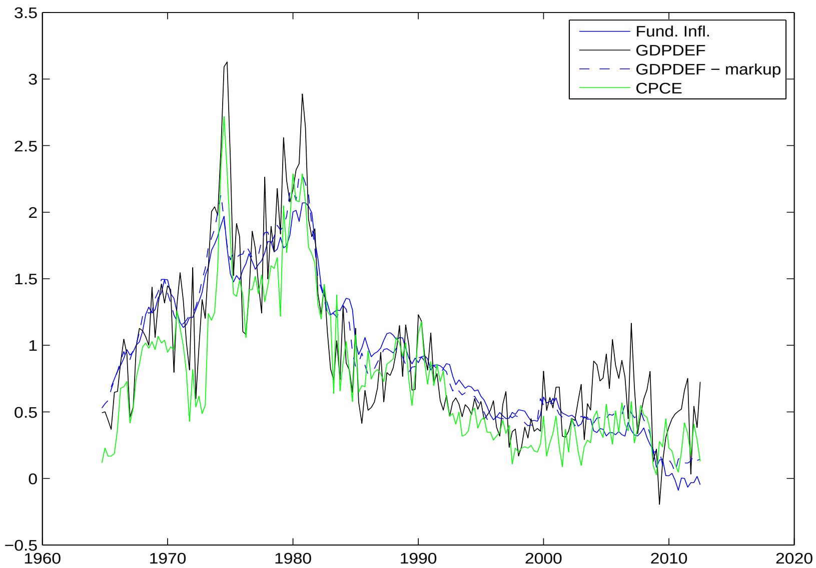

Figure A-2. Inflation, Fundamental Inflation, Counterfactual Inflation without Markup Shocks, and Core Inflation

Note: GDP deflator inflation (solid black); core PCE inflation (solid green); $\tilde{\pi}_t$ from the SWFF model (solid blue); counterfactual GDP deflator inflation $\pi_t^{no\ mkup}$ without markup shocks (dashed blue).

Figure A-3 compares SW fundamental inflation and SW marginal costs. The two series look almost identical, illustrating that for low ζ_p fundamental inflation tracks marginal costs.

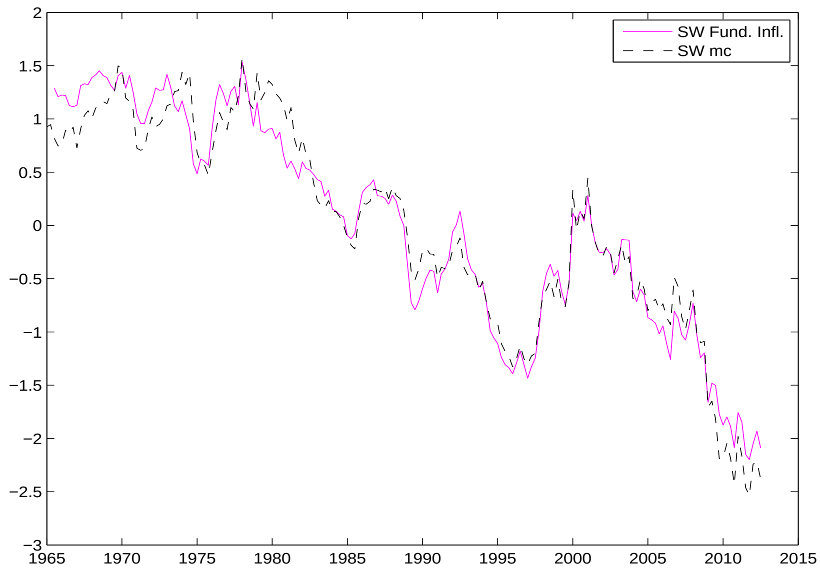

Figure A-3. SW Fundamental Inflation and SW Marginal Costs

Note: Smoothed marginal costs from the SW model (dashed black); fundamental inflation from the SW model (solid purple). Both series are standardized (demeaned and divided by their respective standard deviation).

Figure A-4 shows that the fraction of fundamental inflation attributable to markup shocks is very small for the SWFF model, whereas markup shocks explain most of fundamental inflation in the SW model.

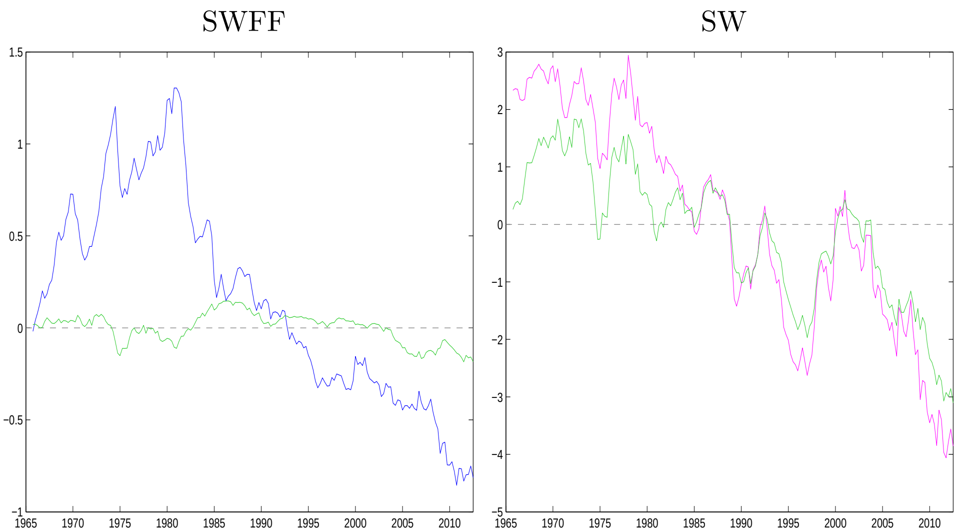

FIGURE A-4. MOVEMENTS IN FUNDAMENTAL INFLATION $\tilde{\pi}_t$ ATTRIBUTABLE TO MARKUP SHOCKS

Note: Left panel: fundamental inflation from the SWFF model (solid blue); movements in fundamental inflation attributable to markup shocks (solid green). Right panel: fundamental inflation from the SW model (solid purple); movements in fundamental inflation attributable to markup shocks (solid green).

III.3. Additional Figures for Section IV.D. — Figure A-5 compares RMSEs for marginal cost forecasts $\mathbb{E}[mc_t|\boldsymbol{Y}_{1:T_{full}}, \hat{\theta}]$ from the SWFF model.

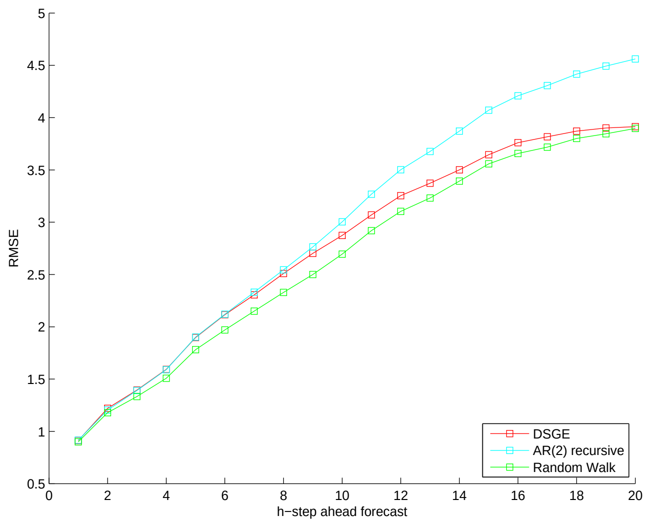

Figure A-5. RMSE of Marginal Cost Forecasts

Note: The figure shows the RMSE of marginal cost forecasts from the SWFF model (red line), a random walk (green) and an AR(2) model estimated recursively on past marginal cost data (light blue) for the period 1989Q4-2012Q3.

Figure A-6 depicts output growth and inflation forecasts that are obtained by replacing real wage growth with the growth rate of detrended real wages. We do not re-estimate the DSGE model parameters; we only re-run the Kalman filter to generate the forecasts.

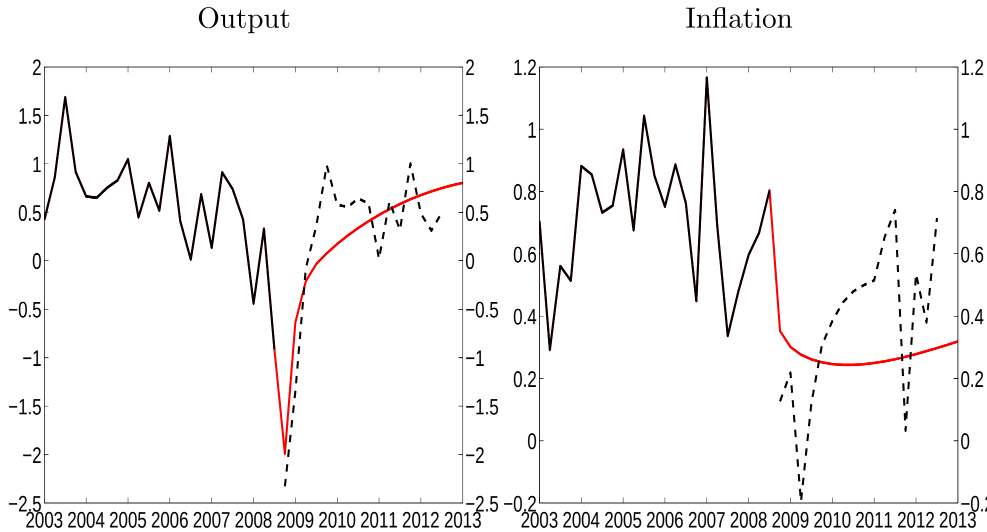

Figure A-6. Forecasts of Output Growth and Inflation Based on Detrended Wages

Note: Output growth and inflation: actuals until 2008Q3 (solid black); forecast paths (solid red); actuals starting 2008Q4 (dashed black).