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Online Appendix to News-driven housing booms: Spain vs. Germany

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Abstract

This Online Appendix completes the contents of the paper *News-driven housing booms: Spain vs. Germany*, by Guinea, Puch and Ruiz (2022). Those contents are organized along sections E to F below, following appendixes A to D in the main text. In particular, here we provide results for: (E) Alternative VAR Identification and Alternative Shocks; (F) Responses to the different shocks in the theoretical model; and (G) A detailed characterization of the two-sector model with home production and Investment Specific Technical Change (ISTC). Refer to the journal article DOI: 10.1515/bejm-2021-0116 in *The B.E. Journal of Macroeconomics* for any details on the contents of this Online Appendix. A permanent link to this document is at Online Appendix.

Keywords: investment-specific technical change; news shocks; housing booms; wealth effects.

JEL Classification C32, D84, E22, E32.

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ONLINE APPENDIX to News-driven housing booms: Spain vs. Germany*

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August 2022

Abstract

This Online Appendix completes the contents of the paper *News-driven housing booms: Spain vs. Germany*, by Guinea, Puch and Ruiz (2022). Those contents are organized along sections E to F below, following appendixes A to D in the main text. In particular, here we provide results for: (E) Alternative VAR Identification and Alternative Shocks; (F) Responses to the different shocks in the theoretical model; and (G) A detailed characterization of the two-sector model with home production and Investment Specific Technical Change (ISTC). Refer to the journal article DOI: 10.1515/bejm-2021-0116 in *The B.E. Journal of Macroeconomics* for any details on the contents of this Online Appendix. A permanent link to this document is at Online Appendix.

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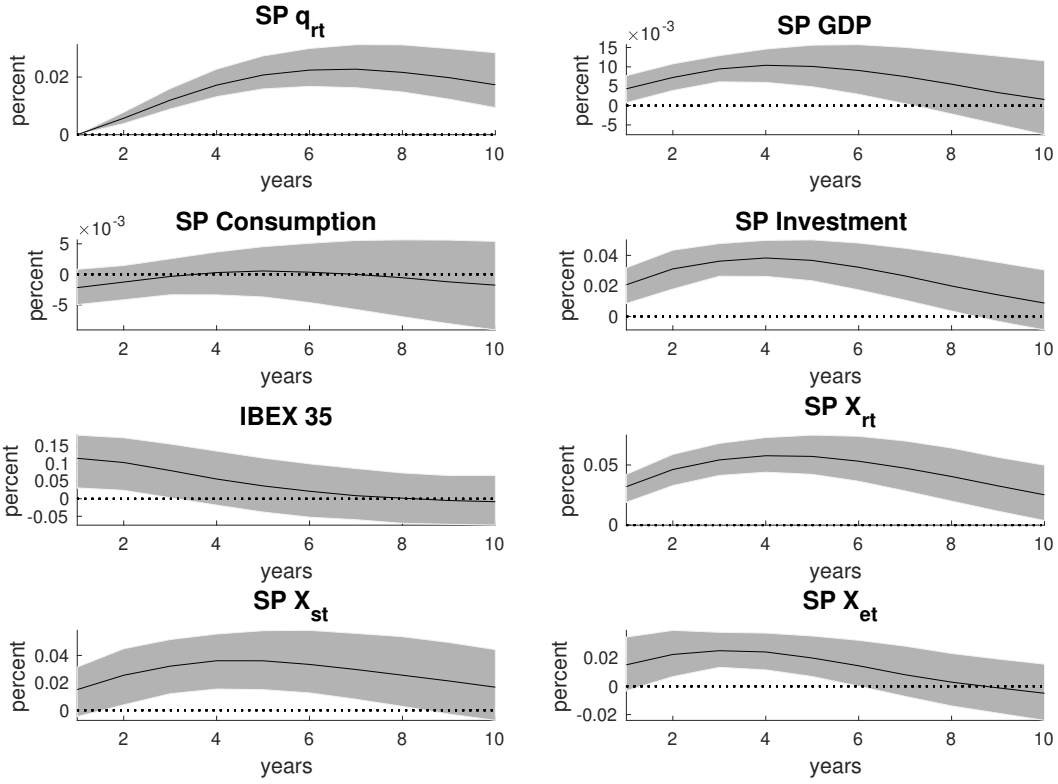
Appendix for Online Use

E Alternative VAR Identification and Alternative Shocks

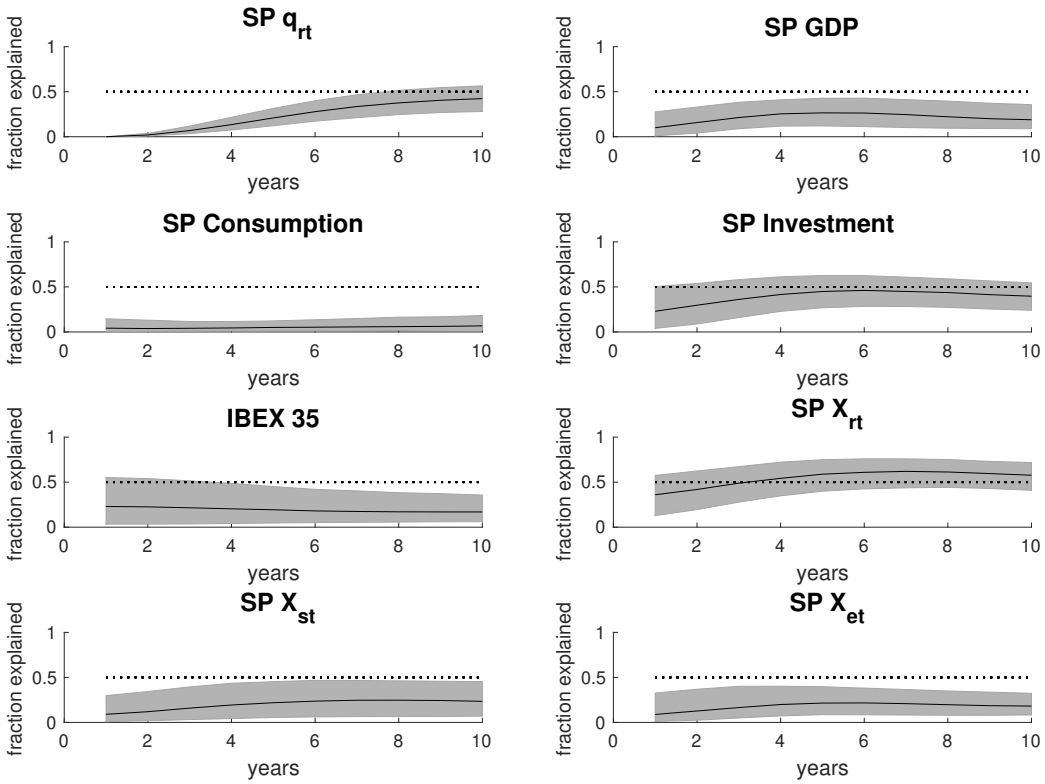
E.1 SPAIN - q_{rt} news shock - alternative VAR

Figure E.1: SPAIN - Impulse responses to a 1% innovation in the q_{rt} news shock - alternative VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.2: SPAIN - Forecast Error Variance (FEV) - q_{rt} news shock - alternative VAR



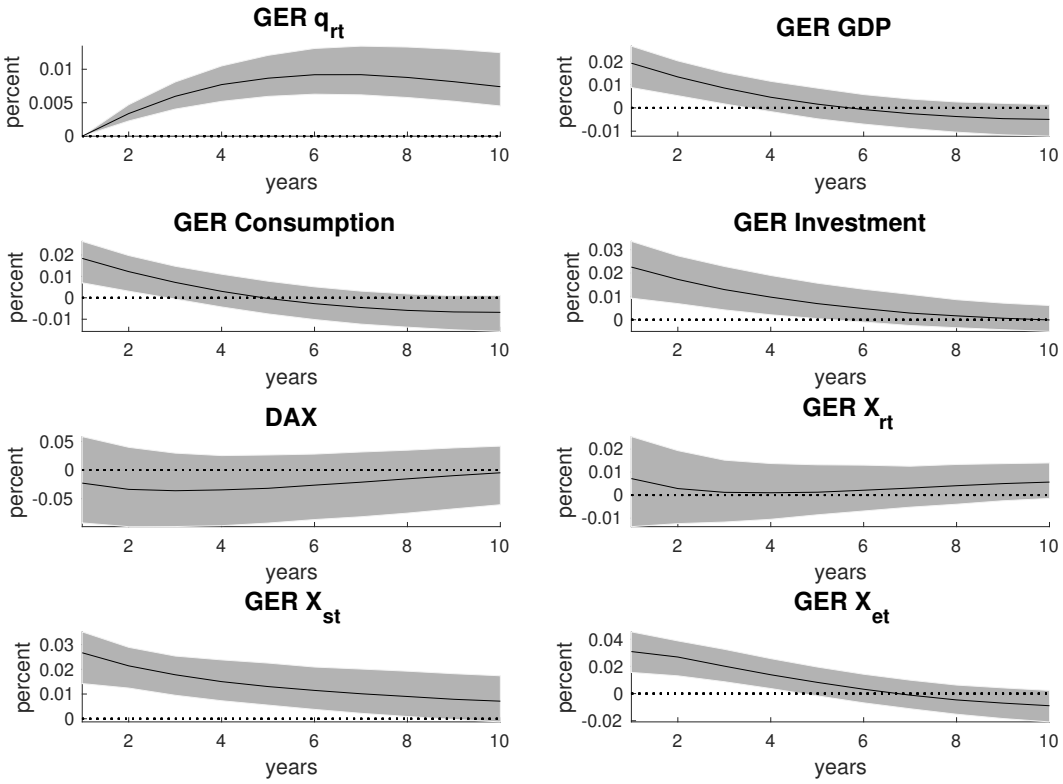
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.1: SPAIN - Maximum Forecast Error Variance (FEV) - q_{rt} news shock; alternative VAR

Spain	q_{rt}	GDP_t	C_t	I_t	IBEX 35	X_e	X_s	X_r
Median contribution	0.41	0.27	0.06	0.46	0.21	0.22	0.23	0.62
Year	10	5	10	5	1	5	7	6

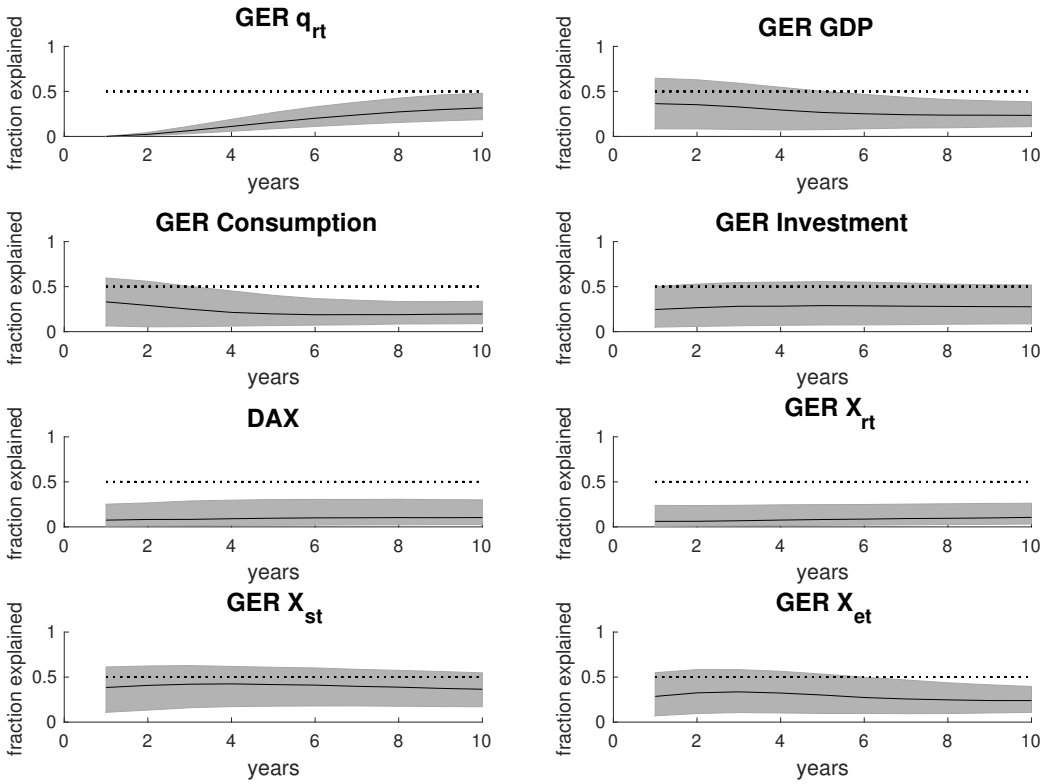
E.2 Germany - q_{rt} news shock - alternative VAR

Figure E.3: GERMANY - Impulse responses to a 1% innov. in the q_{rt} news shock; alternative VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.4: GERMANY - Forecast Error Variance (FEV) - q_{rt} news shock; alternative VAR



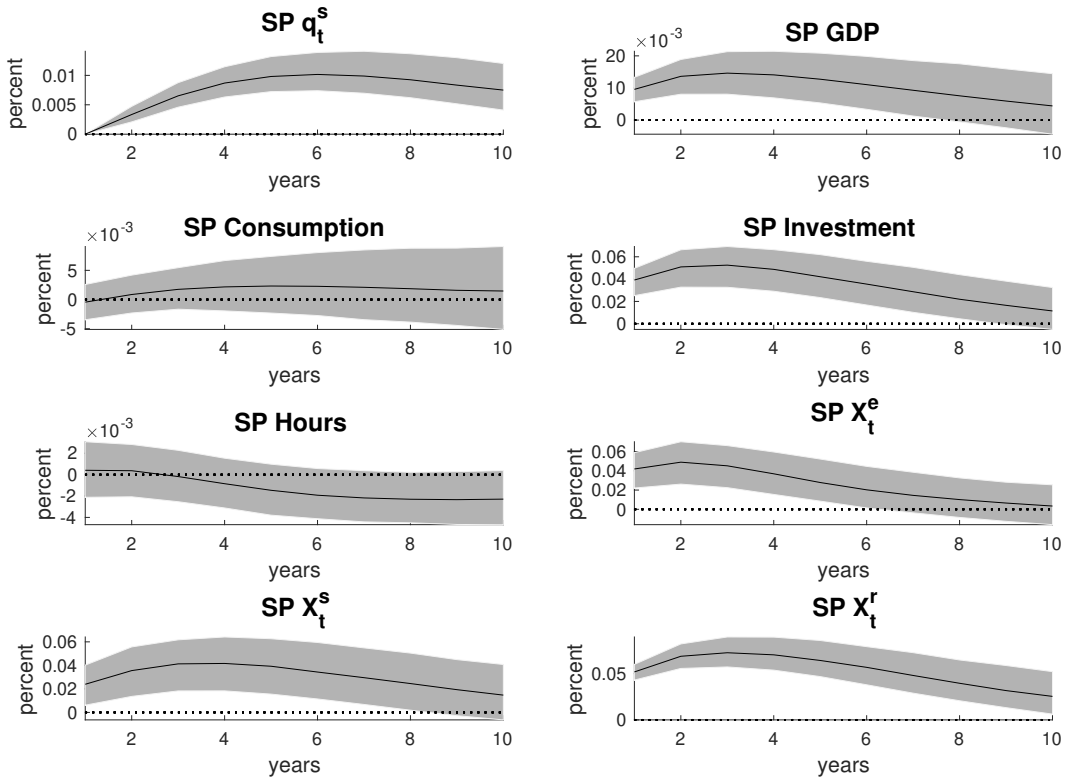
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.2: GERMANY - Maximum Forecast Error Variance (FEV) - q_{rt} news shock; alt. VAR

Germany	q_{rt}	GDP_t	C_t	I_t	DAX	X_e	X_s	X_r
Median contribution	0.32	0.38	0.41	0.20	0.11	0.19	0.41	0.12
Year	10	1	1	6	10	4	5	10

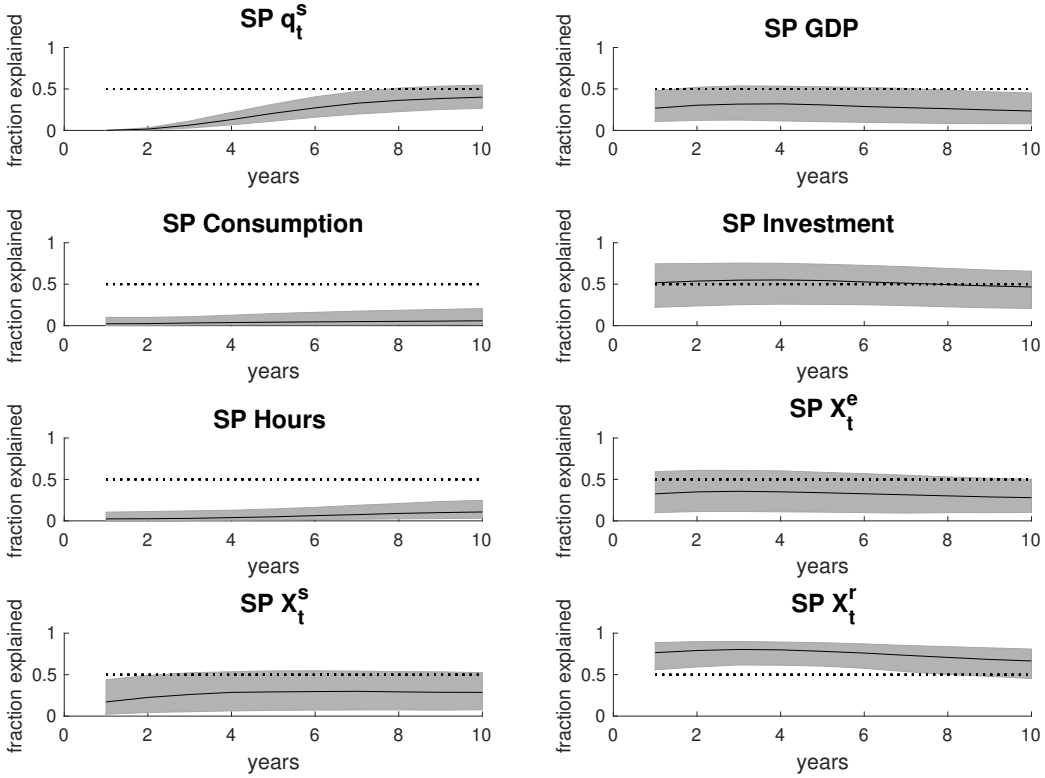
E.3 Spain - q_{st} news shocks - benchmark var

Figure E.5: SPAIN - Impulse responses to a 1% innovation in the q_{st} news shock; benchmark VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.6: SPAIN - Forecast Error Variance (FEV) - q_{st} news shock; benchmark VAR



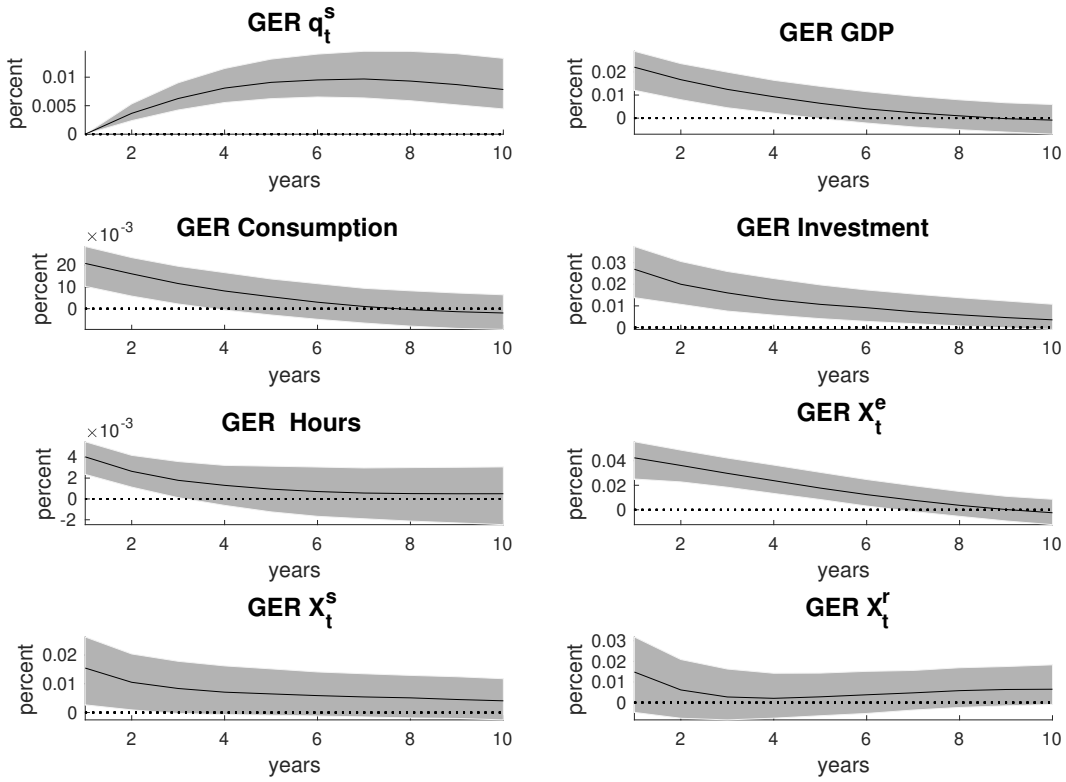
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.3: SPAIN - Maximum Forecast Error Variance (FEV) - q_{st} news shock benchmark VAR

Spain	q_{st}	GDP	Consumption	Investment	Hours	X_e	X_s	X_r
Median contribution	0.40	0.32	0.06	0.55	0.11	0.36	0.30	0.80
Year	10	4	10	4	10	3	7	3

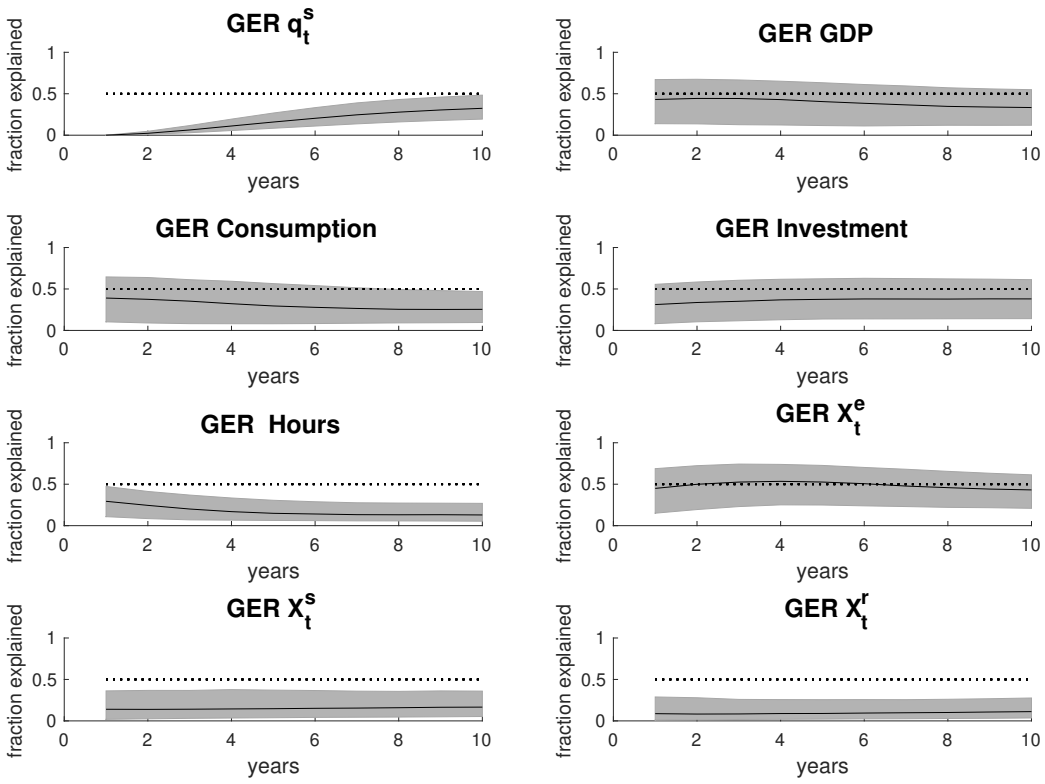
E.4 Germany - q_{st} news shocks - benchmark var

Figure E.7: GERMANY - Impulse responses to a 1% innov. in the q_{st} news shock; benchmark VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.8: GERMANY - Forecast Error Variance (FEV) - q_{st} news shock; benchmark VAR



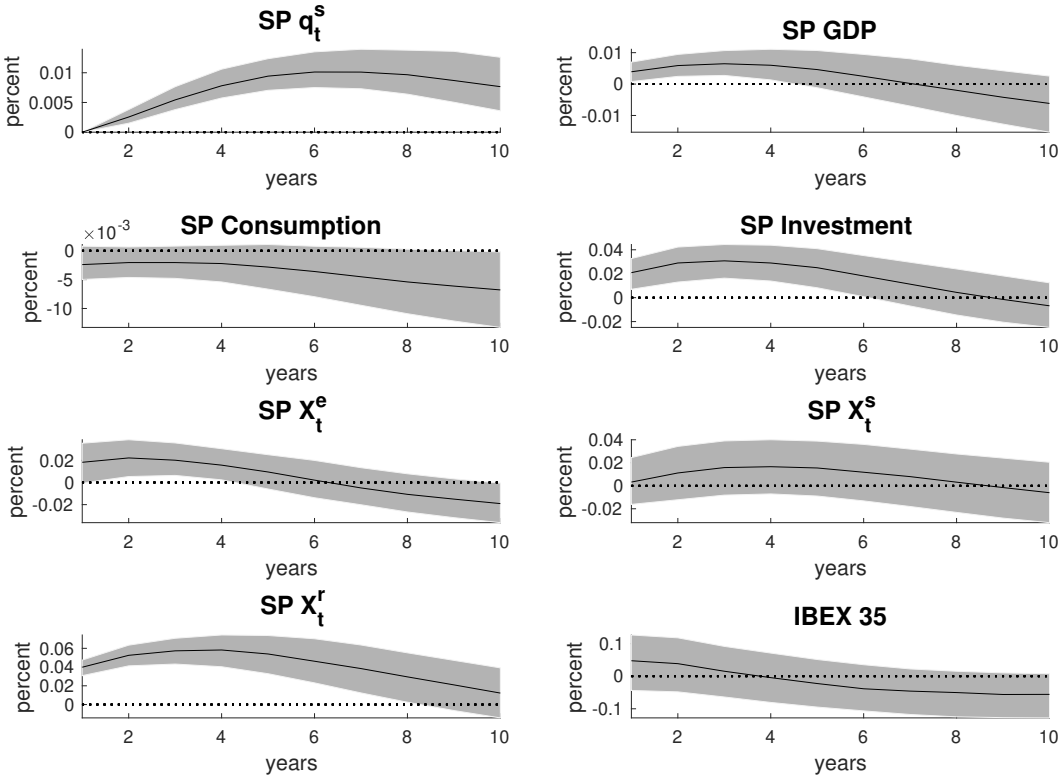
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.4: GERMANY - Maximum Forecast Error Variance (FEV) - q_{st} news shock; benchmark VAR

Germany	q_{st}	GDP	Consumption	Investment	Hours	X_e	X_s	X_r
Median contribution	0.32	0.44	0.39	0.38	0.29	0.53	0.17	0.11
Year	10	2	1	9	1	4	10	10

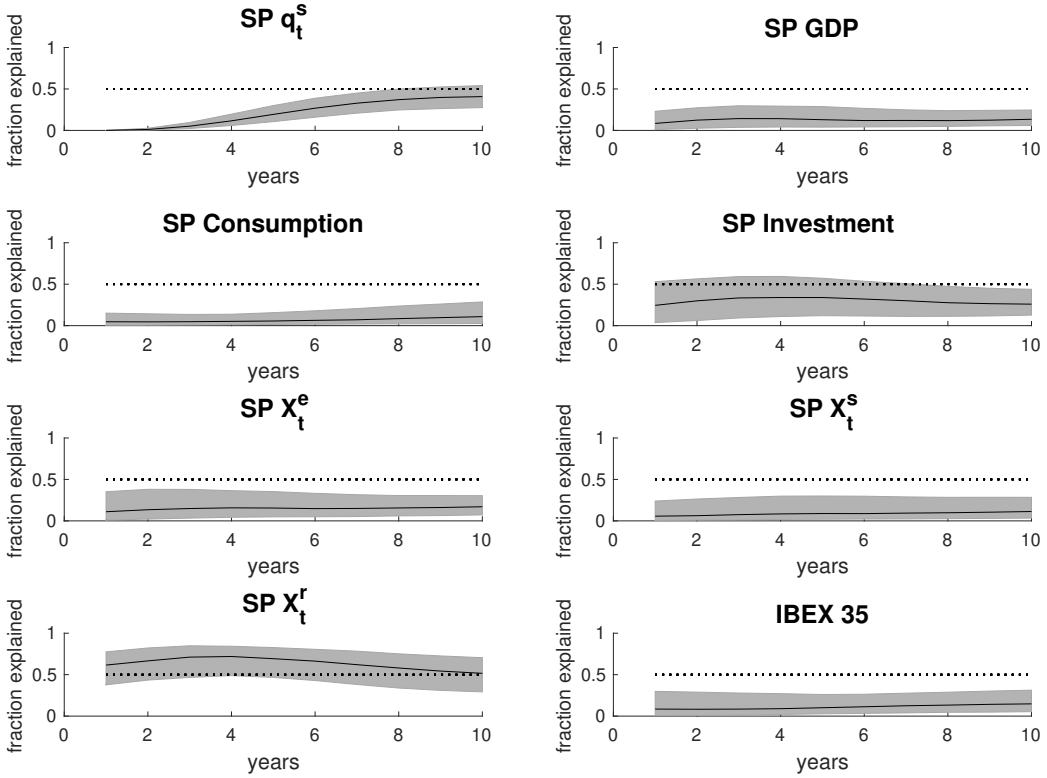
E.5 Spain - q_{st} news shock - Alternative VAR

Figure E.9: SPAIN - Impulse responses to a 1% innovation in the q_{st} news shock; alternative VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.10: SPAIN - Forecast Error Variance (FEV) - q_{st} news shock - alternative VAR



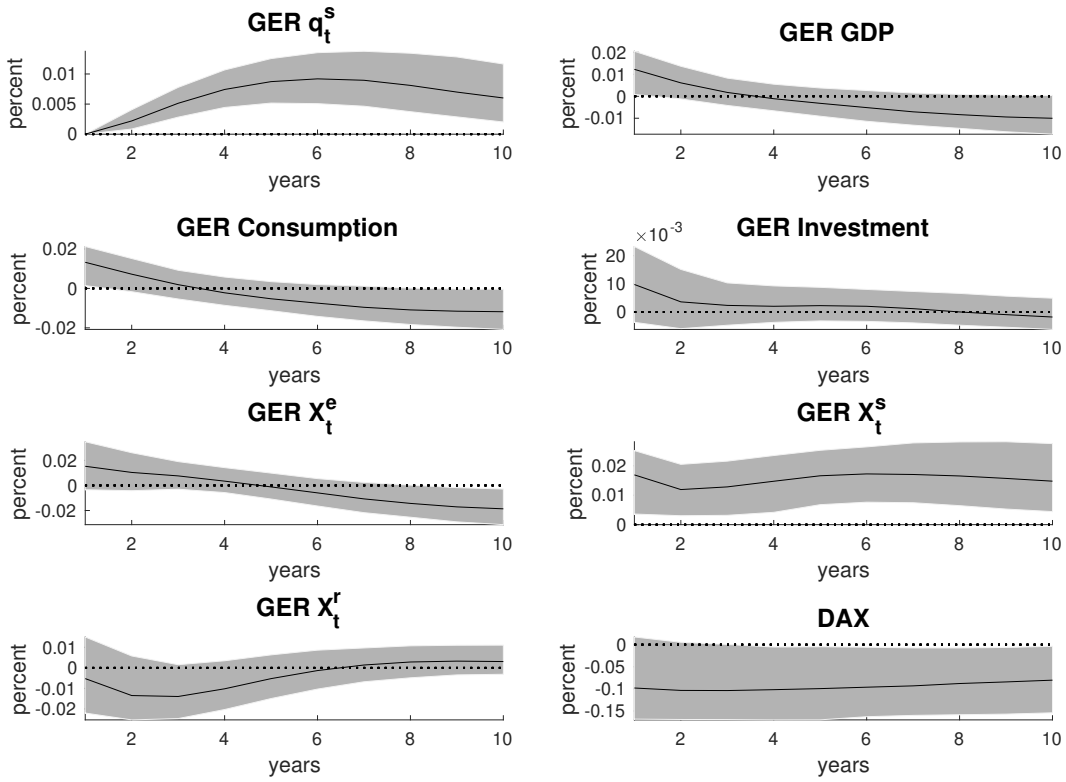
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.5: SPAIN - Maximum Forecast Error Variance (FEV) - q_{st} news shock; alternative VAR

Spain	q_{st}	GDP	Consumption	Investment	X_e	X_s	X_r	IBEX 35
Median contribution	0.41	0.14	0.11	0.34	0.17	0.11	0.72	0.15
Year	10	3	10	5	10	10	4	10

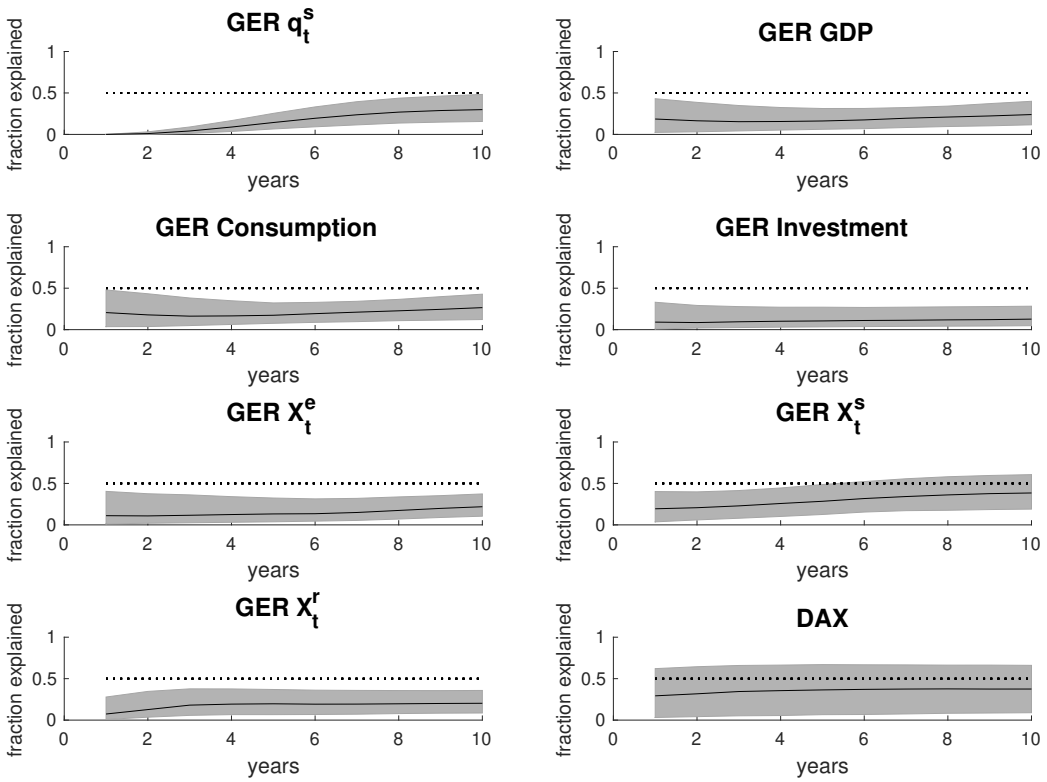
E.6 Germany - q_{st} news shock - Alternative VAR

Figure E.11: GERMANY - Impulse responses to a 1% innov. in q_{st} news shock - alternative VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.12: GERMANY - Forecast Error Variance (FEV) - q_{st} news shock; alternative VAR



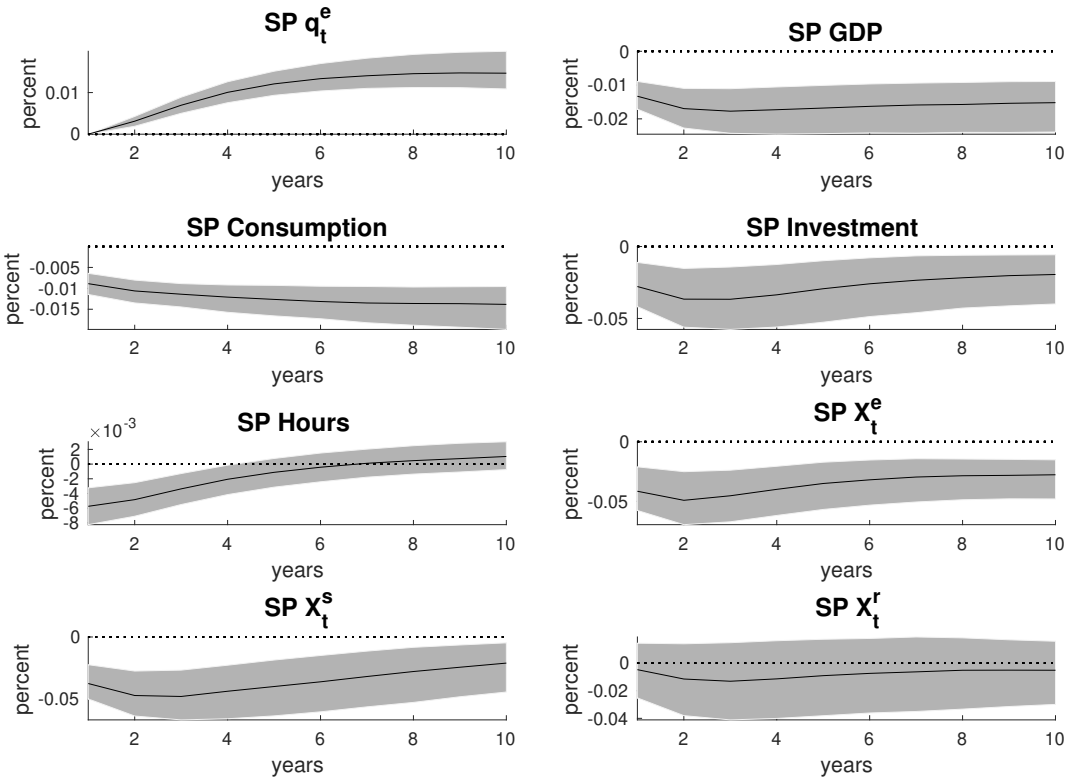
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.6: GERMANY - Maximum Forecast Error Variance (FEV) - q_{st} news shock; alt. VAR

Germany	q_{st}	GDP	Consumption	Investment	X_e	X_s	X_r	DAX
Median contribution	0.30	0.24	0.27	0.13	0.22	0.38	0.20	0.38
Year	10	10	10	10	10	10	10	8

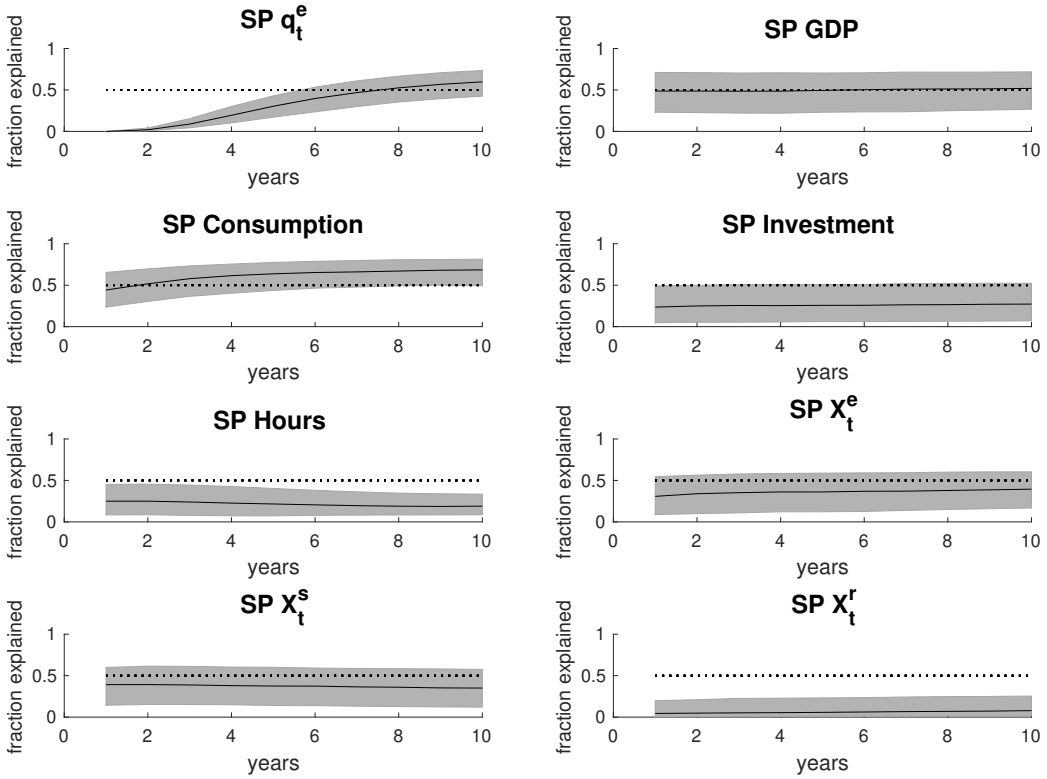
E.7 Spain - q_{et} news shock - benchmark VAR

Figure E.13: SPAIN - Impulse responses to a 1% innovation in the q_{et} news shock; benchmark VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.14: SPAIN - Forecast Error Variance (FEV) - q_{et} news shock; benchmark VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.7: SPAIN - Maximum Forecast Error Variance (FEV) - q_{et} news shocks; benchmark VAR

Spain	q_{et}	GDP	Consumption	Investment	Hours	X_e	X_s	X_r
Median contribution	0.60	0.52	0.68	0.27	0.25	0.39	0.39	0.08
Year	10	10	10	10	1	10	2	10

E.8 Germany - q_{et} news shock - benchmark VAR

Figure E.15: GERMANY - Impulse responses to a 1% innov. in q_{et} news shock; benchmark VAR

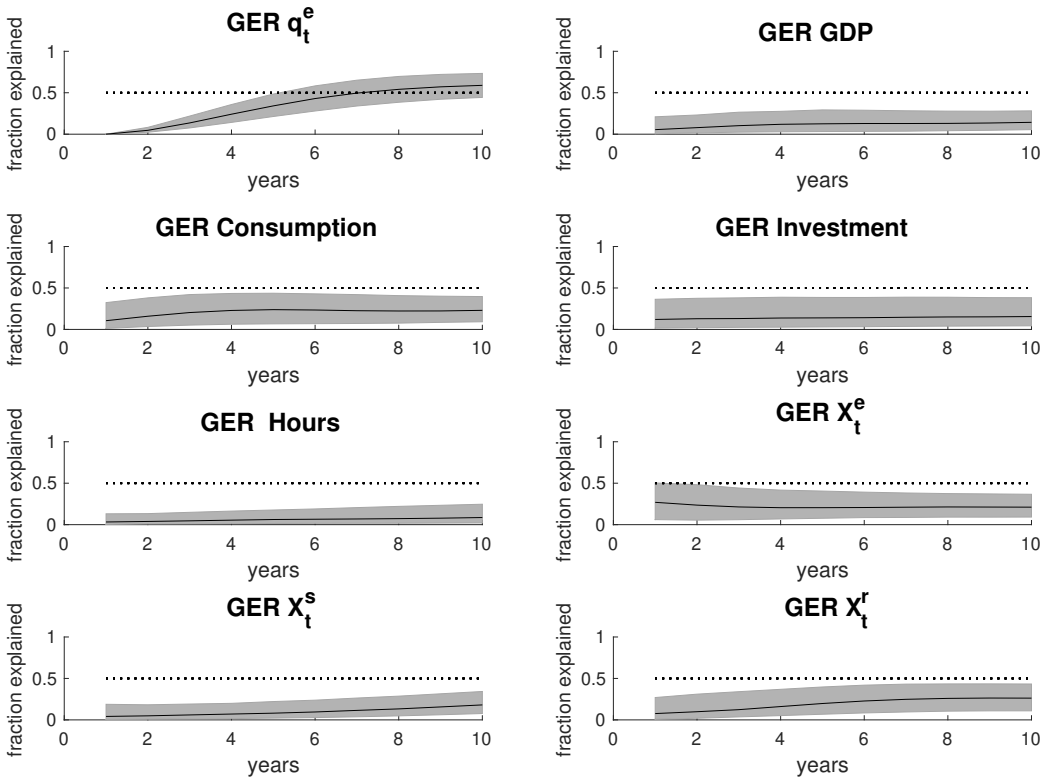


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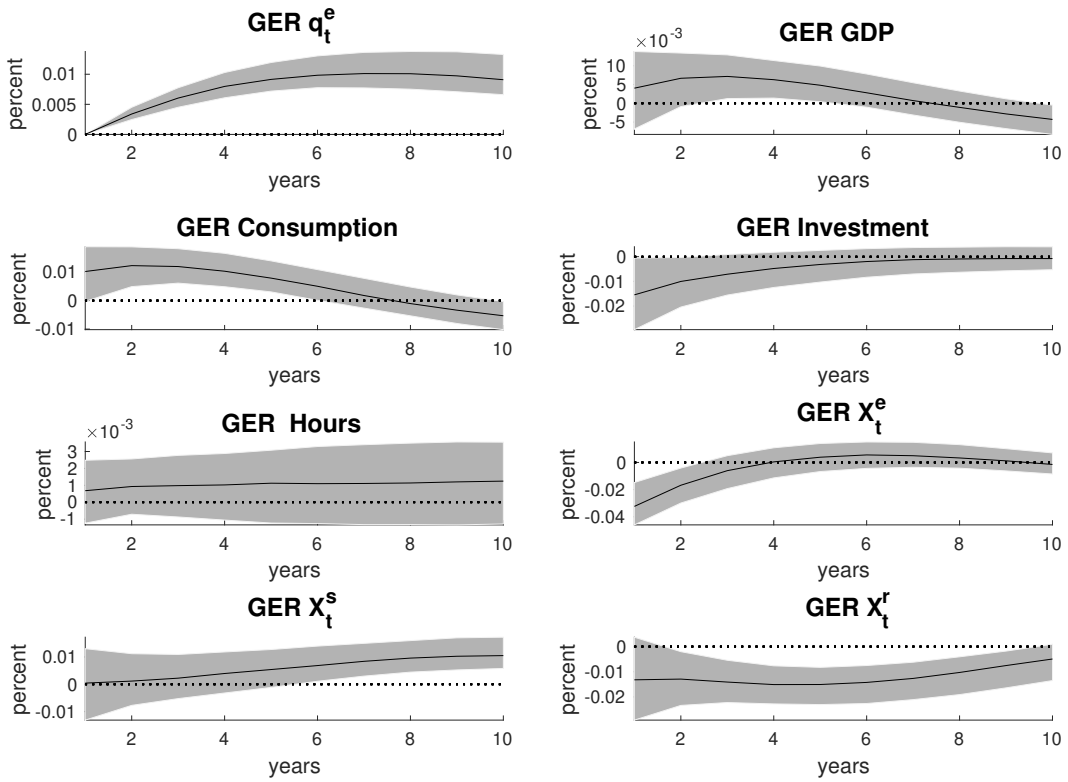
Figure E.16: GERMANY - Forecast Error Variance (FEV) - q_{et} news shock; benchmark VAR



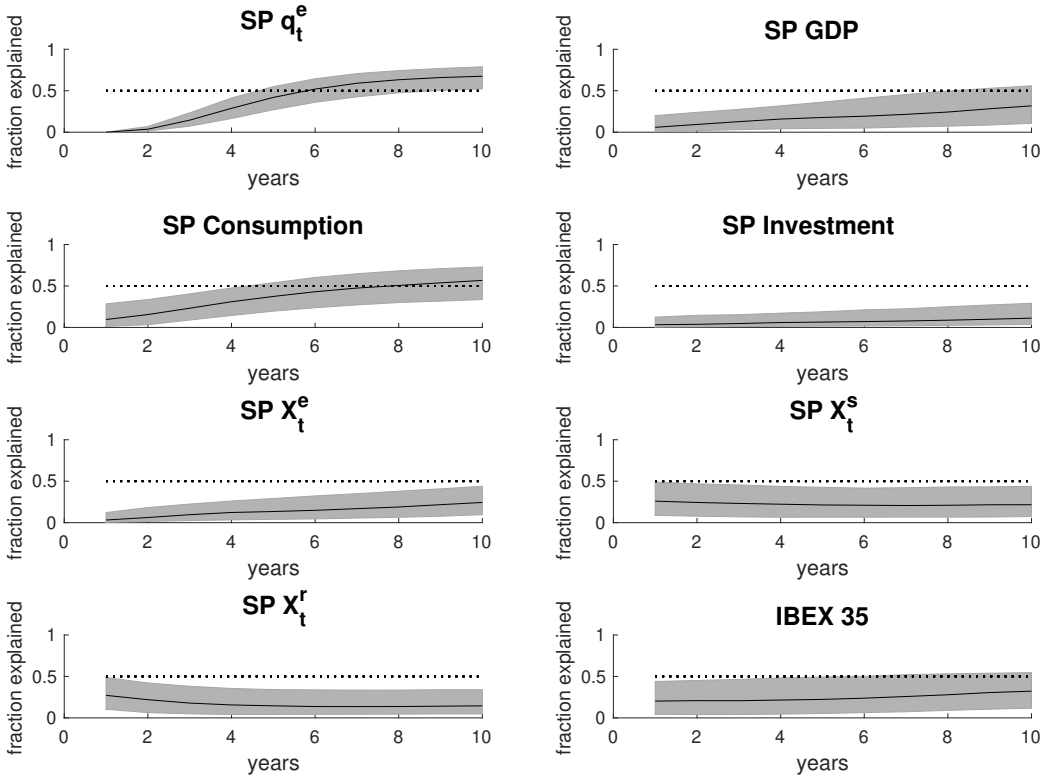
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.8: GERMANY - Maximum Forecast Error Variance (FEV) - q_{et} news shock; bench. VAR

Germany	q_{et}	GDP	Consumption	Investment	Hours	X_e	X_s	X_r
Median contribution	0.59	0.14	0.24	0.16	0.09	0.27	0.18	0.26
Year	10	10	5	10	10	1	10	9

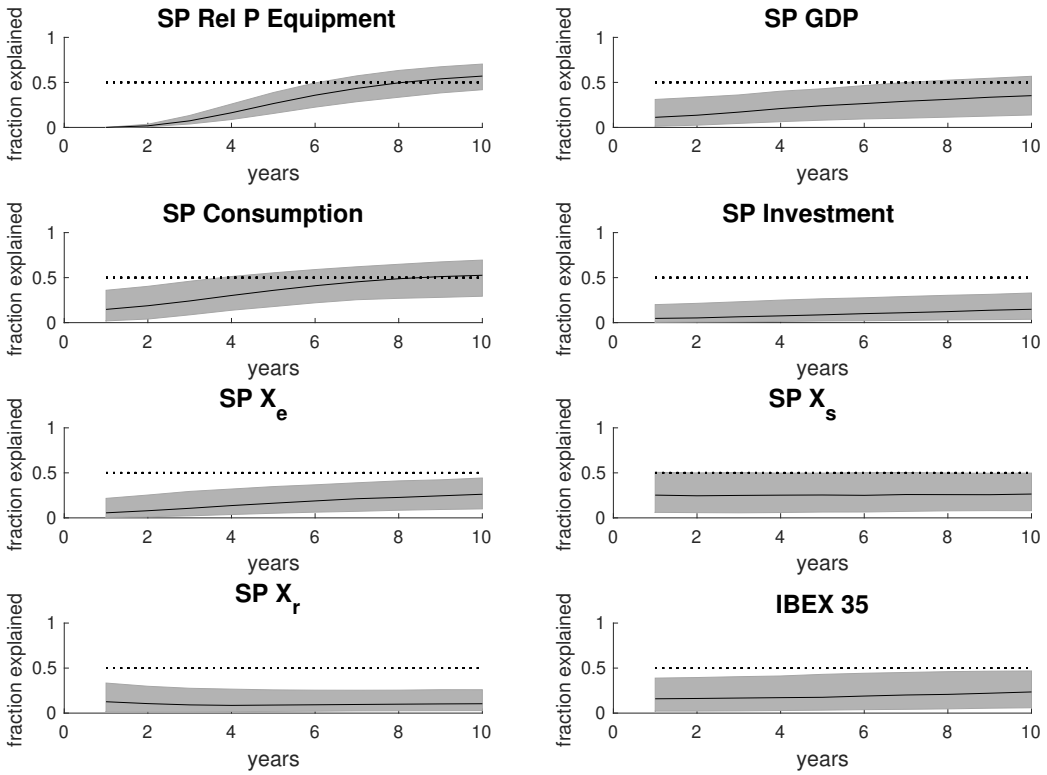
E.9 Spain - q_{et} news shock - alternative VAR

Figure E.17: SPAIN - Impulse responses to a 1% innovation in the q_{et} news shock; alternative VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.18: SPAIN - Forecast Error Variance (FEV) - q_{et} news shock - alternative VAR



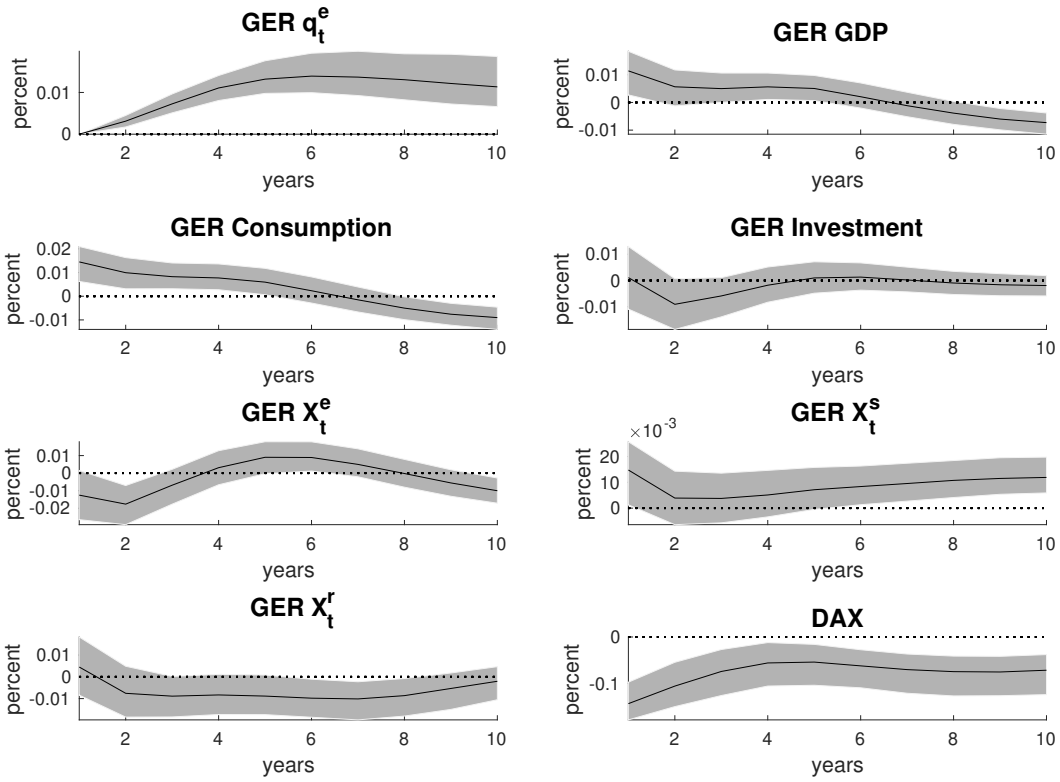
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.9: SPAIN - Maximum Forecast Error Variance (FEV) - q_{et} news shock; alternative VAR

Spain	q_{et}	GDP	Consumption	Investment	X_e	X_s	X_r	IBEX 35
Median contribution	0.67	0.32	0.57	0.11	0.24	0.26	0.27	0.32
Year	10	10	10	10	10	1	1	10

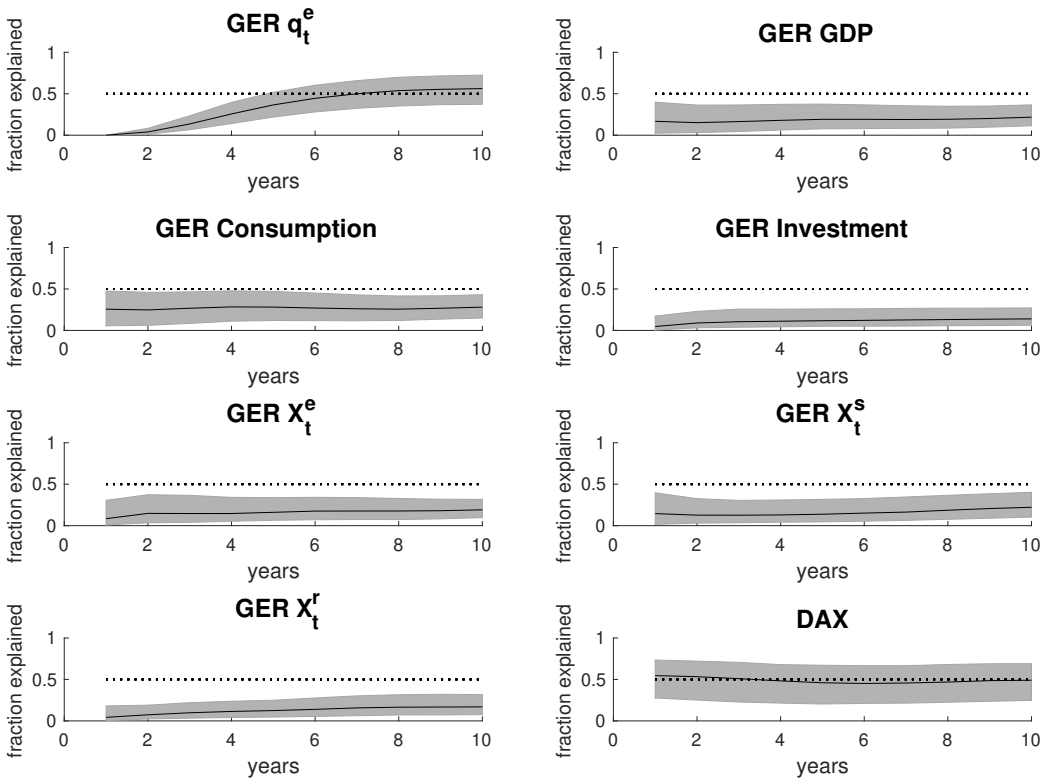
E.10 Germany - q_{et} news shock - alternative VAR

Figure E.19: GERMANY - Impulse responses to a 1% innov. in q_{et} news shock; alternative VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.20: GERMANY - Forecast Error Variance (FEV) - q_{et} news shock; alternative VAR



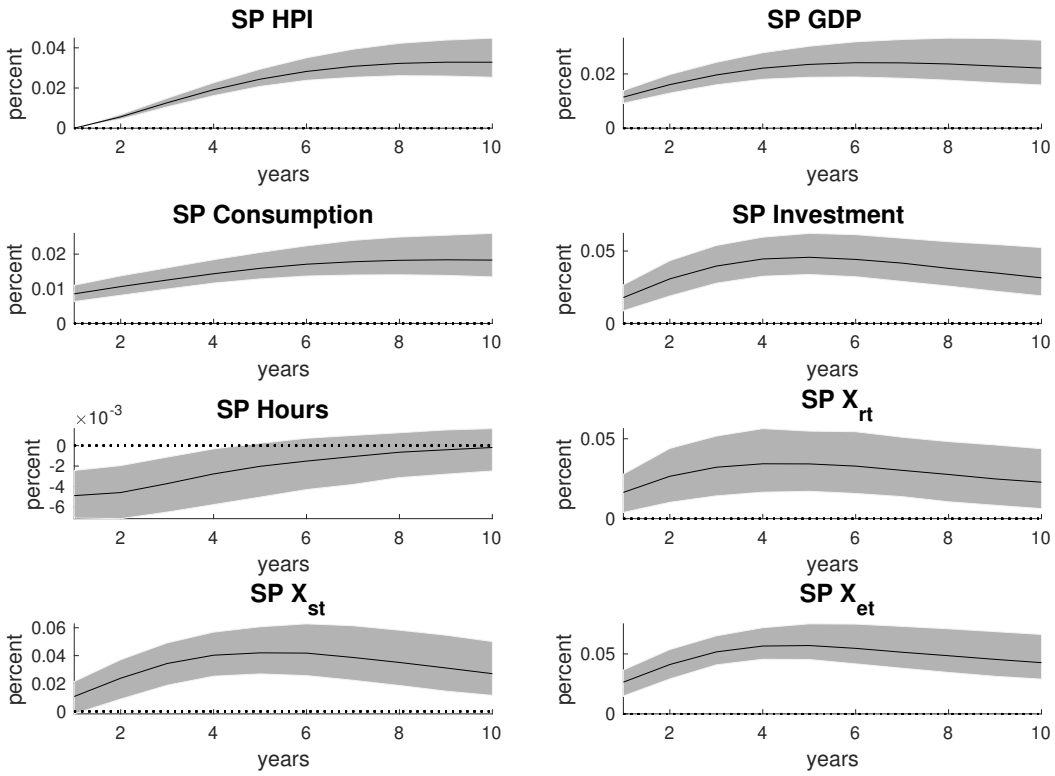
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.10: GERMANY - Maximum Forecast Error Variance (FEV) - q_{et} news shock; alternative VAR

Germany	q_{et}	GDP	Consumption	Investment	X_e	X_s	X_r	DAX
Median contribution	0.56	0.22	0.28	0.14	0.19	0.22	0.17	0.55
Year	10	10	4	10	10	10	10	1

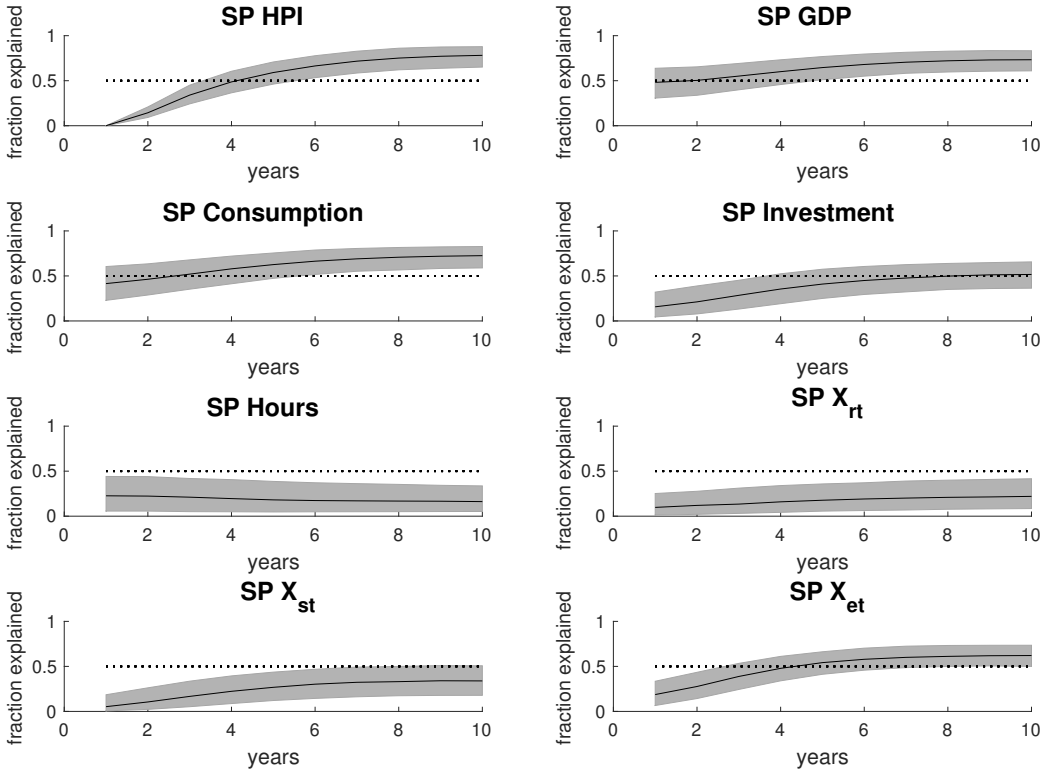
E.11 Spain - HPI news shock - benchmark VAR with housing price news shock

Figure E.21: SPAIN - Impulse responses to a 1% innov. in the HPI news shock; benchmark VAR



***Notes**:* Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.22: SPAIN - Forecast Error Variance (FEV) - HPI news shock - benchmark VAR



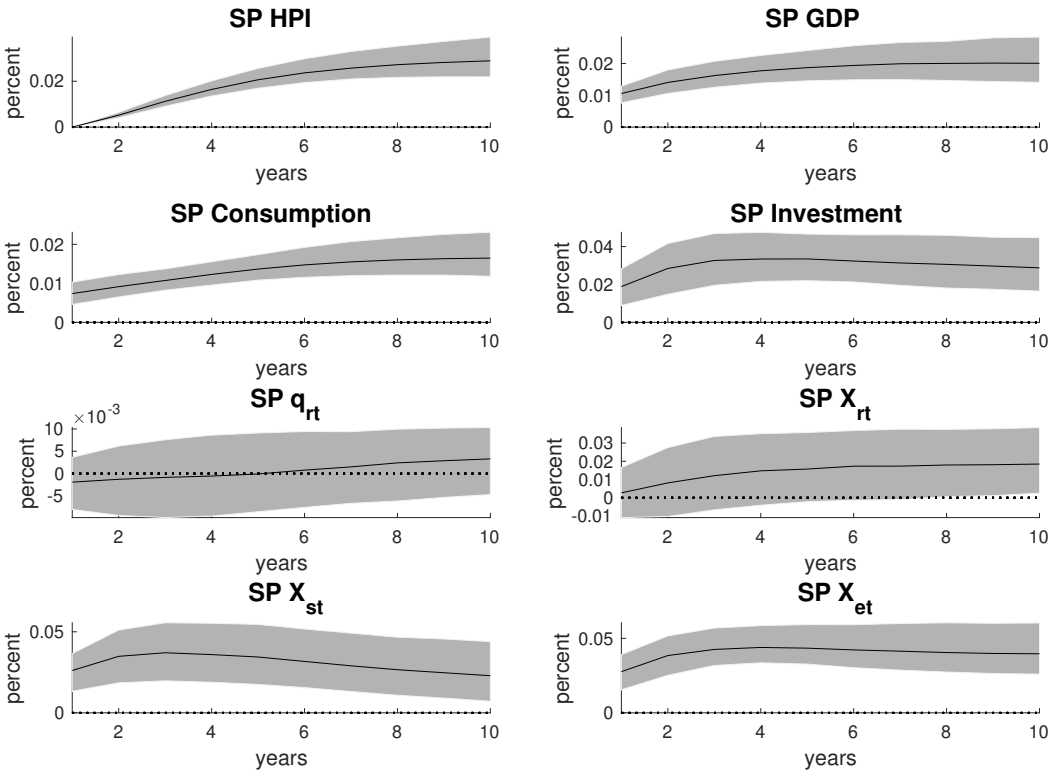
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.11: SPAIN - Maximum Forecast Error Variance (FEV) - HPI news shock; benchmark VAR

Spain	HPI	GDP	Consumption	Investment	X_e	X_s	X_r	IBEX 35
Median contribution	0.73	0.73	0.66	0.57	0.18	0.33	0.40	0.57
Year	10	10	10	9	1	10	9	10

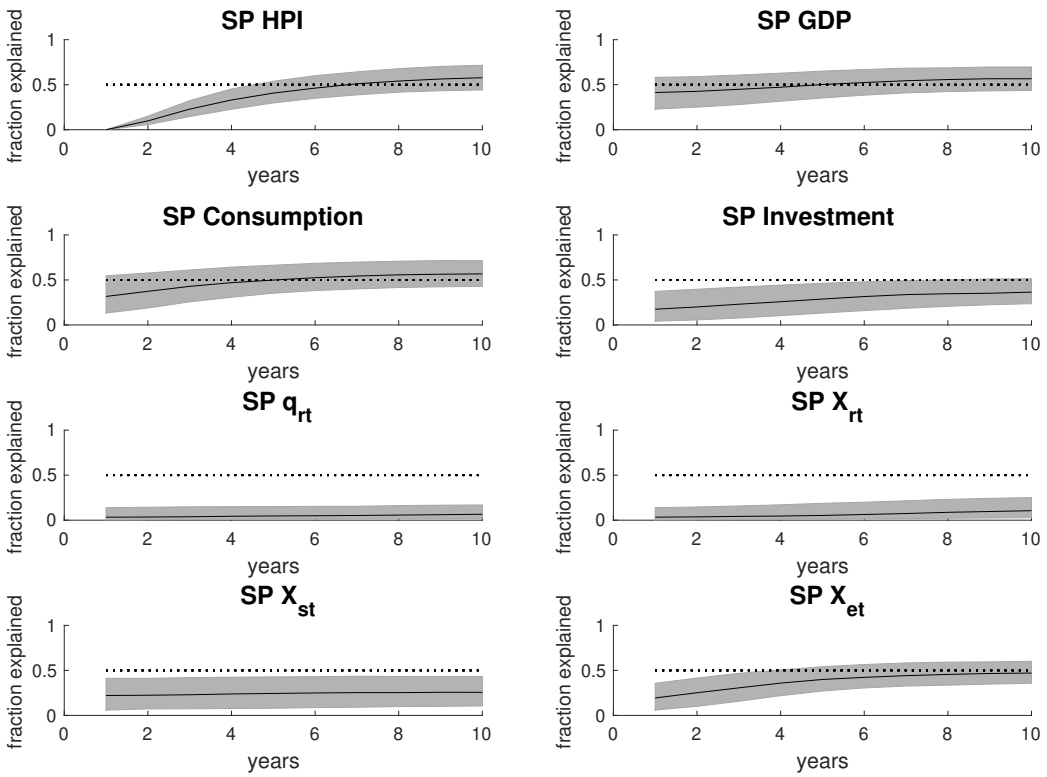
E.12 Spain - HPI news shock - alternative with HPI news shock and RPI in VAR

Figure E.23: SPAIN - Impulse responses to a 1% innov. in the HPI news shock; alternative VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.24: SPAIN - Forecast Error Variance (FEV) - HPI news shock - alternative VAR



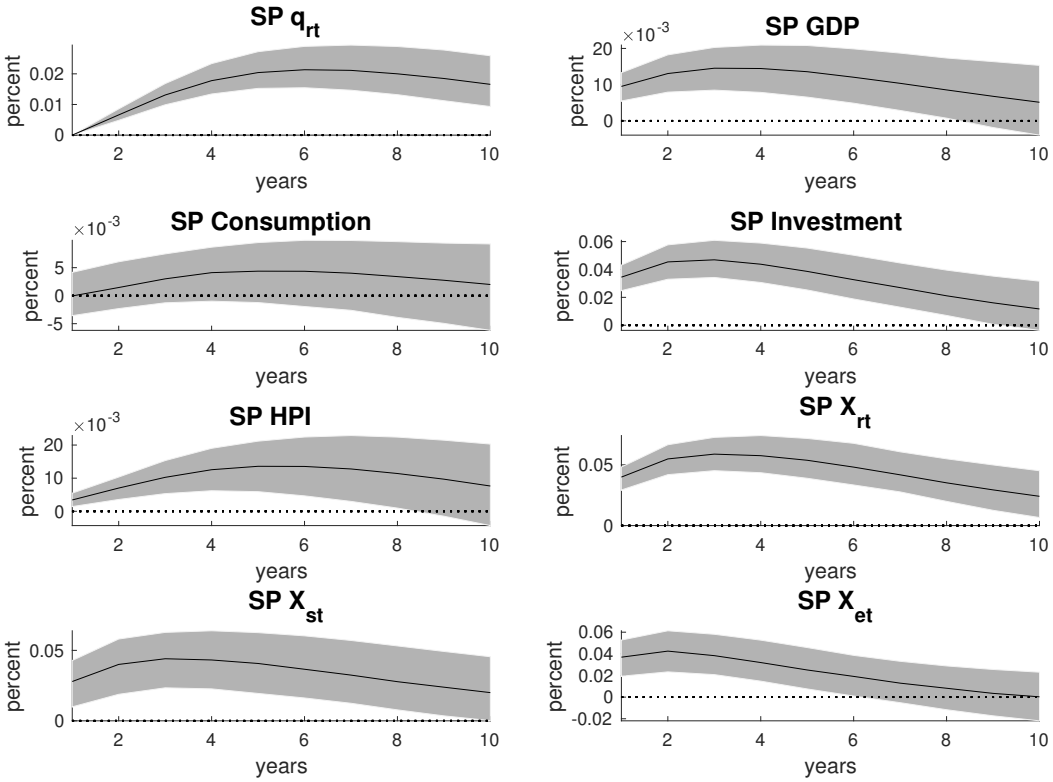
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.12: SPAIN - Maximum Forecast Error Variance (FEV) - HPI news shock; alternative VAR

	HPI	GDP	Consumption	Investment	q_{rt}	X_r	X_s	X_e
Median contribution	0.55	0.58	0.54	0.40	0.07	0.14	0.28	0.46
Year	10	10	10	10	10	10	10	10

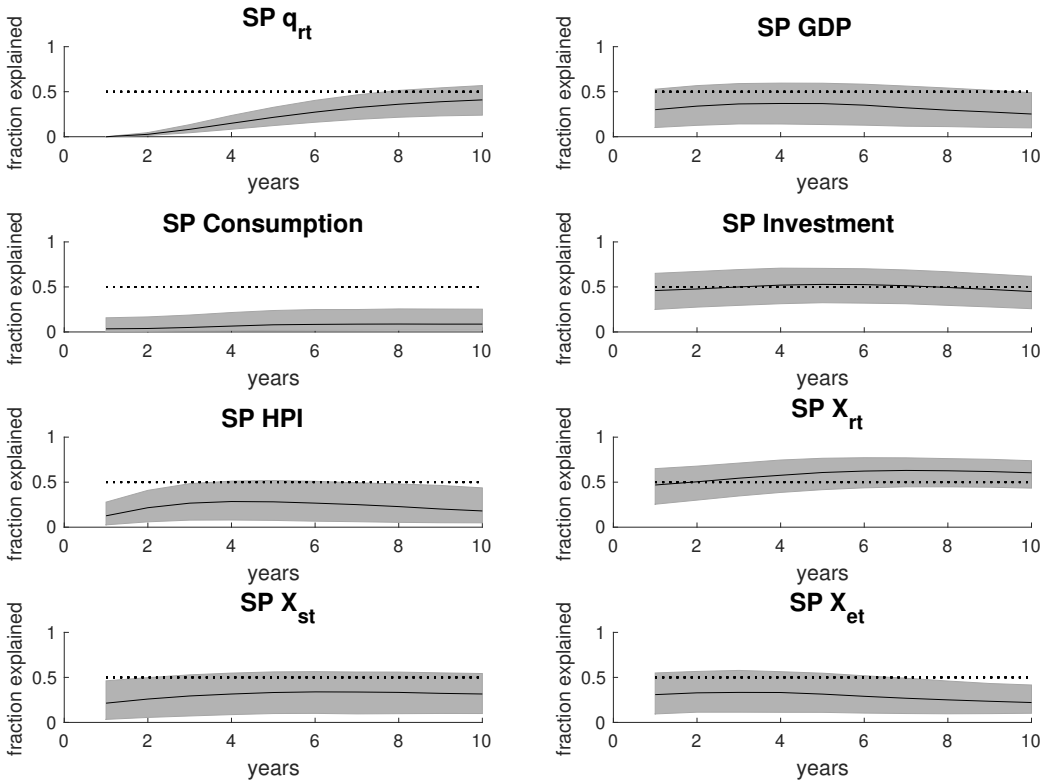
E.13 Spain - HPI news shock - benchmark with RPI and alternative HPI in VAR

Figure E.25: SPAIN - Impulse responses to a 1% innov. in the RPI news shock; alternative VAR



Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure E.26: SPAIN - Forecast Error Variance (FEV) - RPI news shock - alternative VAR

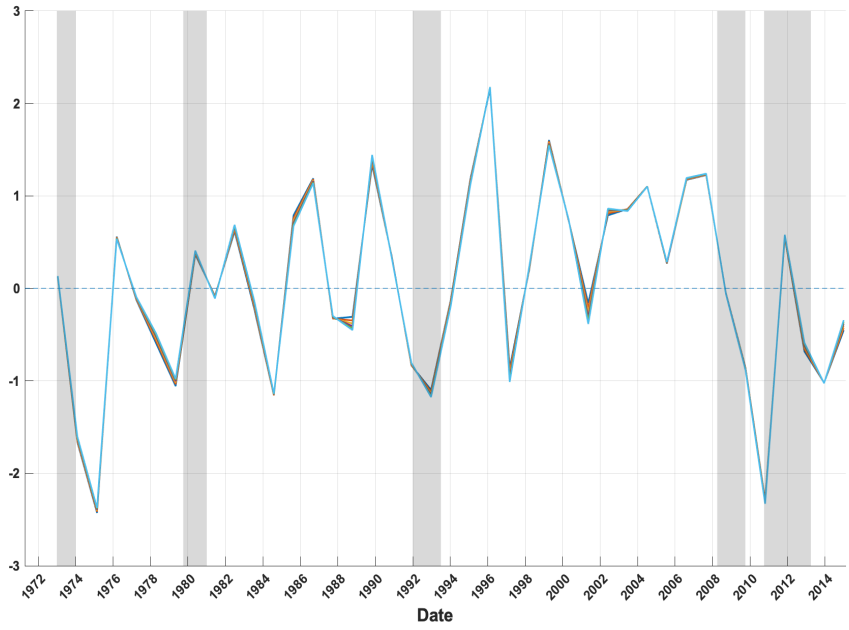


Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.13: SPAIN - Maximum Forecast Error Variance (FEV) - RPI news shock; alternative VAR

	q_{rt}	GDP	Consumption	Investment	HPI	X_r	X_s	X_e
Median contribution	0.41	0.37	0.09	0.53	0.28	0.63	0.34	0.33
Year	10	4	8	5	4	7	6	3

Figure E.27: Spain – The identified news shocks on residential RPI from 10 to 15 periods (years) truncation horizon.



Note: The shaded areas correspond with recession dates for Spain.

Table E.14: Two sample Kolmogorov-Smirnov test for residential RPI news shock from 10 to 15 truncation periods.

Truncation period	11	12	13	14	15
Statistic K-S Test	0.068	0.068	0.068	0.091	0.091
p-value	0.999	0.999	0.999	0.990	0.990

Appendix for Online Use

F Theoretical Model

F.1 q_{rt}, News Shock

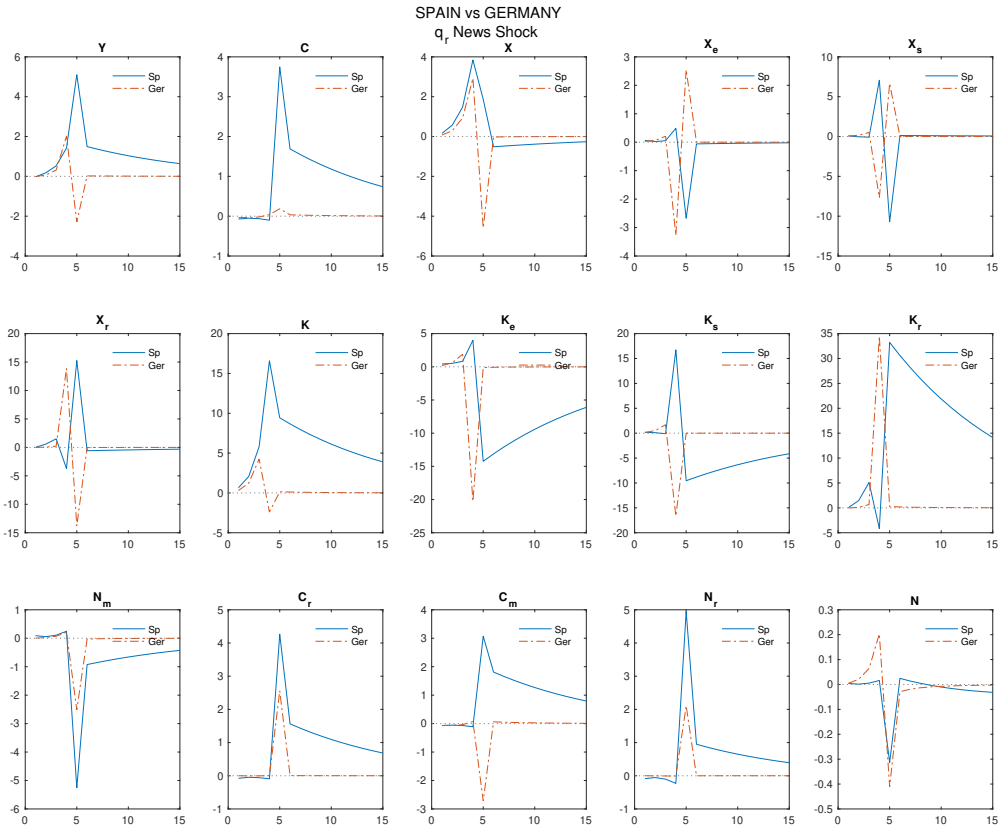


Figure F.1: q_{rt} news shock effects on all model's variables

Figure F.1 shows the overall IRFs of model's variables following a news shock on the relative prices of residential investment increases of 1%.

F.2 q_{st}, News Shock - all var

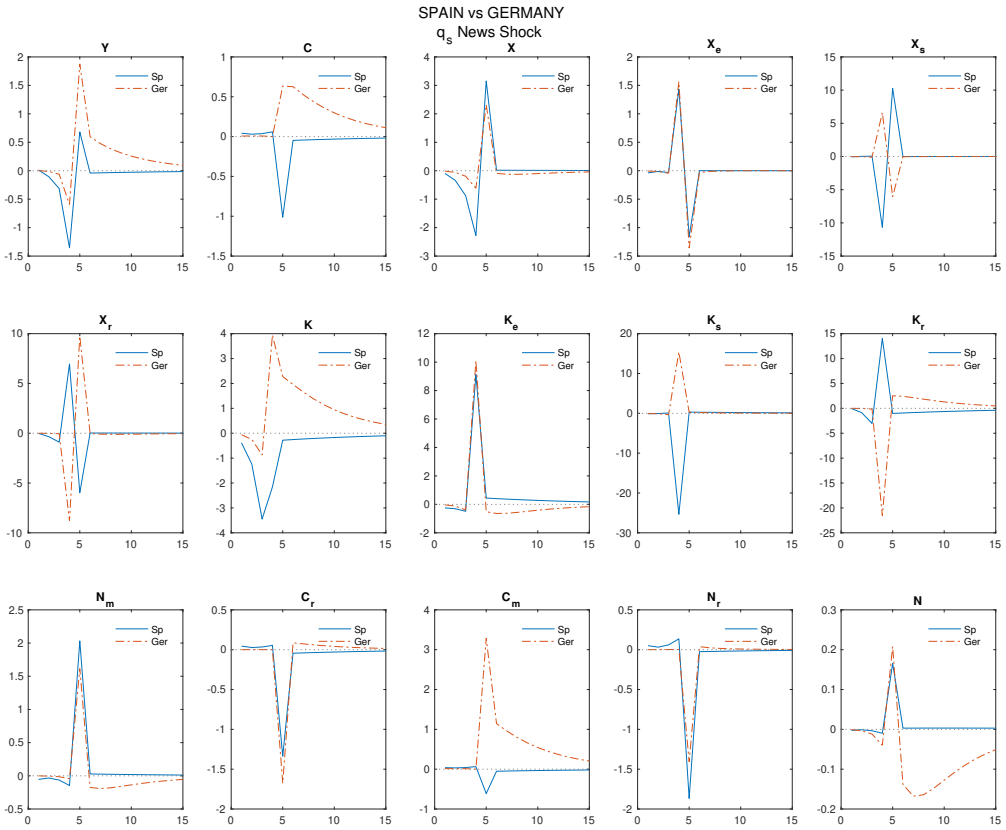


Figure F.2: q_{st} news shock effects on all model's variables

Figure F.2 shows the overall IRFs of model's variables following a news shock on the relative prices of business structures increases of 1%.

F.3 q_{et}, News Shock - all var

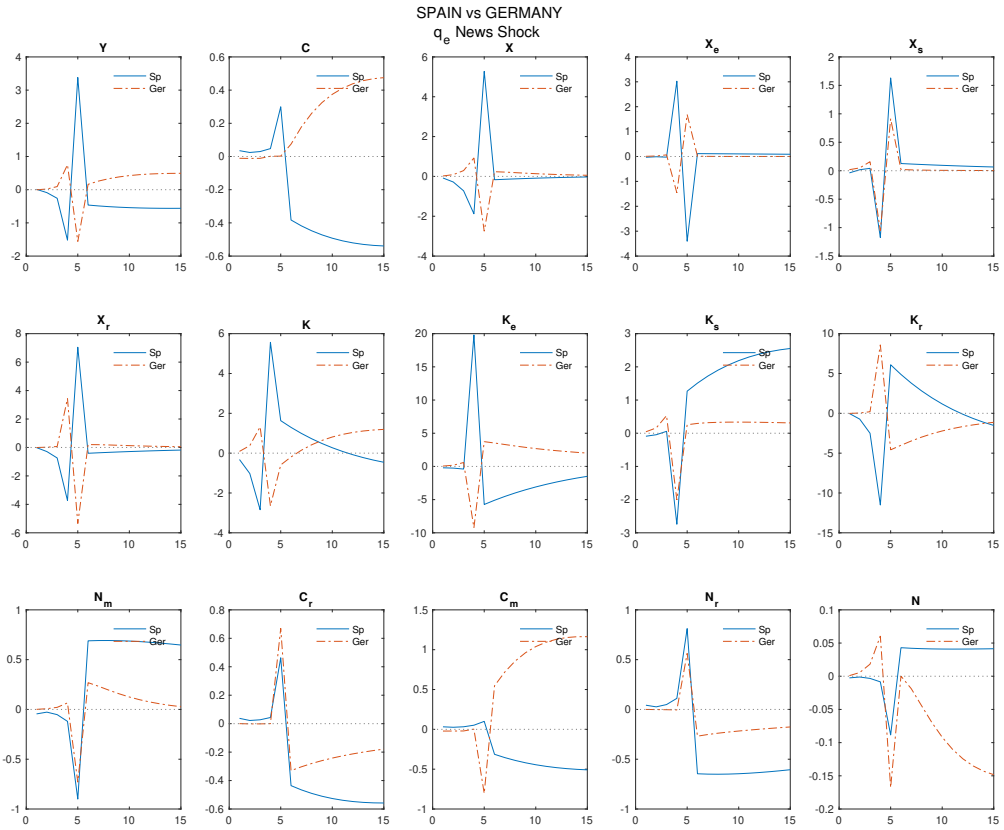


Figure F.3: q_{et} news shock effects on all model's variables

Figure F.3 shows the overall IRFs of model's variables following a news shock on the relative prices of equipment investment decreases of 1%.

F.4 A_t news shock

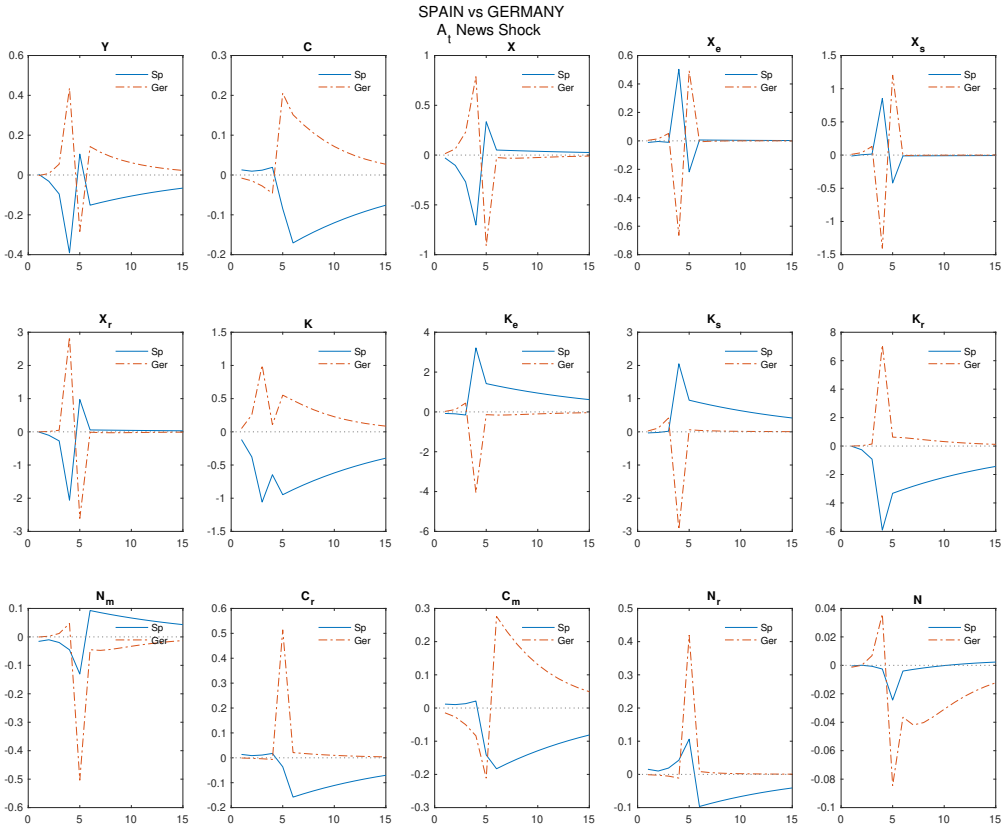


Figure F.4: A_t News Shock

Fig. F.4 shows the IRFs model variables following a news shock on the home production neutral progress of a magnitude of 1%

F.5 TFP vs residential RPI news shock – Spain and Germany

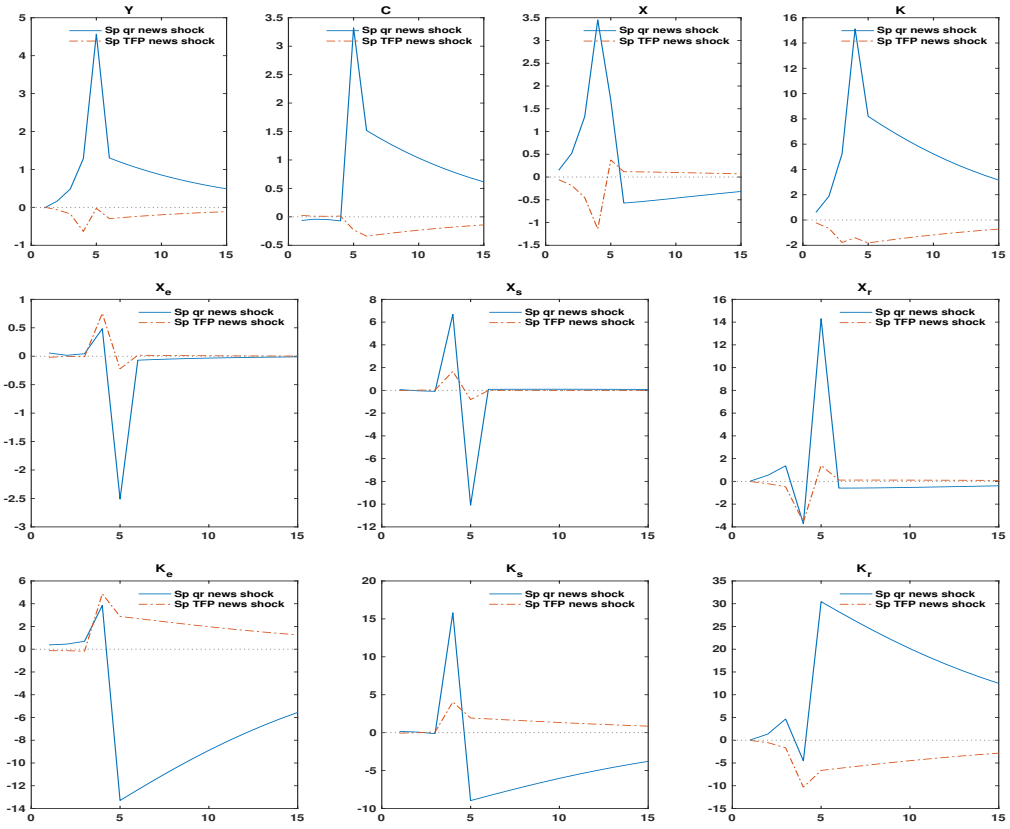


Figure F.5: TFP vs residential RPI News Shock – Spain

Fig. F.5 shows the IRFs of model variables following a news shock either on TFP or the residential RPI of a magnitude of 1%.

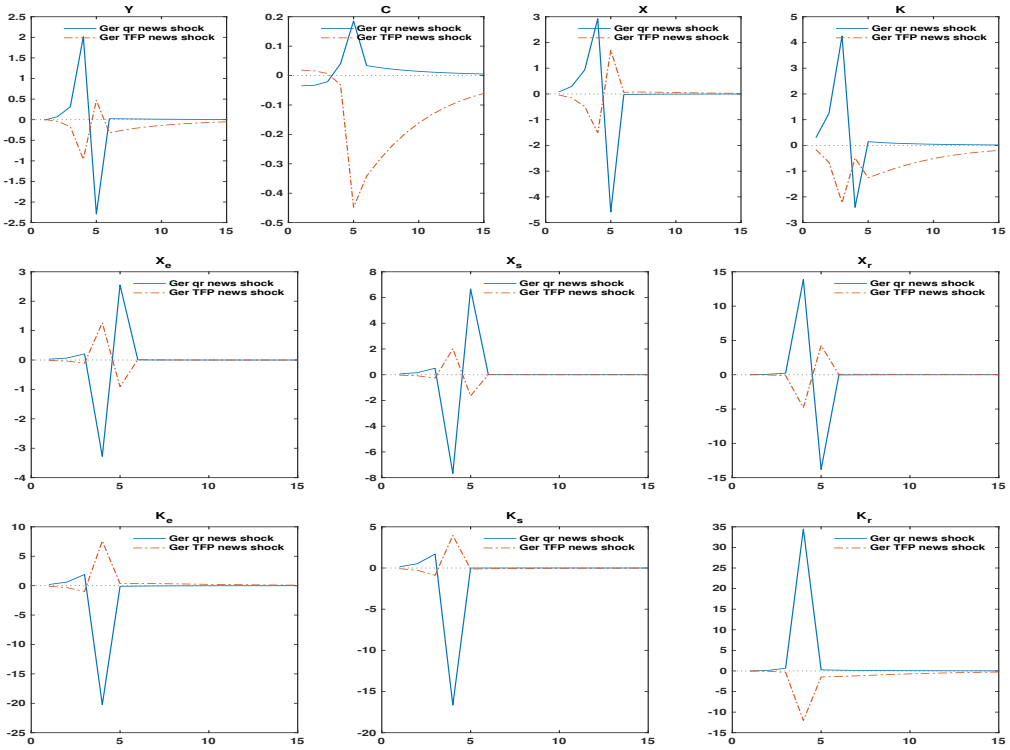
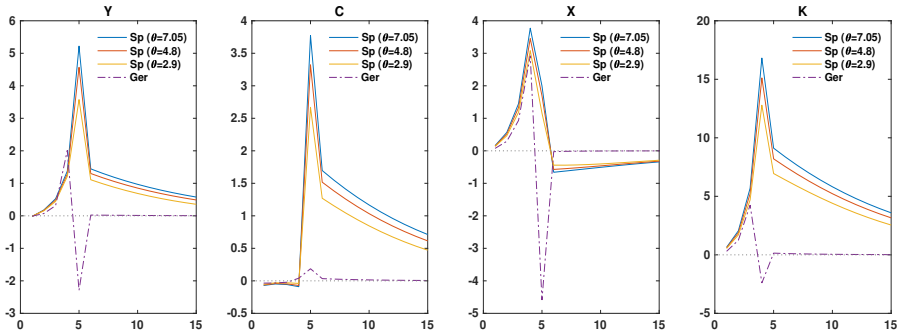


Figure F.6: TFP vs residential RPI News Shock – Germany

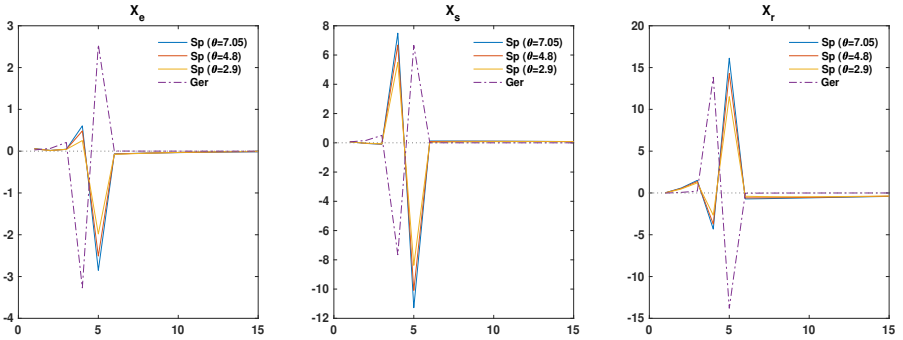
Fig. F.6 shows the IRFs of model variables following a news shock either on TFP or the residential RPI of a magnitude of 1%.

F.6 q_{rt}, News Shock - Response for different θ's (Intertemporal labor supply elast.).

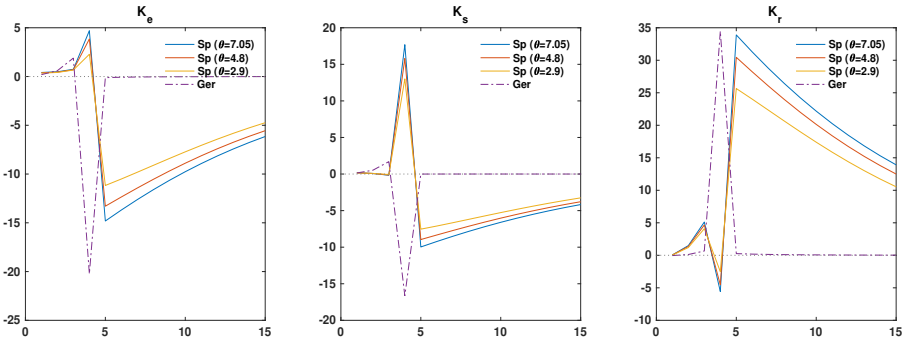
Figure F.7: **Model responses for different θ's Spain vs Germany**



(a) Main aggregates



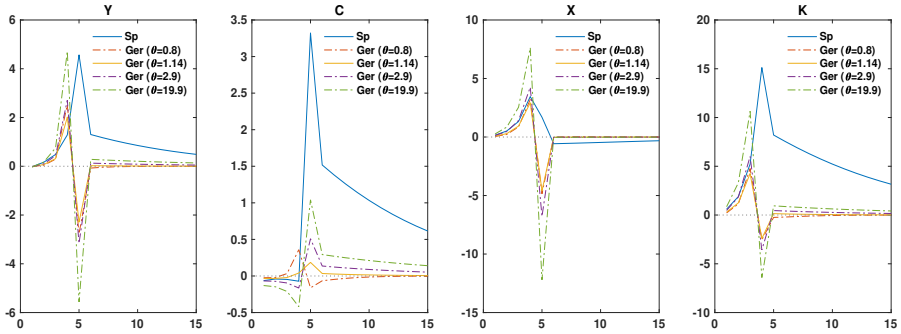
(b) Investment types



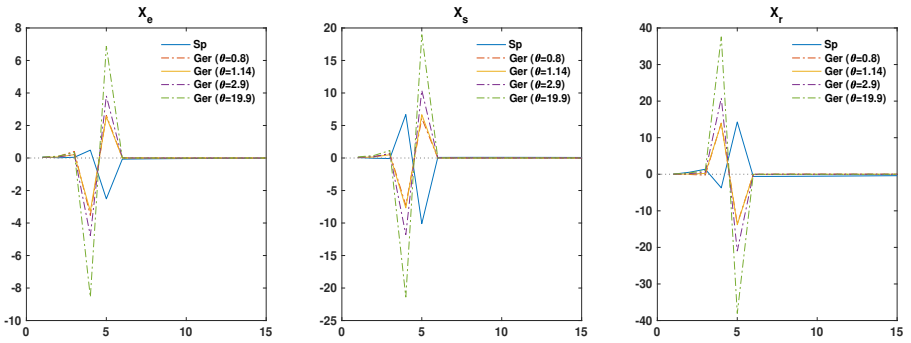
(c) Physical Capital types

Figure F.7 shows the IRFs of model variables following a residential RPI news shock of a magnitude of 1%, for different values of θ in Spain vs Germany.

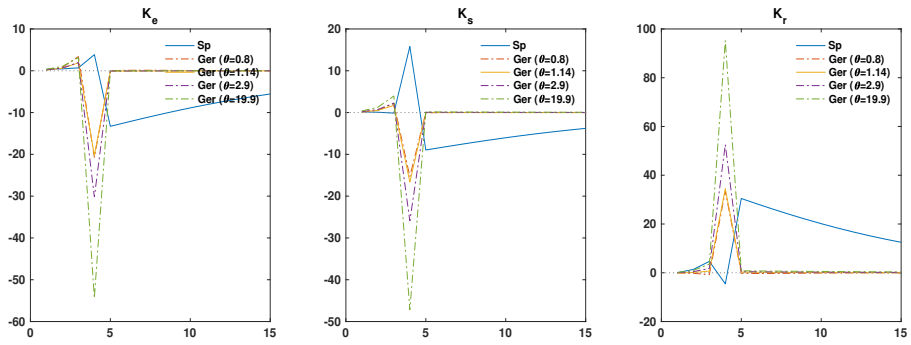
Figure F.8: **Model responses for different θ's Germany vs Spain**



(a) Main aggregates



(b) Investment types



(c) Physical Capital types

Figure F.8 shows the IRFs of model variables following a residential RPI news shock of a magnitude of 1%, for different values of θ in Germany vs Spain.

Appendix for Online Use

G Model Details

The model uses the class of preferences proposed by Jaimovich and Rebelo (2009) that have the ability to parameterize the strength of the short-run wealth effect on the labor supply. In so doing, these preferences nest two classes of utility functions: those characterized in King et al. (1988) - (when parameter $\gamma = 1$) - and in Greenwood et al. (1988) ($\gamma = 0$). Parameter θ helps to generate a rise in hours worked in response to positive news. Therefore, we consider:

$$U(C_t, N_t, \chi_t) = \frac{\left(C_t - \psi N_t^{\theta} \chi_t\right)^{1-\sigma} - 1}{1-\sigma} \quad \text{where} \quad \chi_t = C_t^{\gamma} \chi_{t-1}^{1-\gamma}. \tag{G.1}$$

The presence of χ_t makes preferences non-time-separable in consumption and hours worked. We assume $N_t = N_{mt} + N_{rt}$, and we introduce home production as:

$$C_t = (\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{1/\eta} \tag{G.2}$$

where C_{mt} is market consumption. Finally, home production is given by:

$$C_{rt} = A_{rt} K_{rt}^{1-\theta_h} N_{rt}^{\theta_r} \tag{G.3}$$

Consequently, the utility function is:

$$U(C_{mt}, C_{rt}, N_{mt}, N_{rt}, \chi_t) = \frac{\left(\left(\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta}\right)^{1/\eta} - \psi (N_{mt} + N_{rt})^{\theta_n} \chi_t\right)^{1-\sigma} - 1}{1-\sigma} \tag{G.4}$$

and the household budget constraint is

$$\begin{aligned} C_{mt} + q_{et} K_{et+1} + q_{st} K_{st+1} + q_{rt} K_{rt+1} \\ = W_t N_{mt} + r_{et} K_{et} + r_{st} K_{st} + q_{et}(1-\delta_e) K_{et} + q_{st}(1-\delta_s) K_{st} + q_{rt}(1-\delta_r) K_{rt} \end{aligned} \tag{G.5}$$

The Planner solves:

$$\max_{C_t, N_t, \chi_t} \sum_{t=0}^{\infty} \beta^t U\Big(U(C_{mt}, C_{rt}, N_{mt}, N_{rt}, \chi_t)\Big) \tag{G.6}$$

s.t.:

$$\begin{aligned} C_{mt} + q_{et} K_{et+1} + q_{st} K_{st+1} + q_{rt} K_{rt+1} \\ = W_t N_{mt} + r_{et} K_{et} + r_{st} K_{st} + q_{et}(1-\delta_e) K_{et} + q_{st}(1-\delta_s) K_{st} + q_{rt}(1-\delta_h) K_{rt} \end{aligned}$$

$$\chi_t = C_t^{\gamma}\chi_{t-1}^{1-\gamma},$$
$$C_t = \left(\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta}\right)^{1/\eta},$$
$$C_{rt} = A_t K_{rt}^{1-\theta_r} N_{rt}^{\theta_r},$$

$$Y_t = Z_t K_{et}^{\alpha_e} K_{st}^{\alpha_s} N_{mt}^{1-\alpha_e-\alpha_s},$$
$$Y_t = C_t + q_{et}X_{et} + q_{st}X_{st} + q_{rt}X_{rt},$$
$$X_t = X_{et} + X_{st} + X_{rt},$$

$$K_{et+1} = \Theta_{et}X_{et} + (1-\delta_e)K_{et},$$
$$K_{st+1} = \Theta_{st}X_{st} + (1-\delta_s)K_{st},$$
$$K_{rt+1} = \Theta_{rt}X_{rt} + (1-\delta_r)K_{rt},$$

$$q_{et} = 1/\Theta_{et}$$
$$q_{st} = 1/\Theta_{st}$$
$$q_{ht} = 1/\Theta_{ht}$$

$$\log Z_t = (1-\rho_Z)\log barZ + \rho_Z \log Z_{t-1} + \varepsilon_t^Z,$$
$$\log A_t = (1-\rho_A)\log barA + \rho_A \log A_{t-1} + \varepsilon_t^A,$$
$$\log q_{et} = (1-\rho_{q_e})\log barq_e + \rho_{q_e}\log q_{et-1} + \varepsilon_t^{q_e},$$
$$\log q_{st} = (1-\rho_{q_s})\log \bar{q_s} + \rho_{q_s}\log q_{st-1} + \varepsilon_t^{q_s},$$
$$\log q_{rt} = (1-\rho_{q_r})\log \bar{q_r} + \rho_{q_r}\log q_{rt-1} + \varepsilon_t^{q_r} + \varepsilon_{t-1}^{news},$$

G.1 The Household's Maximization Problem

$$\max_{C_t,N_t,K_{rt+1},K_{et+1},K_{st+1},\chi_t} \mathcal{L} : \sum_{t=0}^{\infty}\beta^t\Bigg\{\Bigg[\frac{\left((\omega C_{mt}^{\eta} + (1-\omega)C_{ht}^{\eta})^{1/\eta} - \psi(N_{mt}+N_{rt})^{\theta_n}X_t\right)^{1-\sigma} - 1}{1-\sigma}\Bigg]$$
$$- \lambda_t\Big(C_{mt} + q_{et}K_{et+1} + q_{st}K_{st+1} + q_{rt}K_{rt+1}$$
$$- w_t N_{mt} - (r_{et} + q_{et}(1-\delta_e))K_{et} - (r_{st} + q_{st}(1-\delta_s))K_{st} - q_{rt}(1-\delta_r)K_{rt}\Big)$$
$$- \mu_t\Big(\chi_t - (\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{\frac{\gamma}{\eta}}\chi_{t-1}^{1-\gamma}\Big) - \xi_t\Big(C_{rt} - A_t K_{rt}^{1-\theta_r}N_{rt}^{\theta_r}\Big)\Bigg\} \quad \text{(G.7)}$$

FOCs

$$\frac{\partial\mathcal{L}}{\partial C_{mt}} : \left((\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{1/\eta} - \psi(N_{mt}+N_{rt})^{\theta_n}\chi_t\right)^{-\sigma}\omega C_{mt}^{\eta-1}(\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{1/\eta-1}$$
$$+ \mu_t\Big(\gamma\omega C_{mt}^{\eta-1}(\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{\gamma/\eta-1}\chi_{t-1}^{1-\gamma}\Big) = \lambda_t \quad \text{(G.8)}$$

$$\frac{\partial \mathcal{L}}{\partial C_{rt}} : \left((\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{1/\eta} - \psi(N_{mt}+N_{rt})^{\theta_n}\chi_t\right)^{-\sigma}(1-\omega)C_{rt}^{\eta-1}(\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{1/\eta-1}$$
$$+ \mu_t\left(\gamma(1-\omega)C_{rt}^{\eta-1}(\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{\gamma/\eta-1}\chi_{t-1}^{1-\gamma}\right) = \xi_t \quad \text{(G.9)}$$

$$\frac{\partial \mathcal{L}}{\partial N_{mt}} : \left((\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{1/\eta} - \psi(N_{mt}+N_{rt})^{\theta_n}\chi_t\right)^{-\sigma}\psi\theta_n(N_{mt}+N_{rt})^{\theta_n-1}\chi_t = \lambda_t w_t \quad \text{(G.10)}$$

$$\frac{\partial \mathcal{L}}{\partial N_{rt}} : \left((\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{1/\eta} - \psi(N_{mt}+N_{rt})^{\theta_n}\chi_t\right)^{-\sigma}\psi\theta_n(N_{mt}+N_{rt})^{\theta_n-1}\chi_t$$
$$= \xi_t(\theta_r A_t K_{rt}^{1-\theta_r} N_{rt}^{\theta_r-1}) \quad \text{(G.11)}$$

$$\frac{\partial \mathcal{L}}{\partial \chi_t} : \left((\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{1/\eta} - \psi(N_{mt}+N_{rt})^{\theta_n}\chi_t\right)^{-\sigma}\psi(N_{mt}+N_{rt})^{\theta_n} + \mu_t =$$
$$E_t\left[\mu_{t+1}\beta\left((1-\gamma)(\omega C_{mt+1}^{\eta} + (1-\omega)C_{rt+1}^{\eta})^{\gamma/\eta}\chi_t^{-\gamma}\right)\right] \quad \text{(G.12)}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_t} : C_{mt} + q_{et}K_{et+1} + q_{st}K_{st+1} + q_{rt}K_{rt+1}$$
$$= w_t N_{mt} + r_{et}K_{et} + r_{st}K_{st} + q_{et}(1-\delta_e)K_{et} + q_{st}(1-\delta_s)K_{st} + q_{rt}(1-\delta_r)K_{rt} \quad \text{(G.13)}$$

$$\frac{\partial \mathcal{L}}{\partial \mu_t} : \chi_t = (\omega C_{mt}^{\eta} + (1-\omega)C_{rt}^{\eta})^{\frac{\gamma}{\eta}}\chi_{t-1}^{1-\gamma} \quad \text{(G.14)}$$

$$\frac{\partial \mathcal{L}}{\partial \xi_t} : C_{rt} = A_t K_{rt}^{1-\theta_h} N_{rt}^{\theta_r} \quad \text{(G.15)}$$

$$\frac{\partial \mathcal{L}}{\partial K_{et+1}} : \lambda_t = \beta E_t\left[\lambda_{t+1}\frac{r_{et+1} + q_{et+1}(1-\delta_e)}{q_{et}}\right] \quad \text{(G.16)}$$

$$\frac{\partial \mathcal{L}}{\partial K_{st+1}} : \lambda_t = \beta E_t\left[\lambda_{t+1}\frac{r_{st+1} + q_{st+1}(1-\delta_s)}{q_{st}}\right] \quad \text{(G.17)}$$

$$\frac{\partial \mathcal{L}}{\partial K_{rt+1}} : \lambda_t = \beta E_t\left[\lambda_{t+1}\frac{q_{rt+1}(1-\delta_r)}{q_{rt}} + \xi_{t+1}\frac{(1-\theta_r)A_{t+1}K_{rt+1}^{-\theta_r}N_{rt+1}^{\theta_r}}{q_{rt}}\right] \quad \text{(G.18)}$$

$$\log Z_t = (1-\rho_Z)\log \bar{Z} + \rho_Z \log Z_{t-1} + \varepsilon_t^Z \tag{G.19}$$

$$\log A_t = (1-\rho_A)\log \bar{A} + \rho_A \log A_{t-1} + \varepsilon_t^A \tag{G.20}$$

$$\log q_{et} = \rho_{q_e} \log q_{et-1} + \varepsilon_t^{q_e} \tag{G.21}$$

$$\log q_{st} = \rho_{q_s} \log q_{st-1} + \varepsilon_t^{q_s} \tag{G.22}$$

$$\log q_{rt} = \rho_{q_r} \log q_{rt-1} + \varepsilon_t^{q_r} + \varepsilon_{t-4}^{news} \tag{G.23}$$

G.2 The Firms problem:

Firm producing final good

$$\max_{K_{et},K_{st},N_t} \Pi_t = Z_t K_{et}^{\alpha_e} K_{st}^{\alpha_s} N_t^{1-\alpha_e-\alpha_s} - r_{et}K_{et} - r_{st}K_{st} - w_t N_{mt}. \tag{G.24}$$

FOCs

$$\frac{\partial \Pi_t}{\partial K_{et}} : \alpha_e Z_t K_{et}^{\alpha_e - 1} K_{st}^{\alpha_s} N_{mt}^{1-\alpha_e-\alpha_s} = r_{et} \tag{G.25}$$

$$\frac{\partial \Pi_t}{\partial K_{st}} : \alpha_s Z_t K_{et}^{\alpha_e} K_{st}^{\alpha_s - 1} N_{mt}^{1-\alpha_e-\alpha_s} = r_{st} \tag{G.26}$$

$$\frac{\partial \Pi_t}{\partial N_t} : (1-\alpha_e-\alpha_s) Z_t K_{et}^{\alpha_e - 1} K_{st}^{\alpha_s} N_{mt}^{-\alpha_e-\alpha_s} = w_t \tag{G.27}$$

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