Supplementary appendix (Not intended for publication)

of "Estimated New-Keynesian Model with Unemployment as Excess Supply of Labor"

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This appendix includes some additional analysis that was mentioned in the text but was not included in the final draft of the paper in order to keep the length down. We show results from three types of analysis. First, we show the whole set of tables describing parameter estimation results, second-moment statistics and variance decomposition for the two estimated models using the extended sample period (1984.1-2013:2), which are summarized in Section 4.5.1 of the paper. Second, we show the estimation results obtained from re-estimating the CMV and SW models without considering any labor measure as observable using data. The results are summarized in Section 4.5.2 of the paper. Finally, we estimated a simple VAR and compared the implied impulse-response functions with those implied by our structural model.

A.1 - Extended sample analysis

Tables A.1.1A (structural parameters) and A.1.1B (shock process parameters) show the parameter estimates of the CMV and SW models using the extended sample period. The estimation results with the extended sample are rather similar to those found using only data from the Great Moderation (shown in Tables 1A and 1B of the paper) with a few exceptions. First, the estimate of the inverse of the Frisch elasticity, $\sigma_l = 5.20$, is larger in the estimated CMV model for the extended sample. The opposite occurs for the SW model ($\sigma_l = 1.47$). Therefore, the difference between the estimates of σ_l across models is larger in the extended sample. Second, the estimate of price stickiness, ξ_p, is similar (0.81) in the two models when considering the extended sample. Thus, the estimated average length of optimal price changes increases from $(1 - 0.75)^{-1} = 4.0$ quarters during the Great Moderation to $(1 - 0.81)^{-1} = 5.27$ quarters when data from the Great Recession is also considered. Similarly, the estimated average length of labor contracts increases to $(1 - 0.84)^{-1} = 6.52$ quarters in the estimated CMV model with the extended sample. Finally, the estimates of wage-push shock parameters in the CMV model change. In particular, the size and persistence of wage-push innovations are lower ($\sigma_w = 1.85$, $\rho_w = 0.76$) in the extended sample period than in the Great Moderation ($\sigma_w = 3.71$, $\rho_w = 0.89$). In contrast, the estimate of the moving average parameter, μ_w, is larger in the extended sample than in the Great Moderation-only period (0.53 *vs.* 0.21) indicating that the recent recession features high-frequency movements of wage shocks.

Table A.1.1A. Priors and estimated posteriors of the structural parameters (Sample: 1984:1-2013:2)

	Priors			Posteriors					
				CMV model			SW model		
	Distr	Mean	Std D.	Mean	5%	95%	Mean	5%	95%
φ: cost of adjusting capital	Normal	4.00	1.50	3.74	2.18	5.31	5.60	3.59	7.02
h: habit formation	Beta	0.70	0.10	0.45	0.33	0.58	0.57	0.47	0.65
σ_c: risk aversion	Normal	1.50	0.37	1.04	0.73	1.33	0.99	0.79	1.17
σ_l: Frisch elasticity	Normal	2.00	0.75	5.20	4.36	6.04	1.47	0.40	1.95
ξ_p: price Calvo probability	Beta	0.50	0.10	0.81	0.76	0.86	0.81	0.70	0.87
ξ_w: wage Calvo probability	Beta	0.50	0.10	0.84	0.79	0.90	0.59	0.35	0.62
ι_w: price indexation	Beta	0.50	0.15	0.36	0.14	0.56	0.48	0.25	0.74
ι_p: wage indexation	Beta	0.50	0.15	0.33	0.12	0.51	0.32	0.16	0.46
ψ: capital utilizat.. adjust. cost	Beta	0.50	0.15	0.88	0.81	0.97	0.79	0.62	0.90
Φ: steady-state price mark-up	Normal	1.25	0.12	1.59	1.43	1.76	1.42	1.30	1.55
r_π: inflation (policy rule)	Normal	1.50	0.25	1.84	1.48	2.20	2.03	1.76	2.35
ρ: inertia (policy rule)	Beta	0.75	0.10	0.84	0.81	0.88	0.84	0.79	0.87
r_y: output gap (policy rule)	Normal	0.12	0.05	0.16	0.09	0.22	0.02	−0.01	0.05
$r_{\Delta y}$: output growth (policy rule)	Normal	0.12	0.05	0.19	0.14	0.24	0.17	0.13	0.21
π: steady-state inflation	Gamma	0.62	0.10	0.65	0.55	0.76	0.69	0.52	0.83
$100(\beta^{-1}-1)$: discount	Gamma	0.25	0.10	0.21	0.09	0.32	0.19	0.09	0.29
$\bar{l}$: steady-state labor	Normal	0.00	2.00	–	–	–	3.01	−0.10	5.84
γ: steady-state output growth	Normal	0.40	0.10	0.37	0.30	0.43	0.39	0.33	0.46
α: capital share	Normal	0.30	0.05	0.15	0.12	0.18	0.17	0.13	0.20
θ: demand elasticity	Normal	6.00	1.50	6.66	4.15	9.00	–	–	–
u: unemployment rate	Normal	6.00	2.00	6.39	5.82	6.98	–	–	–

Table A.1.1B. Priors and estimated posteriors of the shock processes (Sample: 1984:1-2013:2)

	Priors			Posteriors					
				CMV model			SW model		
	Distr	Mean	Std D.	Mean	5%	95%	Mean	5%	95%
σ_a: Std of productivity innovation	Invgamma	0.10	2.00	0.46	0.38	0.53	0.41	0.37	0.46
σ_b: Std of risk premium innov.	Invgamma	0.10	2.00	0.06	0.05	0.08	0.06	0.05	0.07
σ_g: Std of spending innov.	Invgamma	0.10	2.00	0.39	0.34	0.43	0.39	0.35	0.44
σ_i: Std of investment innov.	Invgamma	0.10	2.00	0.34	0.27	0.40	0.34	0.26	0.42
σ_R: Std of monetary innov.	Invgamma	0.10	2.00	0.13	0.11	0.15	0.12	0.11	0.14
σ_p: Std of price index. innov.	Invgamma	0.10	2.00	0.12	0.10	0.14	0.10	0.08	0.12
σ_w: Std of wage index. innov.	Invgamma	0.10	2.00	1.85	0.98	2.70	0.43	0.37	0.55
ρ_a: Persistence of prod. shock	Beta	0.50	0.20	0.99	0.98	0.998	0.96	0.93	0.99
ρ_b: Persist. of risk prem. shock	Beta	0.50	0.20	0.92	0.89	0.96	0.89	0.85	0.94
ρ_g: Persist. of spending shock	Beta	0.50	0.20	0.96	0.93	0.99	0.95	0.91	0.99
ρ_i: Persist. of investment shock	Beta	0.50	0.20	0.75	0.63	0.86	0.67	0.56	0.79
ρ_R: Persist. of monetary shock	Beta	0.50	0.20	0.31	0.20	0.43	0.40	0.26	0.50
ρ_p: Persist. of price shock	Beta	0.50	0.20	0.60	0.37	0.85	0.86	0.81	0.997
ρ_w: Persist. of wage shock	Beta	0.50	0.20	0.76	0.48	0.96	0.98	0.96	0.99
μ_p: moving-average of price shock	Beta	0.50	0.20	0.53	0.29	0.77	0.73	0.64	0.91
μ_w: moving-average of wage shock	Beta	0.50	0.20	0.53	0.32	0.74	0.85	0.66	0.91
ρ_{ga}: correlation of prod. & spend shocks	Beta	0.50	0.20	0.34	0.19	0.47	0.39	0.22	0.54

Regarding the empirical fit of the second-moment statistics in the extended sample, we observe that results are similar to those found using the Great Moderation sample by comparing Table A.1.2 in this appendix with Table 2 in the paper. Thus, the CMV model still matches most second-moment statistics better than the SW model. Moreover, the CMV model is able to capture the weak, negative correlation between unemployment and output growth characterizing the extended sample.

Table A.1.2. Second-moment statistics (Sample: 1984:1-2013:2)

	Δy	Δc	Δi	Δw	l	u	R	π
U.S. data:								
St. dev. (%)	0.62	0.61	1.92	0.84	3.79	1.51	0.72	0.25
Corr. with Δy	1.0	0.69	0.69	0.01	0.21	-0.06	0.25	0.07
Autocorr.	0.39	0.34	0.65	-0.12	0.99	0.98	0.98	0.63
Estimated CMV model:								
St. dev. (%)	0.74	0.70	2.04	0.91	1.42	1.15	0.49	0.28
	(0.68,0.80)	(0.64,0.75)	(1.84,2.28)	(0.79,1.01)	(1.18,1.64)	(0.94,1.32)	(0.37,0.58)	(0.23,0.33)
Corr. with Δy	1.0	0.72	0.57	0.24	0.08	-0.22	-0.09	-0.10
		(0.65,0.79)	(0.49,0.64)	(0.15,0.33)	(0.04,0.14)	(-0.25,-0.17)	(-0.13,-0.04)	(-0.17,-0.04)
Autocorr.	0.31	0.38	0.66	0.16	0.94	0.93	0.96	0.71
	(0.26,0.36)	(0.30,0.44)	(0.60,0.71)	(-0.00,0.30)	(0.92,0.96)	(0.91,0.95)	(0.95,0.98)	(0.61,0.82)
Estimated SW model:								
St. dev. (%)	0.85	0.73	2.18	0.91	3.96	–	0.49	0.39
	(0.77,0.93)	(0.66,0.81)	(1.89,2.39)	(0.82,1.00)	(2.81,4.96)		(0.37,0.58)	(0.31,0.45)
Corr. with Δy	1.0	0.76	0.69	0.29	0.11	–	-0.08	-0.20
		(0.70,0.83)	(0.63,0.74)	(0.19,0.38)	(0.08,0.15)		(-0.13,-0.02)	(-0.30,-0.08)
Autocorr.	0.42	0.50	0.67	0.21	0.98	–	0.96	0.83
	(0.36,0.46)	(0.44,0.57)	(0.62,0.73)	(0.12,0.32)	(0.97,0.99)		(0.95,0.98)	(0.78,0.89)

Finally, Table A.1.3 shows the variance decomposition of the two estimated models for the extended sample. By comparing this table with the variance decomposition of the Great Moderation (shown in Table 3 of the paper), we see that the importance of wage-push shocks in explaining unemployment rate fluctuations sharply decreases from 69% in the Great Moderation sample to 35% in the extended sample. By the same token, the importance of demand shocks, such as risk premium and interest rate shocks, increases in the extended sample (33% and 20%, respectively).

Table A.1.3. Long-run variance decomposition (Sample: 1984:1-2013:2)

Estimated CMV model:

Innovations	Δy	Δc	Δi	Δw	l	u	R	π
Technology, η^a	0.39	0.37	0.03	0.02	0.15	0.02	0.05	0.05
Risk premium, η^b	0.22	0.28	0.15	0.05	0.35	0.33	0.72	0.22
Fiscal/Net exports, η^g	0.14	0.08	0.00	0.00	0.08	0.01	0.02	0.01
Investment, η^i	0.07	0.03	0.68	0.01	0.11	0.06	0.07	0.02
Interest-rate, η^R	0.15	0.20	0.09	0.03	0.19	0.20	0.07	0.04
Wage-push, η^w	0.01	0.01	0.01	0.83	0.08	0.35	0.04	0.18
Price-push, η^p	0.02	0.02	0.03	0.06	0.05	0.02	0.02	0.48

Estimated SW model:

Innovations	Δy	Δc	Δi	Δw	l	u	R	π
Technology, η^a	0.15	0.09	0.03	0.02	0.02	–	0.04	0.02
Risk premium, η^b	0.25	0.40	0.13	0.07	0.11	–	0.69	0.27
Fiscal/Net exports, η^g	0.17	0.02	0.00	0.00	0.04	–	0.01	0.01
Investment, η^i	0.09	0.01	0.59	0.01	0.04	–	0.05	0.01
Interest-rate, η^R	0.15	0.23	0.08	0.04	0.06	–	0.06	0.11
Wage-push, η^w	0.08	0.17	0.05	0.72	0.57	–	0.11	0.26
Price-push, η^p	0.10	0.08	0.13	0.15	0.17	–	0.04	0.34

A.2 - Estimation analysis without a labor measure as observable

Tables A.2.1A (structural parameters) and A.2.1B (shock process parameters) show the parameter estimates of the CMV and SW models without any labor measure as observable. By comparing these tables with those reported in the paper (Tables 1A and 1B), we see that a few parameter estimates are sensitive to ignoring a labor measure as observable. The estimate of wage stickiness in the CMV model, $\xi_w = 0.84$, is larger when ignoring the unemployment rate as an observable variable. This value is also larger than the estimated value in the SW model ($\xi_w = 0.62$). The opposite occurs for the size of wage innovation shock, $\sigma_w = 2.04$, which is lower when the unemployment rate is not considered as an observable in the estimation of the CMV model. Nevertheless, this estimated value is still much larger than the one obtained estimating the SW model. Additionally, the volatility of technology innovations, $\sigma_a = 0.08$, and the persistence of technology and risk premium shocks ($\rho_a = 0.86$ and $\rho_b = 0.77$) are much lower when ignoring the rate of unemployment as observable in the estimated CMV model. Finally, the estimated CMV model parameter values of the cost of adjusting capital, $\varphi = 6.03$, capital adjustment costs, $\psi = 0.68$, the inverse of Frisch elasticity, $\sigma_l = 2.51$, and the steady-state price mark-up, $\Phi = 1.39$, were similar to the estimates found for the SW model either using employment as observable or ignoring it.

Table A.2.1A. Priors and estimated posteriors of the structural parameters (Sample: 1984:1-2007:4)

	Priors			Posteriors					
				CMV model without u as observable			SW model without l as observable		
	Distr	Mean	Std D.	Mean	5%	95%	Mean	5%	95%
φ: cost of adjusting capital	Normal	4.00	1.50	6.03	4.12	7.83	6.01	3.94	7.91
h: habit formation	Beta	0.70	0.10	0.50	0.38	0.62	0.49	0.38	0.61
σ_c: risk aversion	Normal	1.50	0.37	1.20	0.94	1.44	1.22	0.92	1.51
σ_l: Frisch elasticity	Normal	2.00	0.75	2.51	1.47	3.48	2.12	1.12	3.09
ξ_p: price Calvo probability	Beta	0.50	0.10	0.83	0.76	0.90	0.81	0.71	0.90
ξ_w: wage Calvo probability	Beta	0.50	0.10	0.84	0.78	0.90	0.62	0.44	0.83
ι_w: price indexation	Beta	0.50	0.15	0.35	0.15	0.55	0.44	0.20	0.68
ι_p: wage indexation	Beta	0.50	0.15	0.31	0.12	0.49	0.35	0.14	0.57
ψ: capital utilizat.. adjust. cost	Beta	0.50	0.15	0.68	0.50	0.87	0.71	0.54	0.88
Φ: steady-state price mark-up	Normal	1.25	0.12	1.39	1.21	1.57	1.41	1.24	1.58
r_π: inflation (policy rule)	Normal	1.50	0.25	1.92	1.52	2.33	2.04	1.64	2.44
ρ: inertia (policy rule)	Beta	0.75	0.10	0.83	0.79	0.88	0.83	0.78	0.87
r_y: output gap (policy rule)	Normal	0.12	0.05	0.13	0.04	0.21	0.09	0.01	0.18
$r_{\Delta y}$: output growth (policy rule)	Normal	0.12	0.05	0.17	0.12	0.23	0.18	0.13	0.24
π: steady-state inflation	Gamma	0.62	0.10	0.64	0.53	0.76	0.65	0.53	0.78
$100(\beta^{-1}-1)$: discount	Gamma	0.25	0.10	0.18	0.07	0.28	0.19	0.07	0.29
$\bar{l}$: steady-state labor	Normal	0.00	2.00	–	–	–	−0.09	−3.32	3.23
γ: steady-state output growth	Normal	0.40	0.10	0.48	0.43	0.54	0.46	0.39	0.53
α: capital share	Normal	0.30	0.05	0.20	0.16	0.25	0.20	0.16	0.25
θ: demand elasticity	Normal	6.00	1.50	6.55	4.28	8.96	–	–	–
u: unemployment rate	Normal	6.00	2.00	6.00	2.64	9.29	–	–	–

Table A.2.1B. Priors and estimated posteriors of the shock processes (Sample: 1984:1-2007:4)

	Priors			Posteriors					
				CMV model without u as observable			SW model without l as observable		
	Distr	Mean	Std D.	Mean	5%	95%	Mean	5%	95%
σ_a: Std of productivity innovation	Invgamma	0.10	2.00	0.08	0.02	0.14	0.07	0.02	0.13
σ_b: Std of risk premium innov.	Invgamma	0.10	2.00	0.09	0.06	0.12	0.08	0.05	0.11
σ_g: Std of spending innov.	Invgamma	0.10	2.00	0.41	0.36	0.46	0.41	0.36	0.46
σ_i: Std of investment innov.	Invgamma	0.10	2.00	0.31	0.24	0.39	0.31	0.24	0.38
σ_R: Std of monetary innov.	Invgamma	0.10	2.00	0.13	0.11	0.14	0.13	0.11	0.15
σ_p: Std of price index. innov.	Invgamma	0.10	2.00	0.10	0.08	0.12	0.10	0.07	0.13
σ_w: Std of wage index. innov.	Invgamma	0.10	2.00	2.04	1.07	3.09	0.31	0.24	0.39
ρ_a: Persistence of prod. shock	Beta	0.50	0.20	0.86	0.76	0.90	0.50	0.19	0.84
ρ_b: Persist. of risk prem. shock	Beta	0.50	0.20	0.77	0.63	0.92	0.80	0.68	0.92
ρ_g: Persist. of spending shock	Beta	0.50	0.20	0.95	0.93	0.98	0.96	0.93	0.98
ρ_i: Persist. of investment shock	Beta	0.50	0.20	0.72	0.60	0.85	0.72	0.59	0.85
ρ_R: Persist. of monetary shock	Beta	0.50	0.20	0.44	0.28	0.58	0.43	0.28	0.56
ρ_p: Persist. of price shock	Beta	0.50	0.20	0.73	0.55	0.90	0.76	0.60	0.92
ρ_w: Persist. of wage shock	Beta	0.50	0.20	0.87	0.75	0.97	0.89	0.74	0.99
μ_p: moving-average of price shock	Beta	0.50	0.20	0.57	0.35	0.81	0.59	0.36	0.94
μ_w: moving-average of wage shock	Beta	0.50	0.20	0.39	0.21	0.57	0.64	0.42	0.85
ρ_{ga}: correlation of prod. & spend shocks	Beta	0.50	0.20	0.48	0.15	0.81	0.50	0.17	0.83

Regarding the empirical fit of second-moment statistics when ignoring any labor measure in the estimation of the two models shown in Table A.2.2, we observe that the CMV still performs better than the SW model for most statistics, but the overall fit-improvement provided by the CMV model in this case is rather small when compared to the improvement achieved by the CMV model when the unemployment rate is included in the set of observable variables in the estimation procedure shown in Table 2. Three noticeable exceptions are the observed volatility of employment, the contemporaneous correlation between inflation and output growth, and the first autocorrelation of the first-difference of the real wage which are better fitted by the estimated CMV model without unemployment as observable.

Table A.2.2. Second-moment statistics (Sample: 1984:1-2007:4)

	Δy	Δc	Δi	Δw	l	u	R	π
U.S. data:								
St. dev. (%)	0.54	0.50	1.47	0.72	2.00	1.04	0.59	0.23
Corr. with Δy	1.0	0.56	0.61	0.00	0.04	0.14	0.09	-0.14
Autocorr.	0.23	0.10	0.52	0.13	0.97	0.98	0.98	0.61
Estimated CMV model (without unemployment as observable):								
St. dev. (%)	0.70	0.61	1.75	0.80	1.99	1.98	0.40	0.30
	(0.62,0.79)	(0.53,0.67)	(1.40,1.96)	(0.69,0.90)	(1.30,2.45)	(1.31,2.46)	(0.31,0.45)	(0.22,0.37)
Corr. with Δy	1.0	0.61	0.62	0.25	0.22	-0.28	-0.09	-0.14
		(0.49,0.74)	(0.54,0.70)	(0.13,0.37)	(0.18,0.25)	(-0.33,-0.23)	(-0.16,0.01)	(-0.25,-0.03)
Autocorr.	0.34	0.43	0.62	0.26	0.96	0.95	0.94	0.75
	(0.27,0.42)	(0.35,0.52)	(0.55,0.73)	(0.11,0.40)	(0.94,0.97)	(0.92,0.97)	(0.93,0.96)	(0.62,0.84)
Estimated SW model (without employment as observable):								
St. dev. (%)	0.71	0.61	1.79	0.82	2.54	–	0.42	0.35
	(0.61,0.79)	(0.53,0.68)	(1.50,2.03)	(0.70,0.92)	(1.38,3.41)		(0.33,0.50)	(0.23,0.43)
Corr. with Δy	1.0	0.61	0.64	0.28	0.20	–	-0.10	-0.19
		(0.50,0.73)	(0.56,0.72)	(0.16,0.43)	(0.14,0.25)		(-0.18,-0.01)	(-0.35,-0.04)
Autocorr.	0.36	0.44	0.63	0.33	0.97	–	0.95	0.79
	(0.27,0.44)	(0.36,0.54)	(0.55,0.72)	(0.18,0.47)	(0.94,0.99)		(0.93,0.97)	(0.70,0.89)

Finally, Table A.2.3 shows the variance decomposition of the two estimated models without any labor measure as observable. Comparing the decomposition results of this table with those reported in Table 3 of the paper, we conclude that considering the unemployment rate as observable in the estimated CMV model becomes crucial for identifying the large importance of productivity shocks in both output growth and consumption growth variability.

Table A.2.3. Long-run variance decomposition (Sample: 1984:1-2007:4)

Estimated CMV model (without unemployment as observable):

Innovations	Δy	Δc	Δi	Δw	l	u	R	π
Technology, η^a	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Risk premium, η^b	0.28	0.51	0.07	0.03	0.20	0.16	0.43	0.05
Fiscal/Net exports, η^g	0.27	0.05	0.01	0.00	0.12	0.01	0.04	0.01
Investment, η^i	0.16	0.04	0.81	0.02	0.18	0.05	0.18	0.02
Interest-rate, η^R	0.20	0.31	0.07	0.03	0.20	0.14	0.13	0.06
Wage-push, η^w	0.03	0.05	0.02	0.82	0.22	0.63	0.14	0.32
Price-push, η^p	0.05	0.05	0.03	0.09	0.08	0.02	0.07	0.55

Estimated SW model (without employment as observable):

Innovations	Δy	Δc	Δi	Δw	l	u	R	π
Technology, η^a	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
Risk premium, η^b	0.25	0.44	0.06	0.06	0.13	–	0.43	0.08
Fiscal/Net exports, η^g	0.26	0.05	0.01	0.00	0.09	–	0.04	0.01
Investment, η^i	0.15	0.03	0.78	0.02	0.12	–	0.18	0.04
Interest-rate, η^R	0.18	0.29	0.06	0.05	0.13	–	0.10	0.09
Wage-push, η^w	0.08	0.13	0.05	0.74	0.44	–	0.18	0.35
Price-push, η^p	0.08	0.07	0.06	0.13	0.08	–	0.08	0.43

A.3 - Impulse response analysis

In this section we follow a referee's recommendation and estimate a simple VAR(1) system with the seven observables in order to compare the implied dynamics with those implied by our structural mediums-scale DSGE model. We select the VAR(1) based on the Schwarz identification criterion. Additionally, we impose a standard recursive identification scheme, with this order: inflation, real wages, unemployment, output growth, consumption growth, investment growth and nominal interest rates. Thus, only the nominal interest rate contemporaneously react to all shocks while inflation reacts with a lag to all shocks.

But before we start the comparison analysis a word of caution is in order because the mapping between our structural model and a VAR is rather problematic for several reasons. First, and most importantly, it is very hard to interpret similarly the shocks of a VAR and those of a structural model. Typically, meaningful shocks in a VAR are identified via recursive/triangular schemes (Christiano, Eichenbaum and Evans, 1999), long-run restrictions (Blanchard and Quah, 1989) or sign restrictions (Faust, 1998). Now, all of these schemes impose restrictions that are at odds with those of the structural model, which imposes cross-equation restrictions in a Rational Expectations setting. For instance, in the recursive scheme, some variables do not react to all shocks contemporaneously, while in the structural model this is exactly the case. As a result there is no mapping between the structural shocks identified in our framework (technology, risk premium and so on) and those of the VAR, which are essentially "residual equation" shocks. Second, as specified in the variables summary of Appendix 4 in the paper, our model comprises 27 endogenous variables, while we estimate the model with 7 observable variables in order to identify model dynamics. Thus, many of the variables of the model (such as the natural rates or the flexible price variables) are not observables. In relatively stylized models with a small number of observables and unobservables, you can still derive the implied-reduced forms in terms of observables, so that there is a mapping in terms of lag-order between the structural model and the VAR. For instance, Bekaert, Cho and Moreno (2010) show that a simple New-Keynesian model with 3 observables and 2 unobservables has a VAR(1) reduced-form in the 5 variables and a VARMA(3,2) reduced-form in the 3 observables. This point has been also emphasized in Fry and Pagan (2011). In our setting with 27 variables, 7 observables and a very rich structure for the shocks (some are AR(1), others are ARMA(1,1)) is virtually impossible to determine what the reduced-form dynamics are in terms of observables. As a result, it is not clear what lag order we should impose in the system.

Figures A.1-A.7 show the responses of all seven observables to a consumption shock, inflation shock, investment shock, interest rate shock, output shock, real wage shock and unemployment shock, respectively; together with the corresponding $\pm$ two-standard deviation confidence interval. In order to simplify the exposition, we comment only on those impulse responses which seem easier to match with those in the model. Thus, following an interest rate shock, similarly to effects of the monetary policy shock in the structural model, the interest rate and unemployment go up during some period, while investment and output decrease. However, real wages and inflation increase. The increase of inflation in this type of VARs is a well-known anomaly (price puzzle, Sims, 1992) due to the restricted information set in the VAR. Following an inflation shock, inflation increases while output, consumption, investment and real wages decrease. These responses are similar to those of a price-push shock in the structural model. Finally, the responses of the interest rate seem to be in sync with the model and with macroeconomic wisdom, as it increases with inflation, output, consumption, investment and real wage shocks, while it decreases with unemployment rate shocks.

NEW CITATIONS

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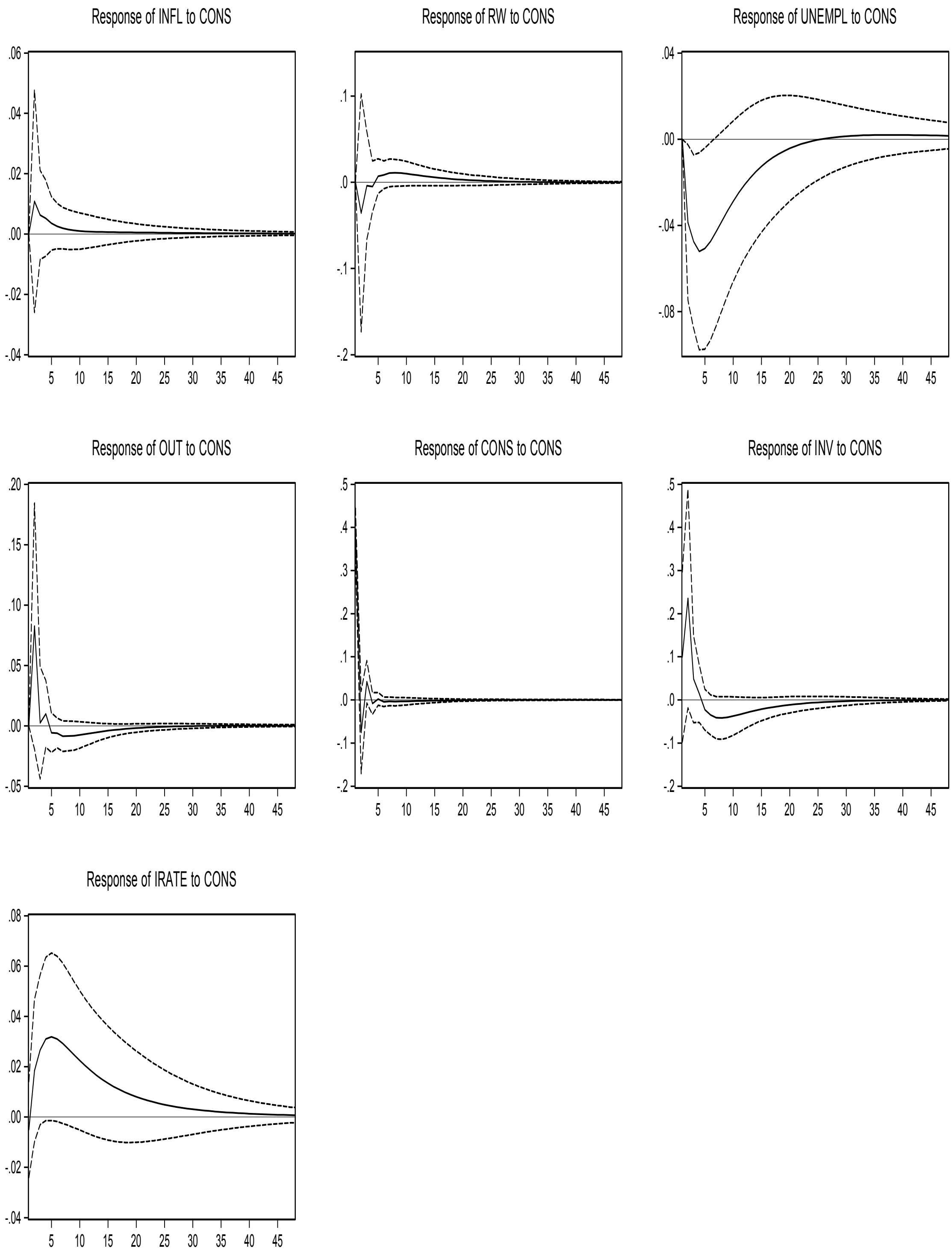

Figure A.1. Responses to a consumption innovation

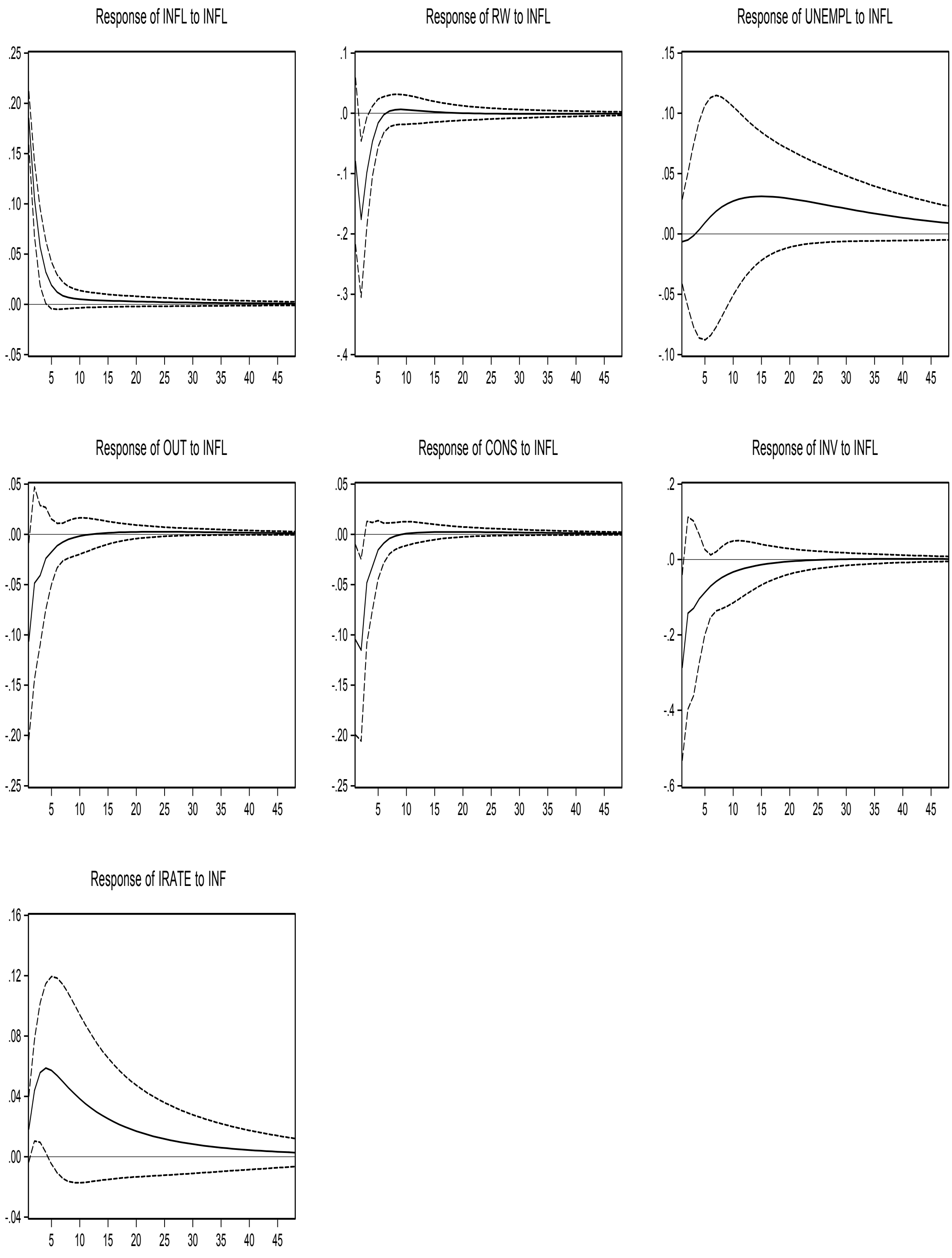

Figure A.2. Responses to an inflation innovation

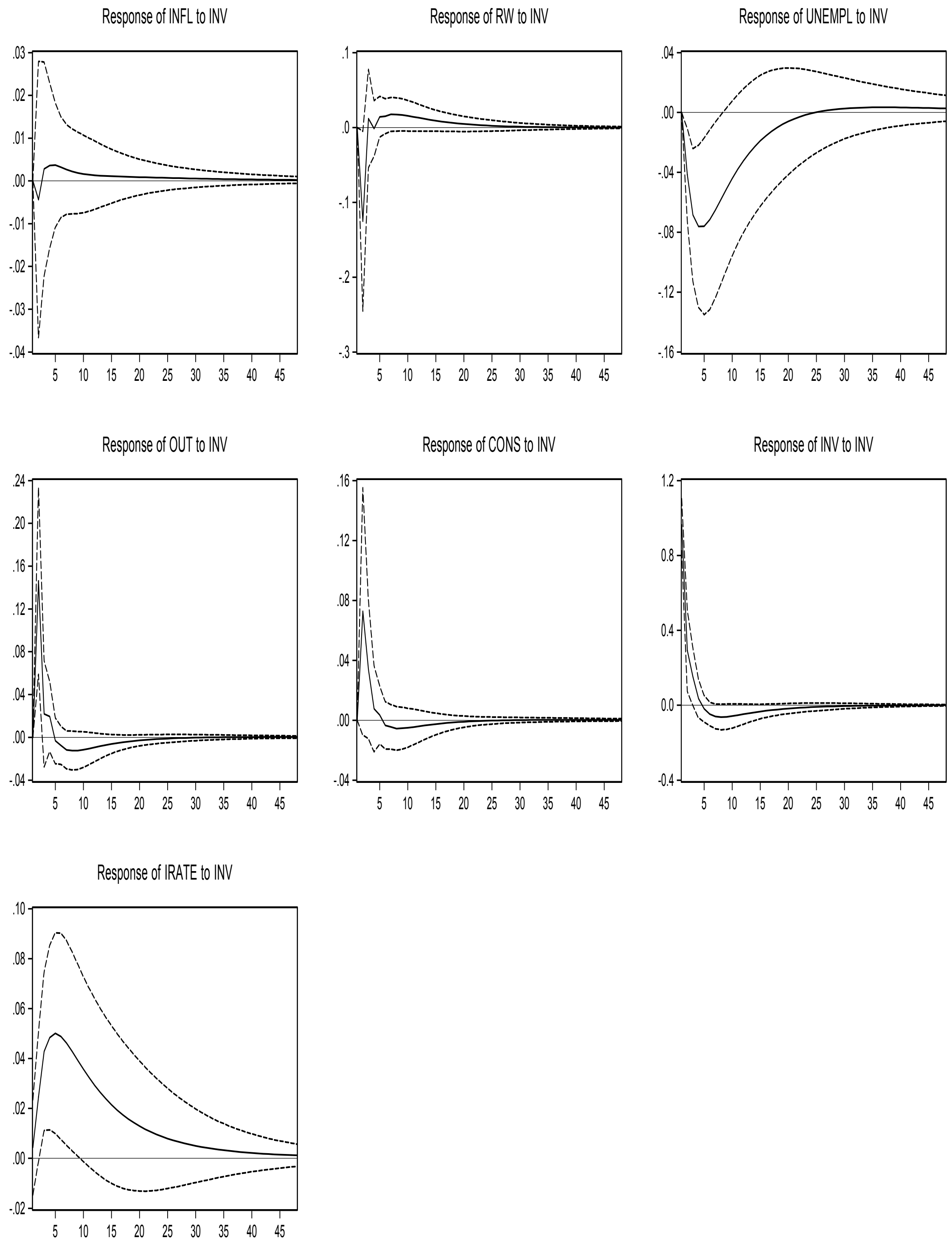

Figure A.3. Responses to an investment innovation

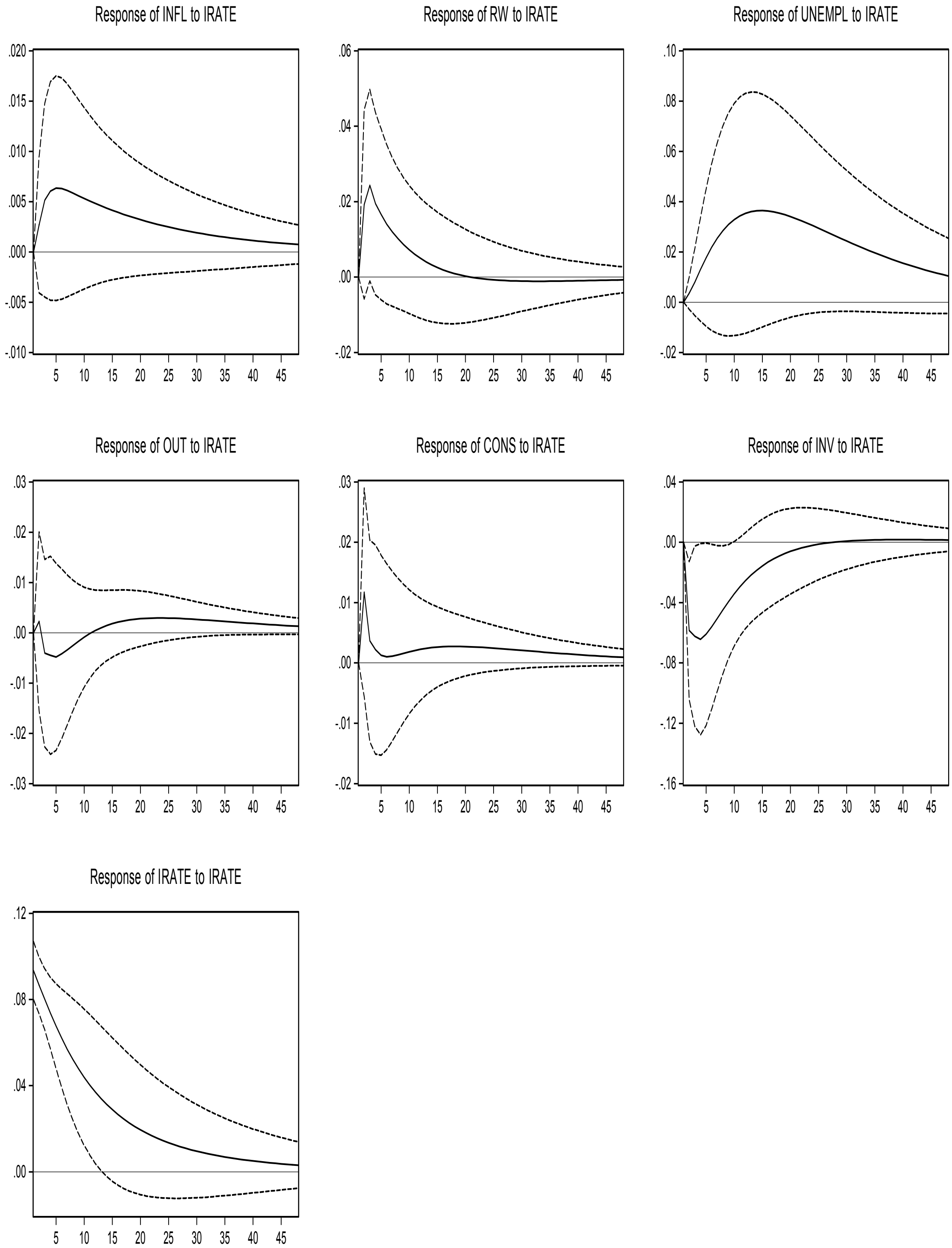

Figure A.4. Responses to a nominal interest rate innovation

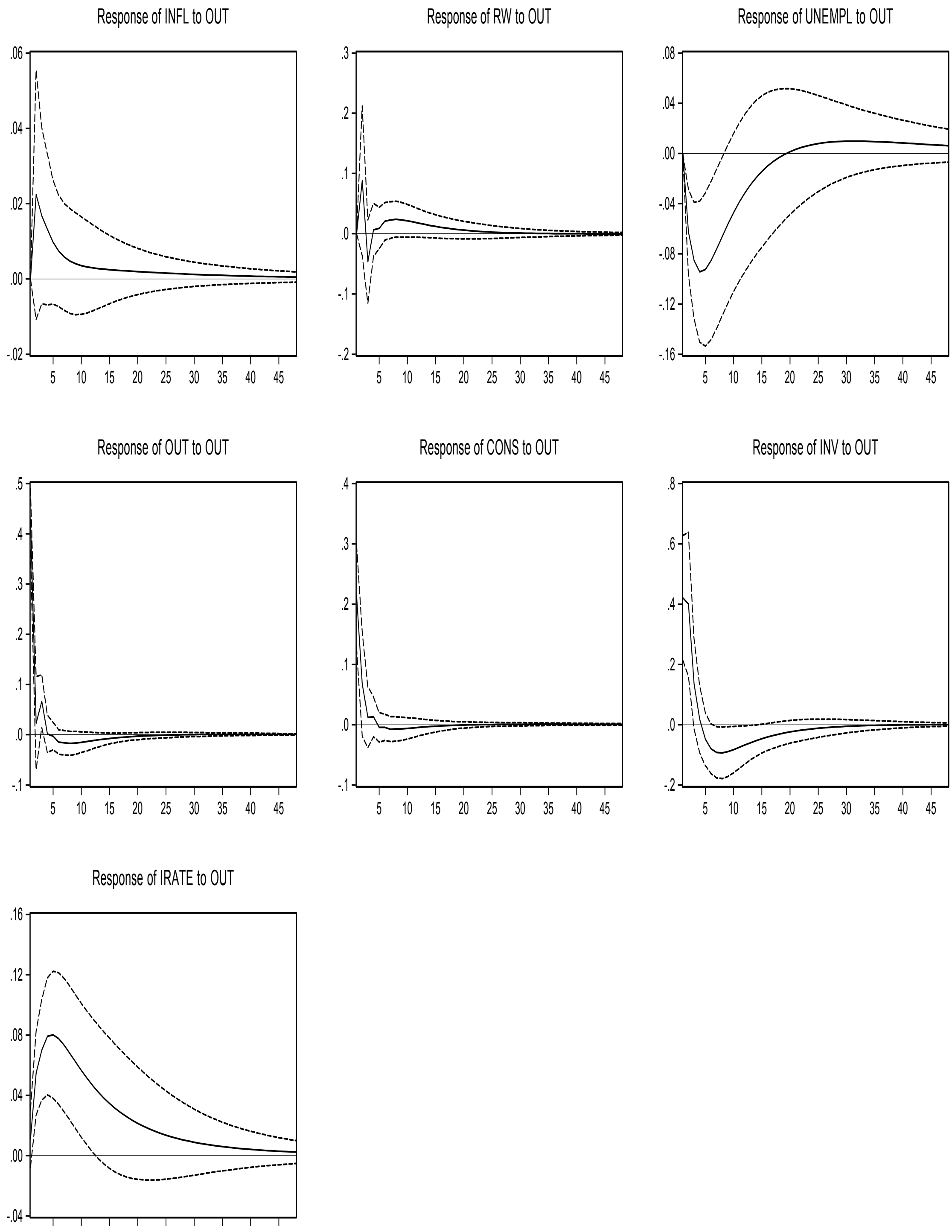

Figure A.5. Responses to an output innovation

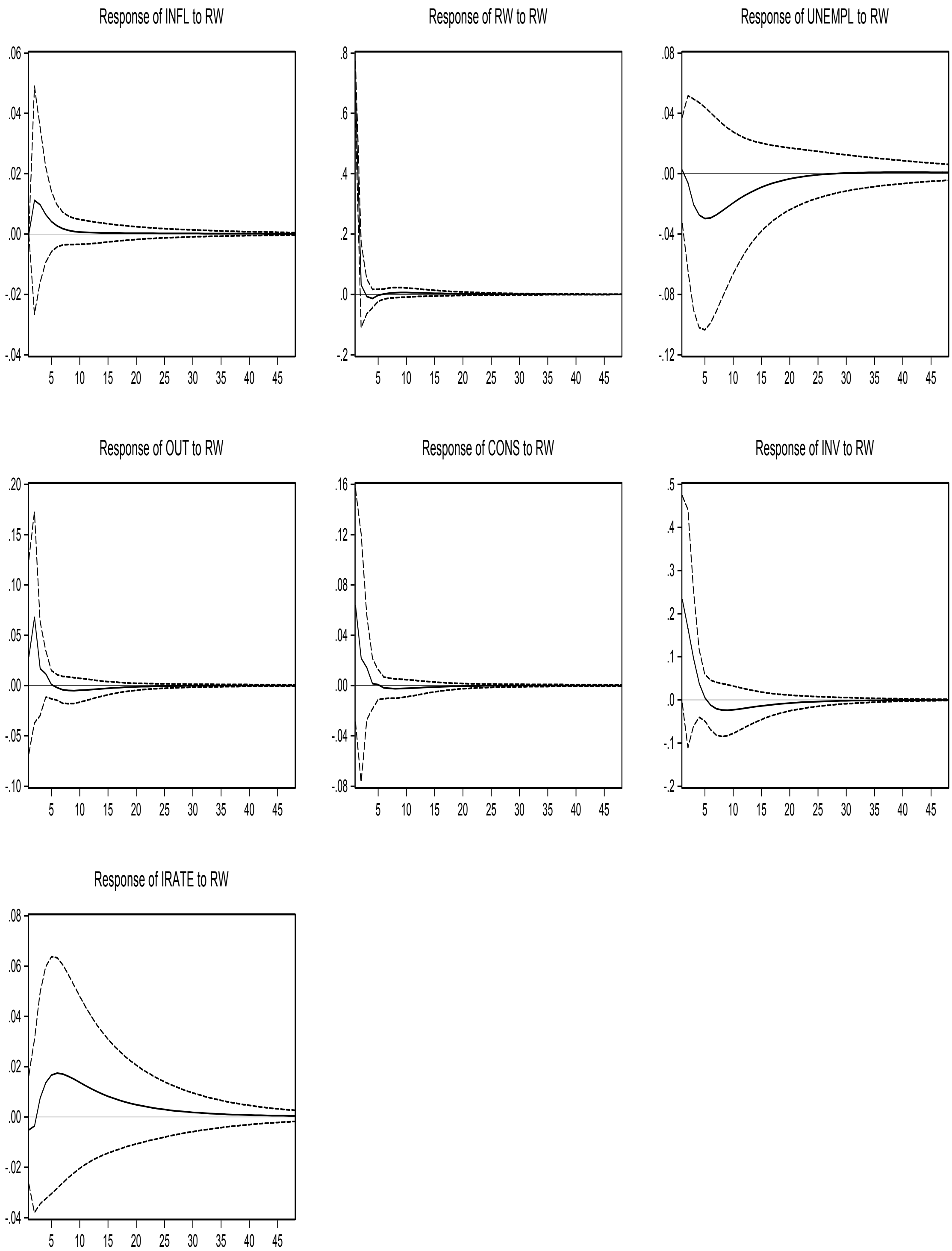

Figure A.6. Responses to a real wage innovation

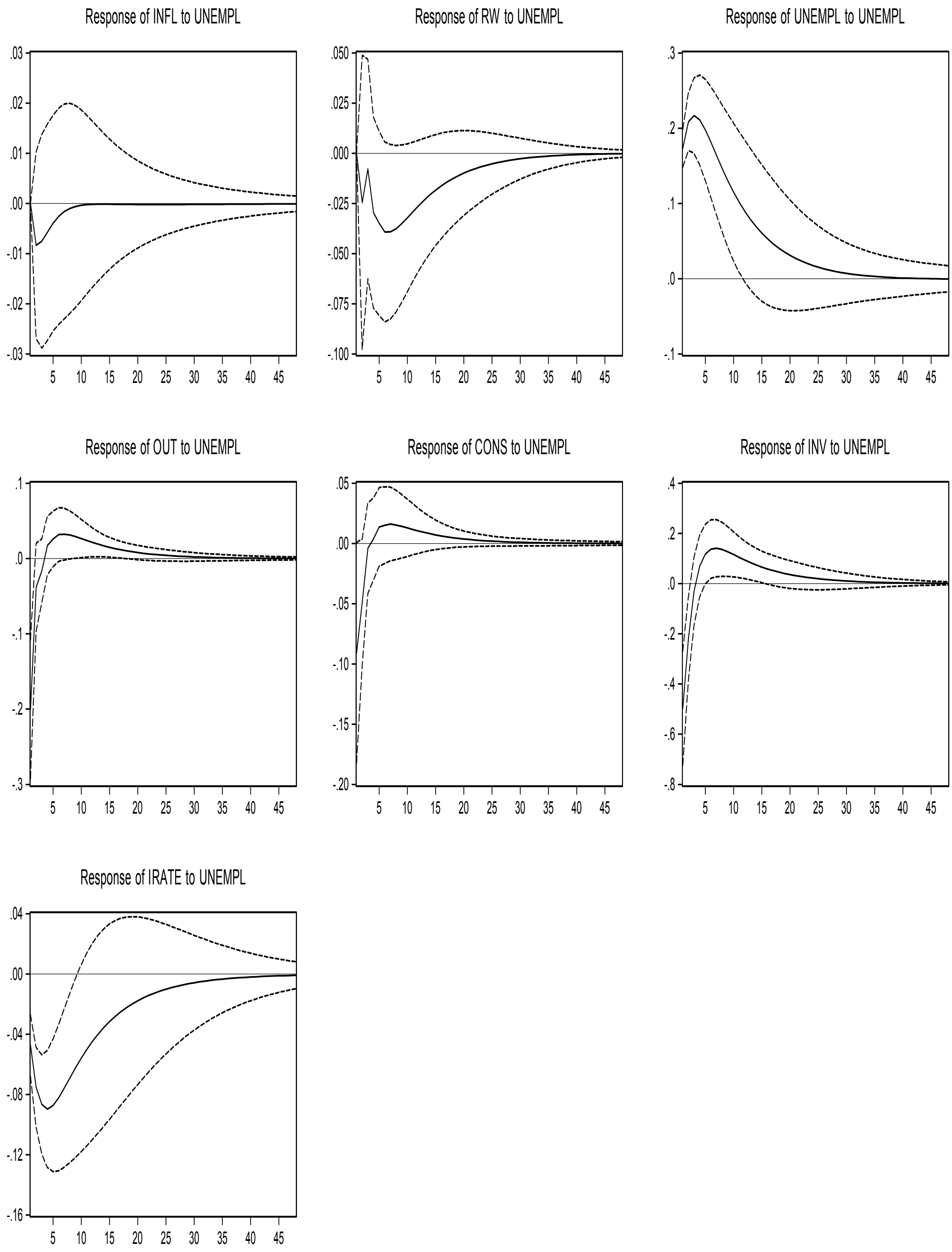

Figure A.7. Responses to an unemployment innovation