International inflation spillovers – the role of different shocks

Appendix – For online publication

Gregor Bäurle[*], Matthias Gubler[†], and Diego R. Känzig[‡]

Contents

[*]Swiss National Bank, Economic Analysis, P.O. Box, CH-8022 Zurich, Switzerland, e-mail: gregor.baeurle@snb.ch

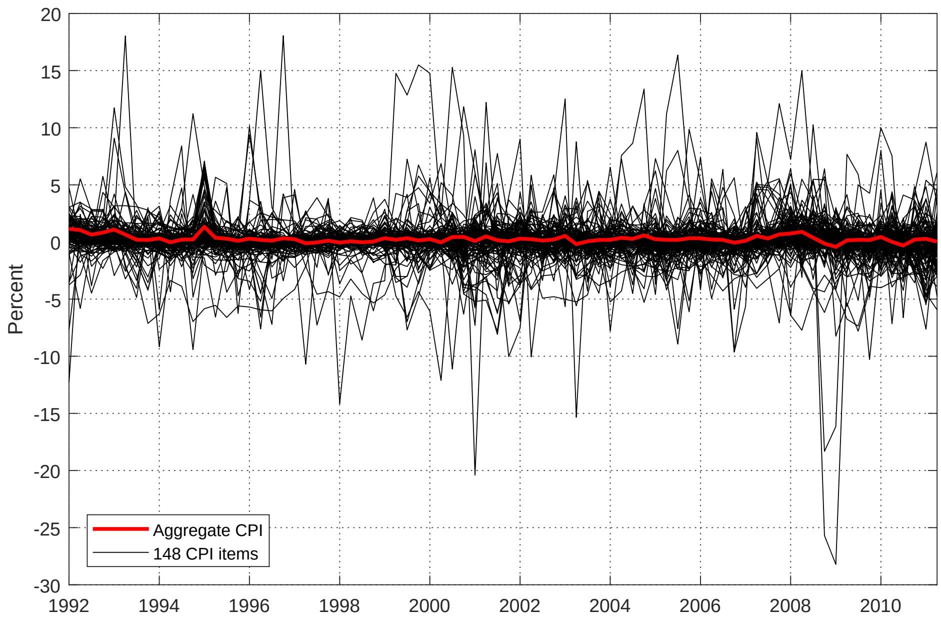
[†]Swiss National Bank, Inflation Forecasting, P.O. Box, CH-8022 Zurich, Switzerland, e-mail: matthias.gubler@snb.ch

[‡]London Business School, London NW1 4SA, UK, e-mail: dkaenzig@london.edu

A Disaggregated price data

For the disaggregated price data, we rely on micro data at the consumer item level collected by the Swiss Federal Statistical Office (SFSO). It is important to note that the number of consumer items may change over time due to revisions of the CPI. To obtain a homogenous dataset, we group the data into 148 CPI items accounting for the major Swiss CPI revisions. The dataset accounts for approximately 99% of the CPI on average because certain items, for which we were unable to find an appropriate group, are excluded from the panel. The resulting CPI items are seasonally and calendar adjusted, and items featuring collection frequencies lower than a quarter are interpolated. Figure A.1 shows the historical evolution of aggregate CPI inflation together with the inflation series of the 148 CPI items (both calculated as qoq rates).

Figure A.1 – Aggregate and disaggregated inflation series (qoq)



There is a substantial degree of heterogeneity among different CPI items. Furthermore, inflation rates of single items turn out to be more volatile and generally less persistent than aggregate CPI inflation. These observations are confirmed by looking at the standard deviations and the AR(1) coefficients of aggregate CPI inflation and different price categories as shown in Table A.1 and are in line with evidence of Boivin et al. (2009) on the United States.

Table A.1 – Volatility and persistence of inflation series (qoq)

Category	**Std. deviation**				**Persistence**			
	Mean	5th	50th	95th	Mean	5th	50th	95th
Aggregate CPI	0.31				0.45			
Categories								
CPI (148)	1.10	0.40	0.83	2.46	0.29	−0.16	0.30	0.64
Core (131)	0.94	0.40	0.77	1.91	0.29	−0.16	0.30	0.64
Energy (4)	4.64	1.21	4.08	9.22	0.27	0.10	0.25	0.48
Imported goods excl. energy (65)	0.98	0.38	0.84	2.02	0.36	0.01	0.40	0.66
Domestic goods excl. energy (46)	1.16	0.47	0.92	2.97	0.15	−0.24	0.20	0.55
Private services excl. rents (28)	0.73	0.28	0.69	1.27	0.36	0.06	0.35	0.80
Rents (1)	0.43	0.43	0.43	0.43	0.56	0.56	0.56	0.56
Public services (5)	1.23	0.68	1.21	1.76	0.17	−0.03	0.18	0.44

Note: The table shows the volatility and persistence of aggregate CPI inflation and inflation rates of different CPI categories (number of items in the categories are depicted in brackets). Volatility and persistence of each category are calculated as the unweighted average of the item-specific volatilities and persistence measures of those items included in the respective category. The persistence of the series is measured by the estimated first-order autoregressive coefficient.

B Detailed model description and estimation method

In this section, we provide a description of the estimation method. As the posterior distribution cannot be derived analytically, we use Markov Chain Monte Carlo (MCMC) methods to simulate from the posterior distribution. In our setting, this can be done using a Gibbs sampling approach (see, e.g., Kim and Nelson (1999) with one iteration of the Gibbs sampler involving the following steps:

Step 1: Draw the factors conditional on a set of model parameters

Step 2: Draw parameters in the observation equation conditional on the factors

Step 3: Draw parameters in the state equation conditional on the factors

Iterating over these steps delivers draws from the posterior distribution of the parameters and the factors. Subsequently, we provide a detailed description of the three steps including the specification of the prior distribution.

Step 1: Drawing the factors To draw from the joint distribution of the factors given the parameter in the model, we use the algorithm of Carter and Kohn (1994) and Frühwirth-Schnatter (1994). The algorithm uses a Kalman filter. In our setting, the filter has to be adapted for autoregressive errors and potentially co-linear states, see, e.g., Anderson and Moore (1979) and Kim and Nelson (1999).

Step 2: Drawing parameters in the observation equation We use an informative prior on the factor loadings as this 'identifies' the factors in the sense that it puts curvature into the posterior density function for regions in which the likelihood function is flat, see, e.g., discussion in Bäurle (2013). In our implementation, the prior is centered such that, a priori, the series are all related with loading one to the unobserved factors contemporaneously and with loading zero to the lagged factors. However, the variance of the prior is chosen to be large, such that if the data are informative about the loadings, this will be reflected in the posterior distribution.

Regarding the parametric form of the prior, we use the specification of the conjugate prior described in Bauwens et al. (1999), p.58: The prior distribution $p(R_n, \Lambda_n \mid \Psi_n)$, where n denotes the respective row in the observation equation, is of the normal-inverted gamma-2 form (as defined in the appendix of Bauwens et al. (1999)):

$$R_n \sim \mathrm{iG}_2(s, \nu)$$

$$\Lambda_n \sim \mathrm{N}(\Lambda_{0,n}, R_n M_{0,n}^{-1})$$

Λ_0 is the prior mean of the distribution. The parameters s and ν parameterize the distribution of the variance of the measurement error. M_0 is a matrix of parameters that influences the tightness of the priors in the observation equation. The larger the elements of M_0 are, the closer we relate the observed series to the factors a priori. The choice of the tightness is determined by the a priori confidence in the prior belief. We set $M_{0,n,\varrho} = \varrho^2$ for all n and $\varrho = 1, \ldots, q$. Thus, the tightness of the prior increases quadratically with the lag of the factor. Following Boivin and Giannoni (2006), we set $s = 3$ and $\nu = 0.001$. By adding a standard normal prior for Ψ_n, we have specified a complete prior distribution for the parameters in the observation equation. The derivation of the posterior distribution is standard, see, e.g., Chib (1993) and Bauwens et al. (1999).

Step 3: Drawing parameters in the state equation We implement an independent normal Wishart prior for the parameters in the state equation in our baseline version allowing us to implement zero-restrictions on the reduced form coefficients. The prior mean and variances are of a "Minnesota-type", following Karlsson (2013). We set the hyper-parameter as follows. In Karlsson (2013)'s notation, we use $\pi_1 = \pi_2 = \pi_3 = 1$ to implement a very loose prior and set the prior mean of the first own lag to zero as we model stationary series. The prior is conjugate, i.e., the conditional densities $p(\Sigma|F,\Phi)$ and $p(\Phi|F,\Sigma)$ can be shown to be multivariate normal and inverse Wishart densities, respectively (see Bauwens et al. (1999) or Karlsson (2013)). Hence, we introduce this additional Gibbs-sampling step into our MCMC algorithm.

C The role of aggregation in the variance decomposition

As outlined in the main body of the paper, we compute the variance decompositions of the different price categories for the particular indices and not as the average of the decomposition for the items in a given category. Intuitively, one would expect that the item-specific part in the decomposition for the index is smaller than in the average of the decomposition for the different items in the category. This is because by aggregating the items of a category to an index, some of the item-specific variations might cancel out. In contrast, the average of the variance decomposition for the different items in a category still reflects all item-specific variation. In this sense, the foreign contributions to domestic inflation reported in Monacelli and Sala (2009) can be thought of as a lower bound.

This is confirmed by our results. Table C.1 shows the variance decomposition for the indices and the (weighted) average of the decomposition for the components in the categories at different horizons. One sees that the item-specific part is much larger for the weighted averages than for the indices, particularly in the short run. Conversely, common factors, both domestic and foreign, explain a larger share for the indices. Thus, when interpreting the contribution of common factors, one should bear in mind that the higher the level of aggregation is, the higher the contribution of common factors and the smaller the item-specific part.

Table C.1 – Variance decomposition for the indices and (weighted) average of variance decompositions for the items in the different categories at different horizons.

$h = 0$	Index					Weighted Average				
Sector/Shock	D	MP	CP	Dom	Idio	D	MP	CP	Dom	Idio
Swiss CPI	0.03	0.13	0.26	0.24	0.34	0.02	0.02	0.04	0.16	0.76
Core	0.02	0.02	0.05	0.60	0.33	0.02	0.02	0.03	0.16	0.77
Energy	0.06	0.24	0.27	0.04	0.39	0.03	0.11	0.12	0.17	0.56
Imported goods excl. energy	0.02	0.04	0.02	0.22	0.70	0.02	0.02	0.02	0.08	0.86
Domestic goods excl. energy	0.01	0.01	0.02	0.18	0.77	0.02	0.02	0.03	0.12	0.81
Private services excl. rents	0.02	0.02	0.02	0.75	0.20	0.01	0.02	0.02	0.33	0.61
Rents	0.02	0.01	0.05	0.05	0.88	0.02	0.01	0.05	0.05	0.88
Public services	0.02	0.02	0.09	0.41	0.47	0.01	0.02	0.06	0.22	0.68

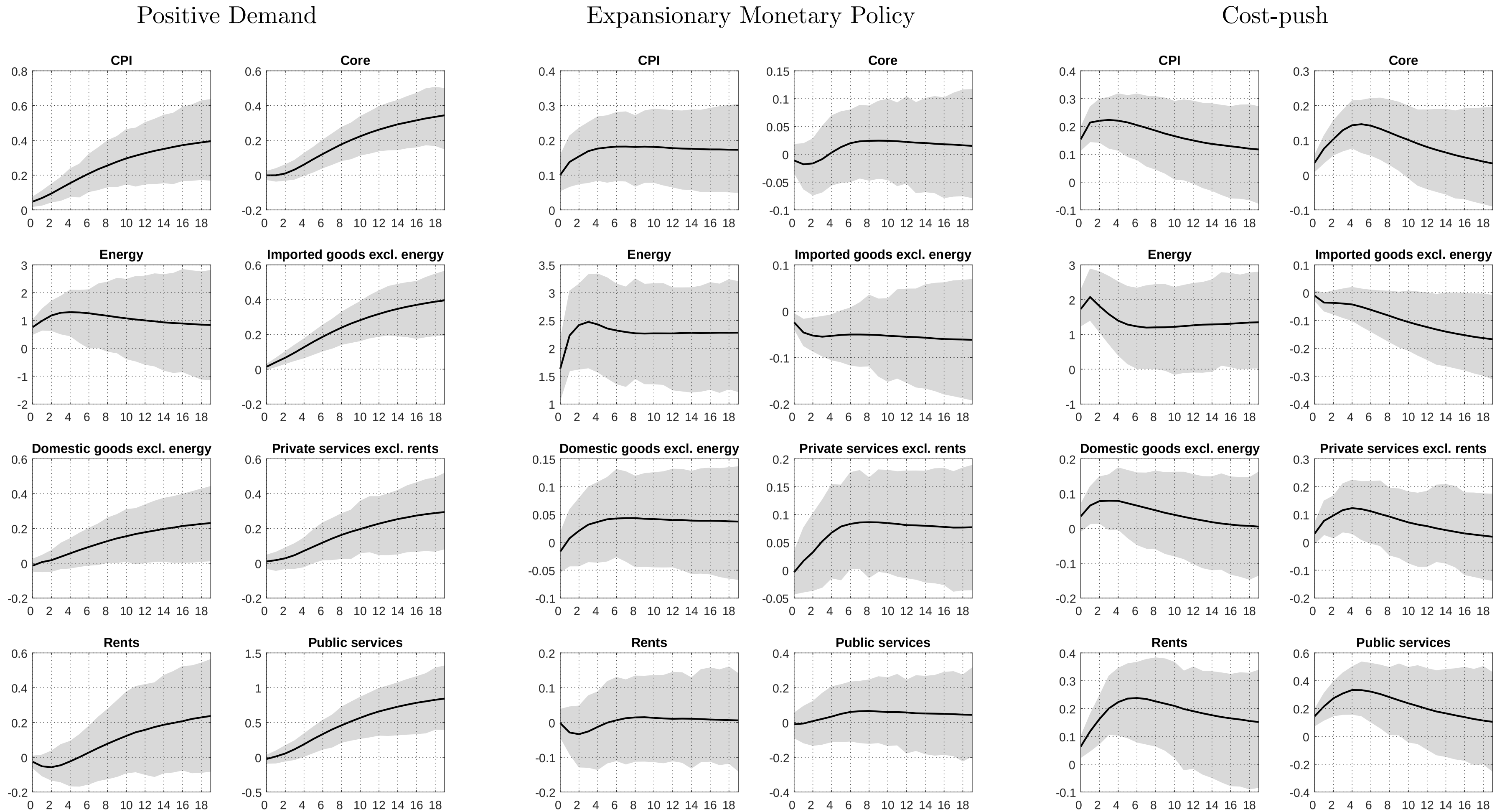
$h = 4$	Index					Weighted Average				
Sector/Shock	D	MP	CP	Dom	Idio	D	MP	CP	Dom	Idio
Swiss CPI	0.09	0.12	0.24	0.22	0.33	0.07	0.03	0.04	0.15	0.70
Core	0.12	0.03	0.06	0.49	0.30	0.07	0.02	0.04	0.16	0.71
Energy	0.07	0.24	0.26	0.05	0.39	0.06	0.11	0.12	0.17	0.54
Imported goods excl. energy	0.18	0.04	0.04	0.16	0.59	0.06	0.02	0.03	0.08	0.80
Domestic goods excl. energy	0.04	0.02	0.03	0.17	0.74	0.05	0.02	0.03	0.12	0.77
Private services excl. rents	0.06	0.03	0.04	0.68	0.20	0.07	0.03	0.03	0.32	0.55
Rents	0.06	0.02	0.05	0.05	0.81	0.06	0.02	0.05	0.05	0.81
Public services	0.13	0.03	0.09	0.34	0.42	0.11	0.02	0.07	0.20	0.59

$h = 16$	Index					Weighted Average				
Sector/Shock	D	MP	CP	Dom	Idio	D	MP	CP	Dom	Idio
Swiss CPI	0.13	0.12	0.24	0.21	0.30	0.10	0.03	0.05	0.15	0.66
Core	0.19	0.03	0.08	0.43	0.26	0.10	0.03	0.05	0.15	0.67
Energy	0.09	0.23	0.26	0.05	0.38	0.07	0.11	0.12	0.17	0.53
Imported goods excl. energy	0.25	0.04	0.06	0.14	0.51	0.10	0.03	0.04	0.08	0.76
Domestic goods excl. energy	0.07	0.02	0.04	0.17	0.71	0.07	0.03	0.04	0.12	0.74
Private services excl. rents	0.10	0.03	0.05	0.64	0.19	0.11	0.03	0.04	0.30	0.52
Rents	0.10	0.02	0.06	0.05	0.76	0.10	0.02	0.06	0.05	0.76
Public services	0.19	0.03	0.10	0.30	0.38	0.16	0.03	0.08	0.19	0.54

Note: The weights used in the calculations of the average are based on the CPI weights.

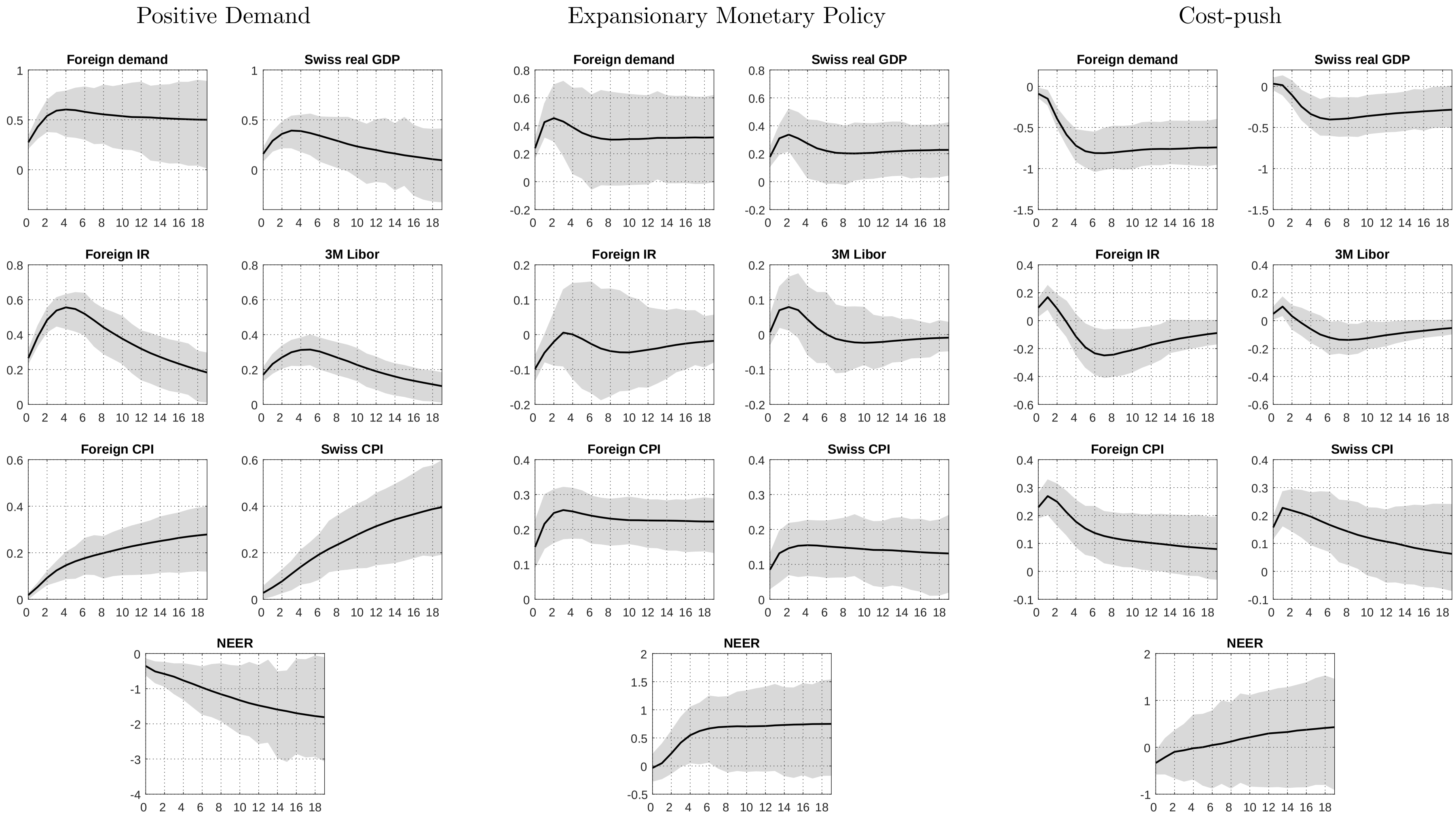
D Additional figures and robustness analyses

Figure D.1 – Impact of foreign inflationary shocks on different price categories



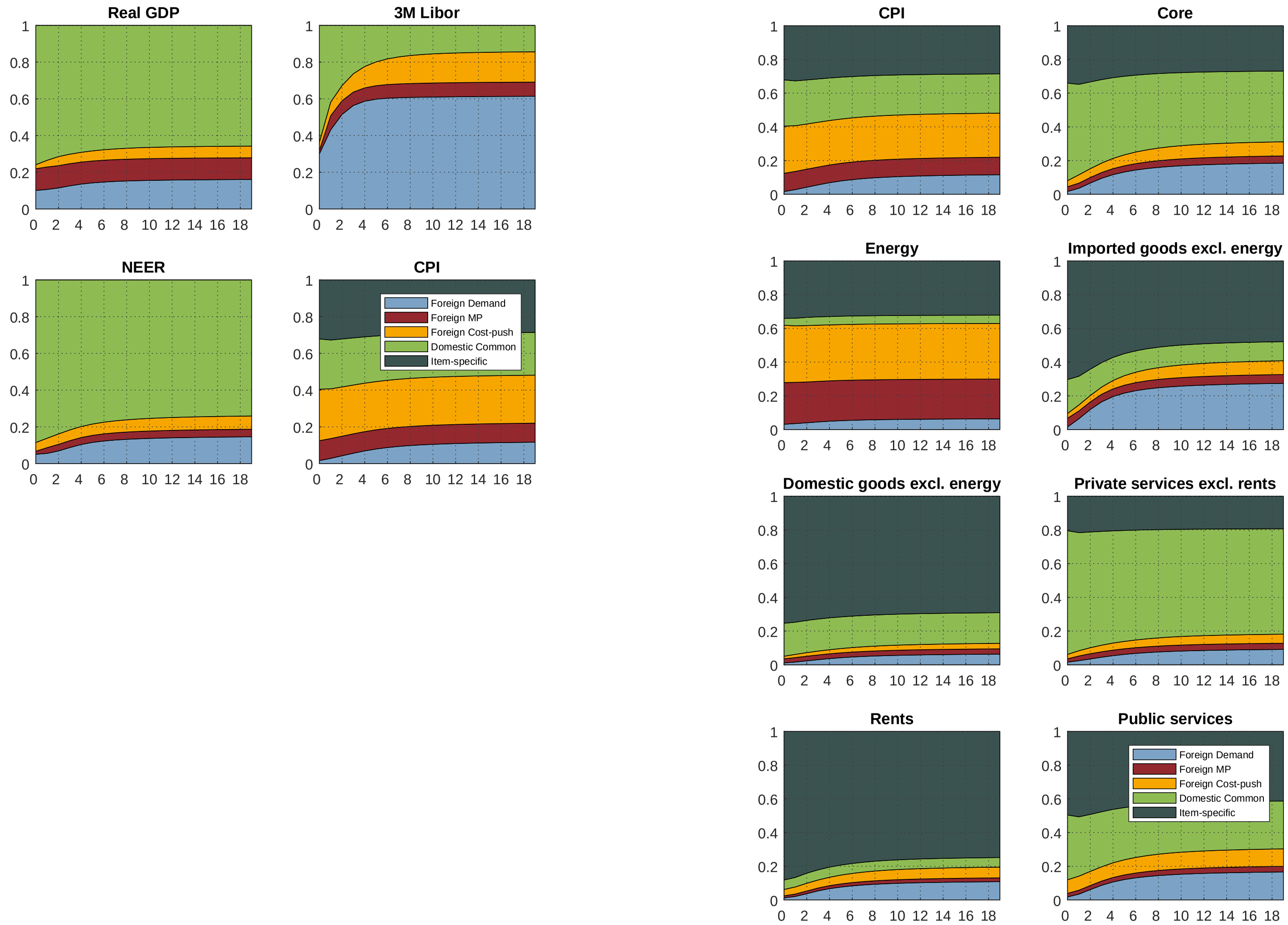
Note: The figure illustrates the cumulative impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. The responses along the y-axis denote percentage changes.

Figure D.2 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model with the world block



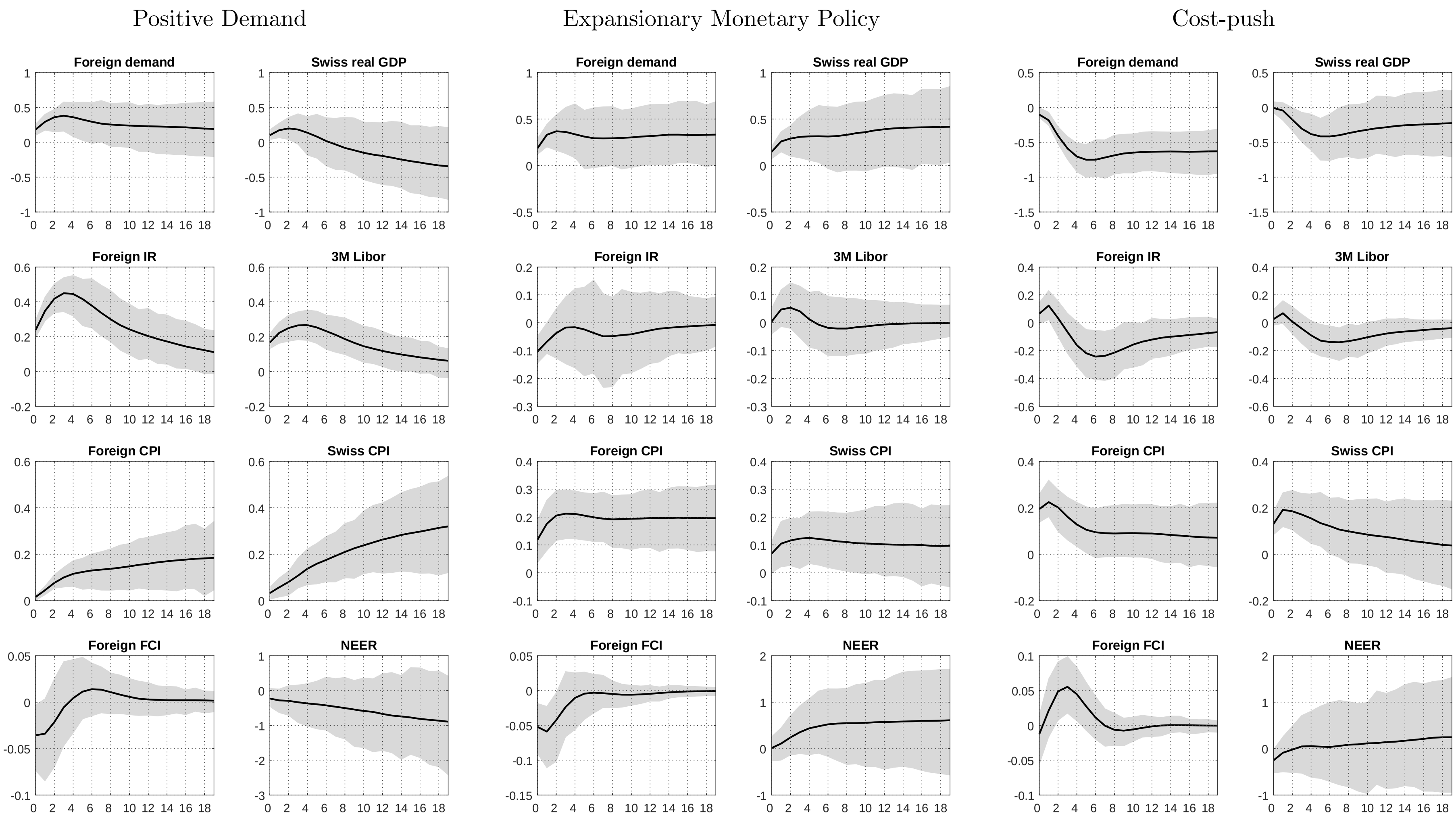
Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

Figure D.3 – Variance decomposition of Swiss variables and different price categories for the model with the world block



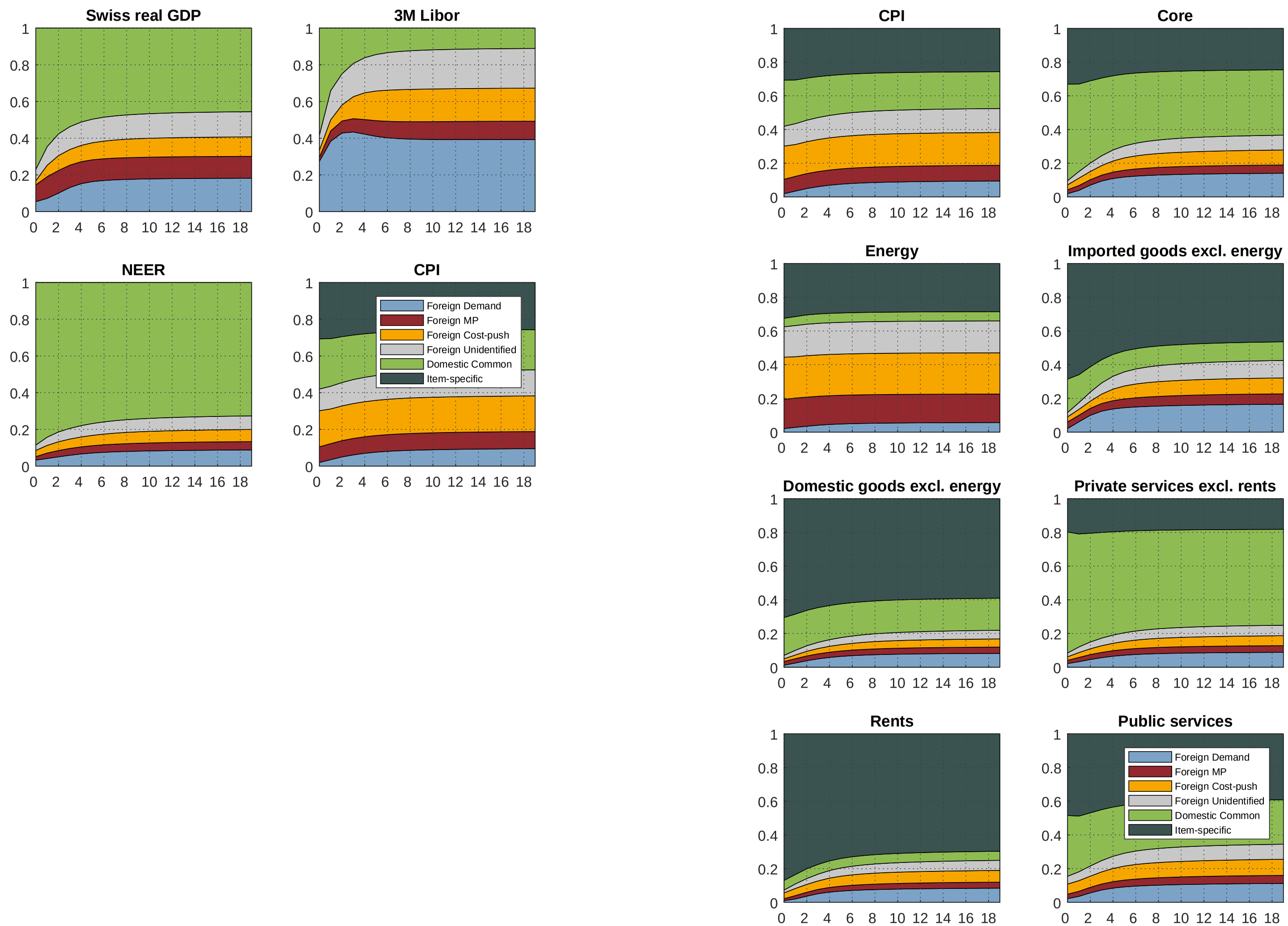
Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

Figure D.4 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model with the world block and foreign FCI



Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

Figure D.5 – Variance decomposition of Swiss variables and different price categories for the model with the world block and foreign FCI

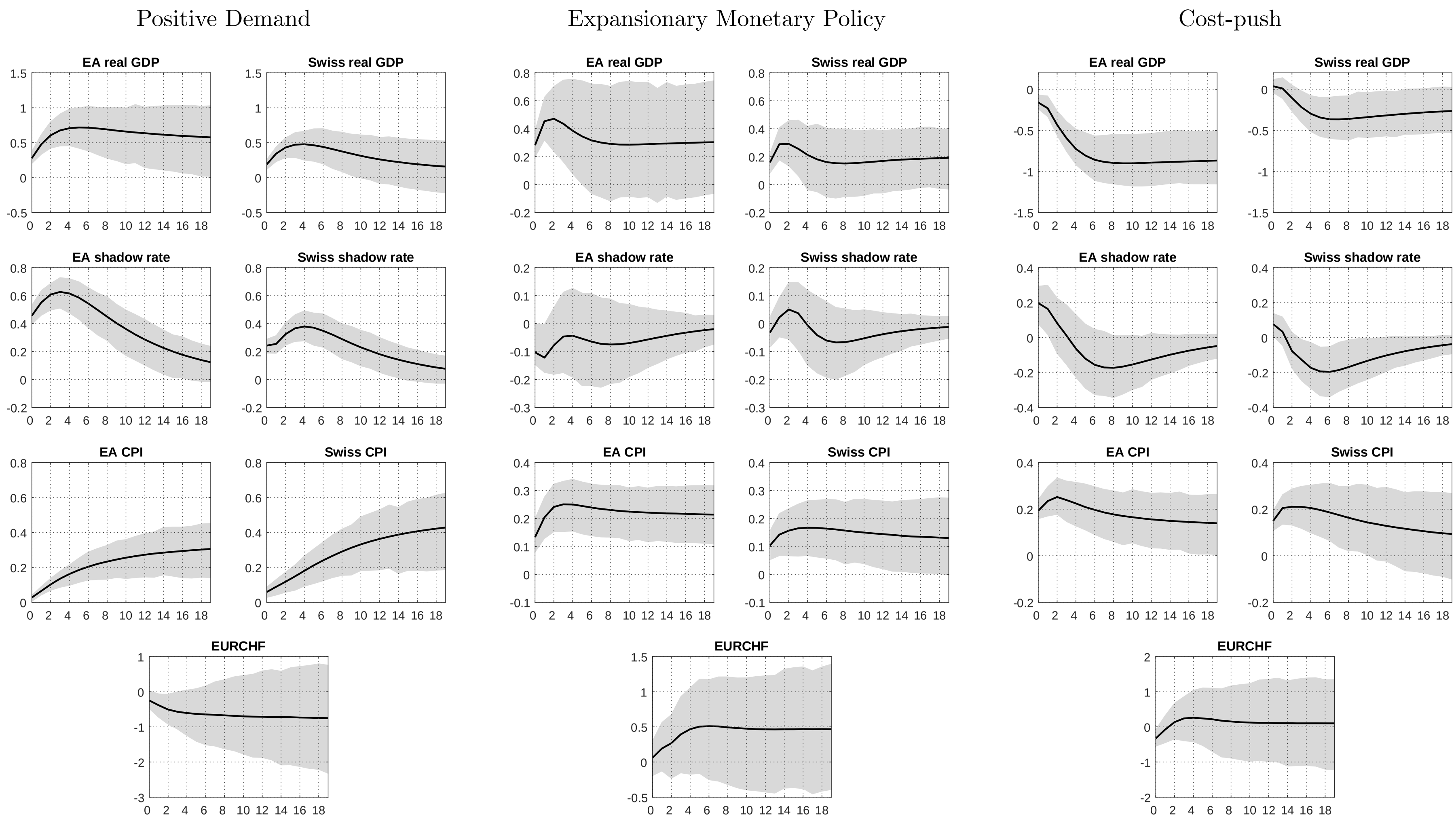


Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

Figure D.6 – Observed and shadow interest rates for Switzerland and the euro area

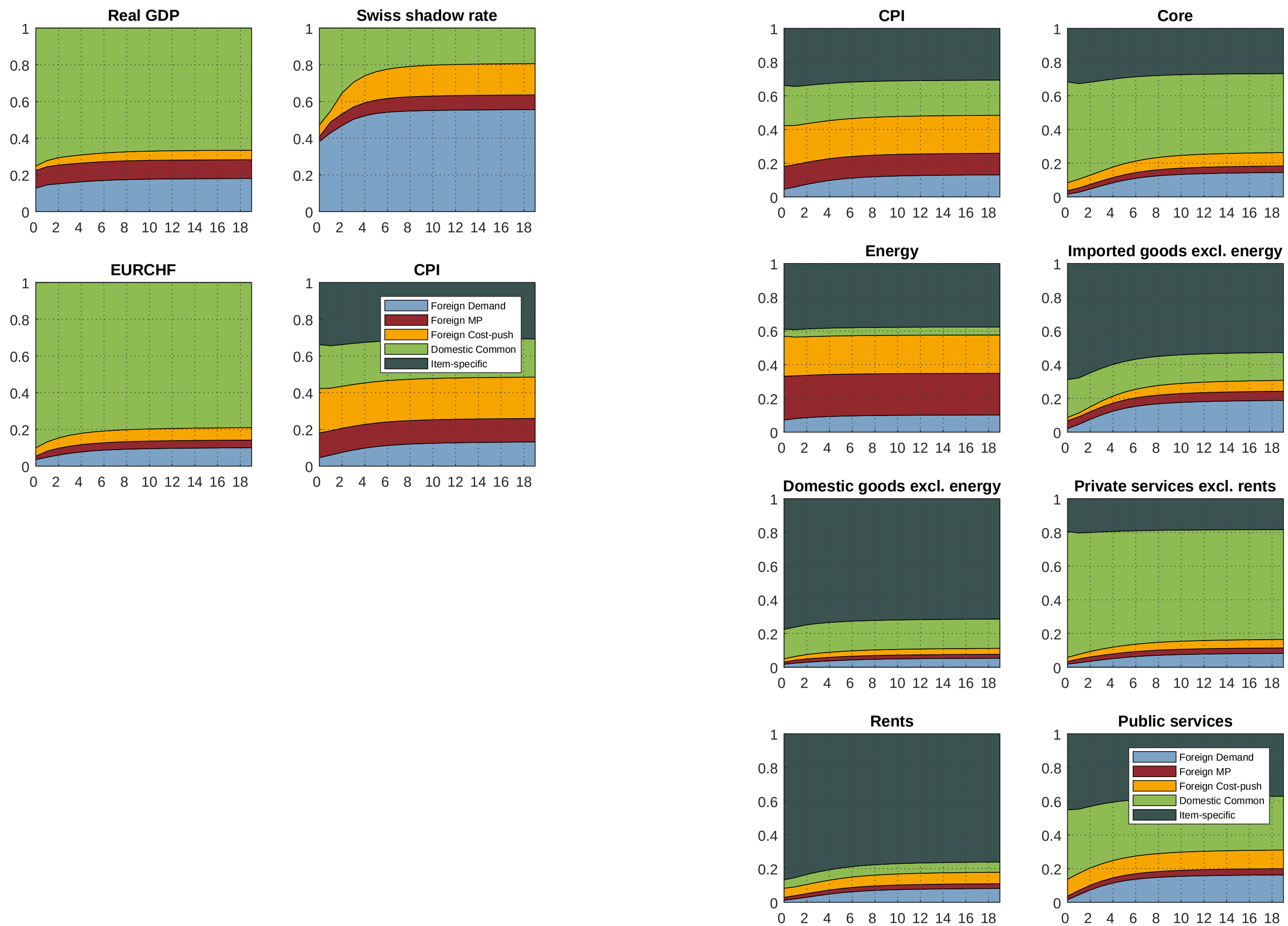
Note: The figure illustrates the 3M Libor, 3M Euribor and the shadow short-term interest rates from Krippner (2013) for Switzerland and the euro area.

Figure D.7 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model estimated with shadow interest rates



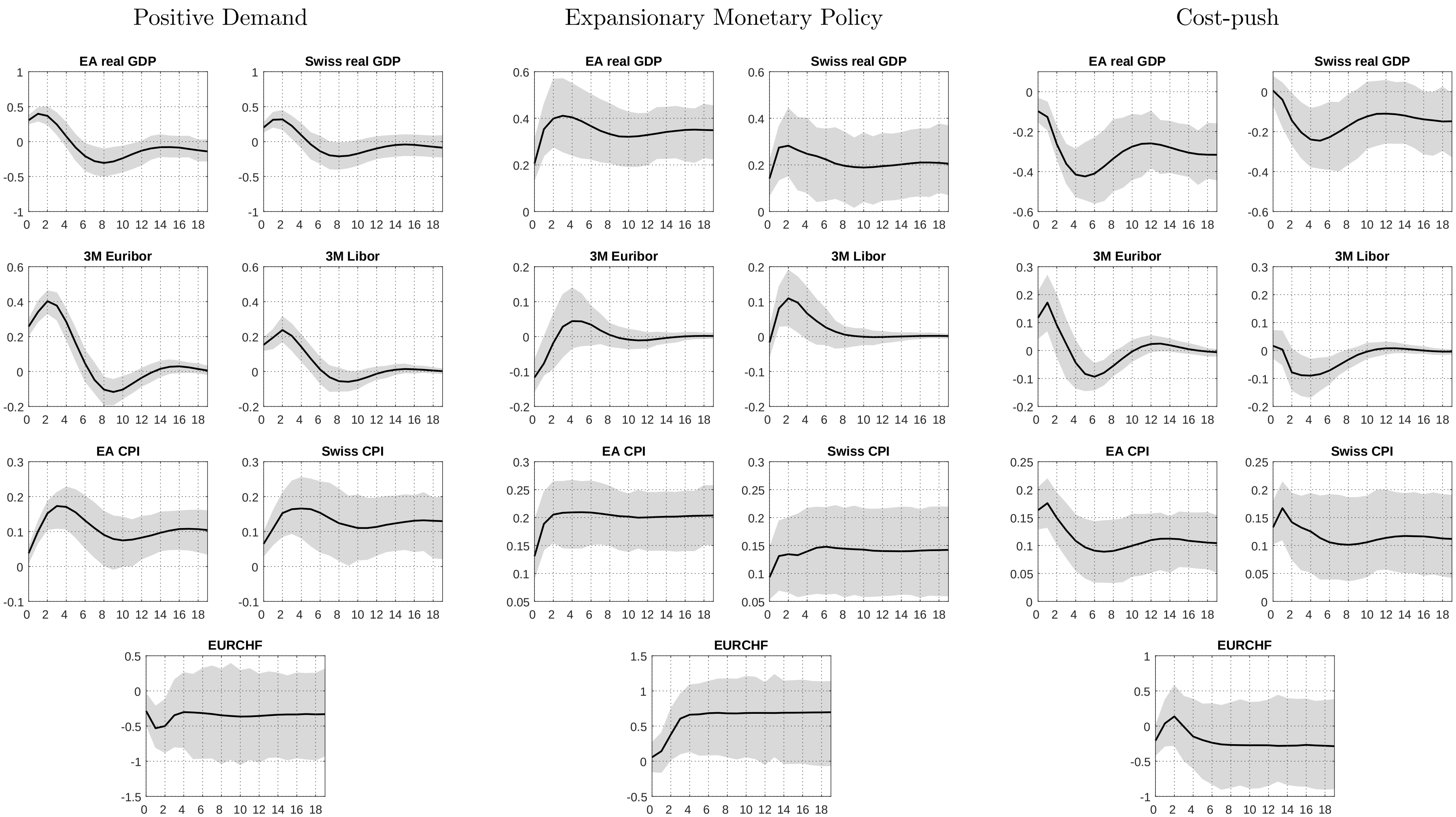
Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

Figure D.8 – Variance decomposition of Swiss variables and different price categories for the model estimated with shadow interest rates



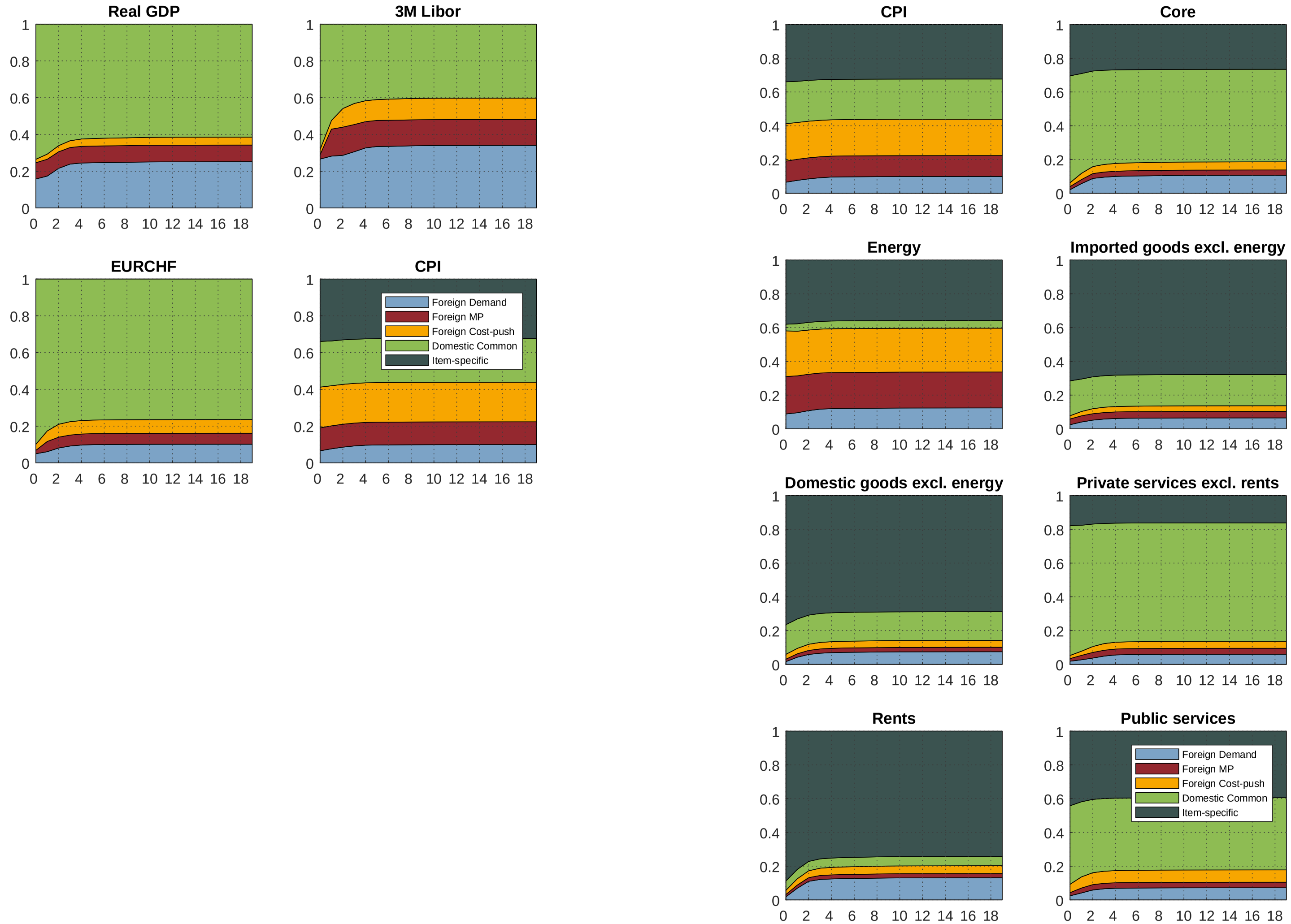
Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

Figure D.9 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model with two-sided Hodrick-Prescott de-trended variables



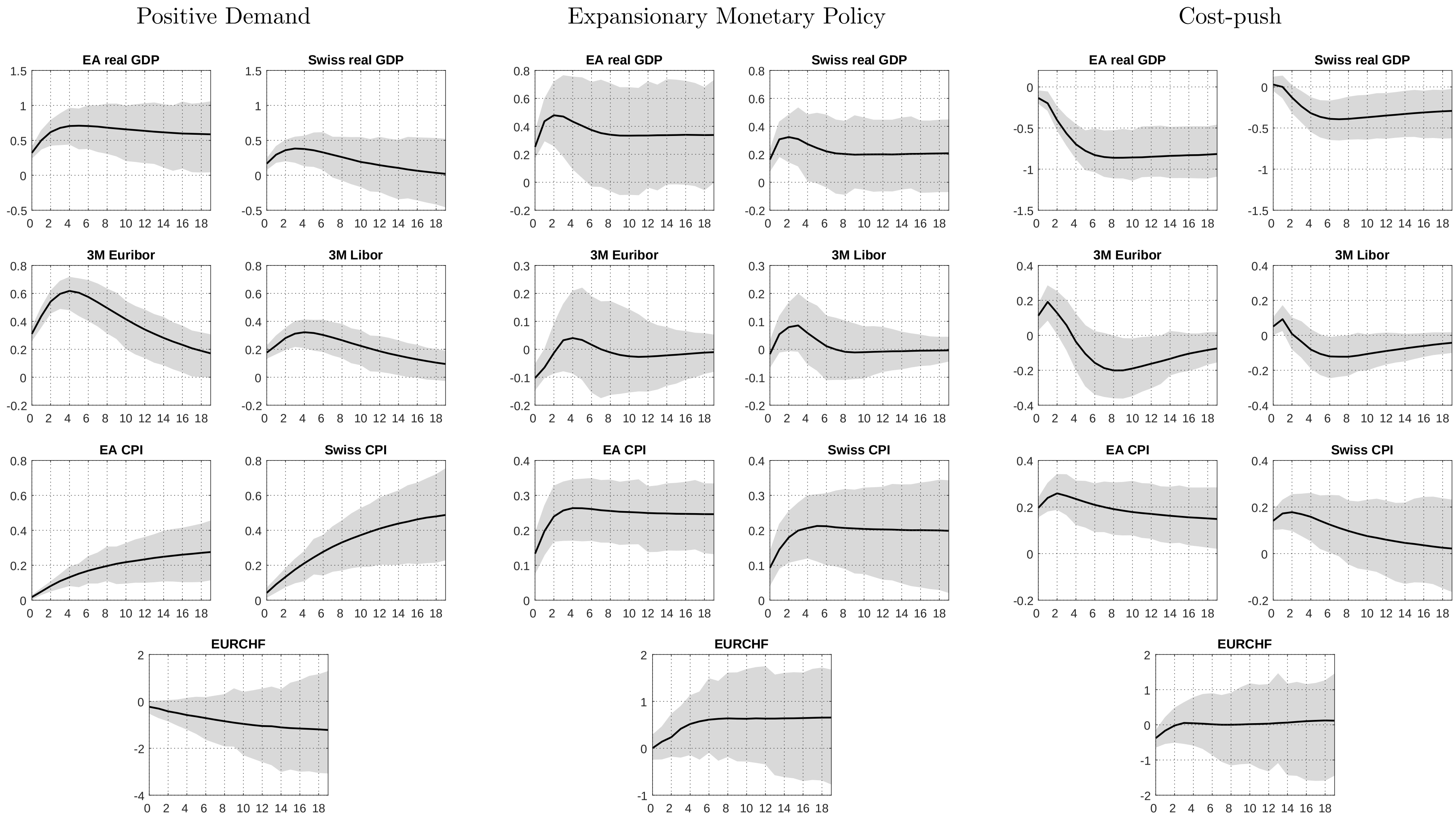
Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points of the de-trended cyclical components. All other responses along the y-axis denote percentage changes of the de-trended cyclical components.

Figure D.10 – Variance decomposition of Swiss variables and different price categories for the model with two-sided Hodrick-Prescott de-trended variables



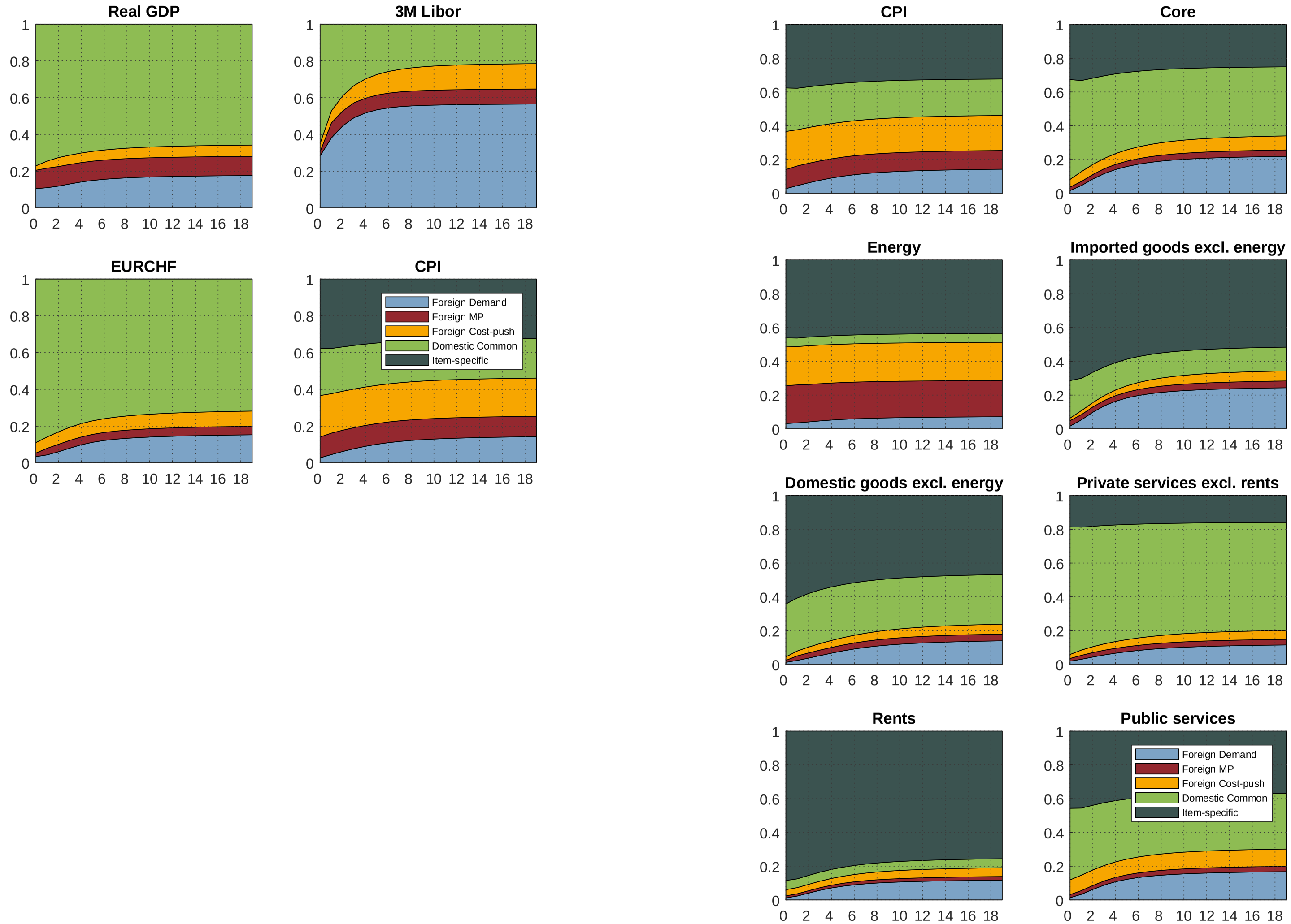
Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

Figure D.11 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model with 2 unobserved factors and with 2 lag in the state equation and 0 lags in the observation equation



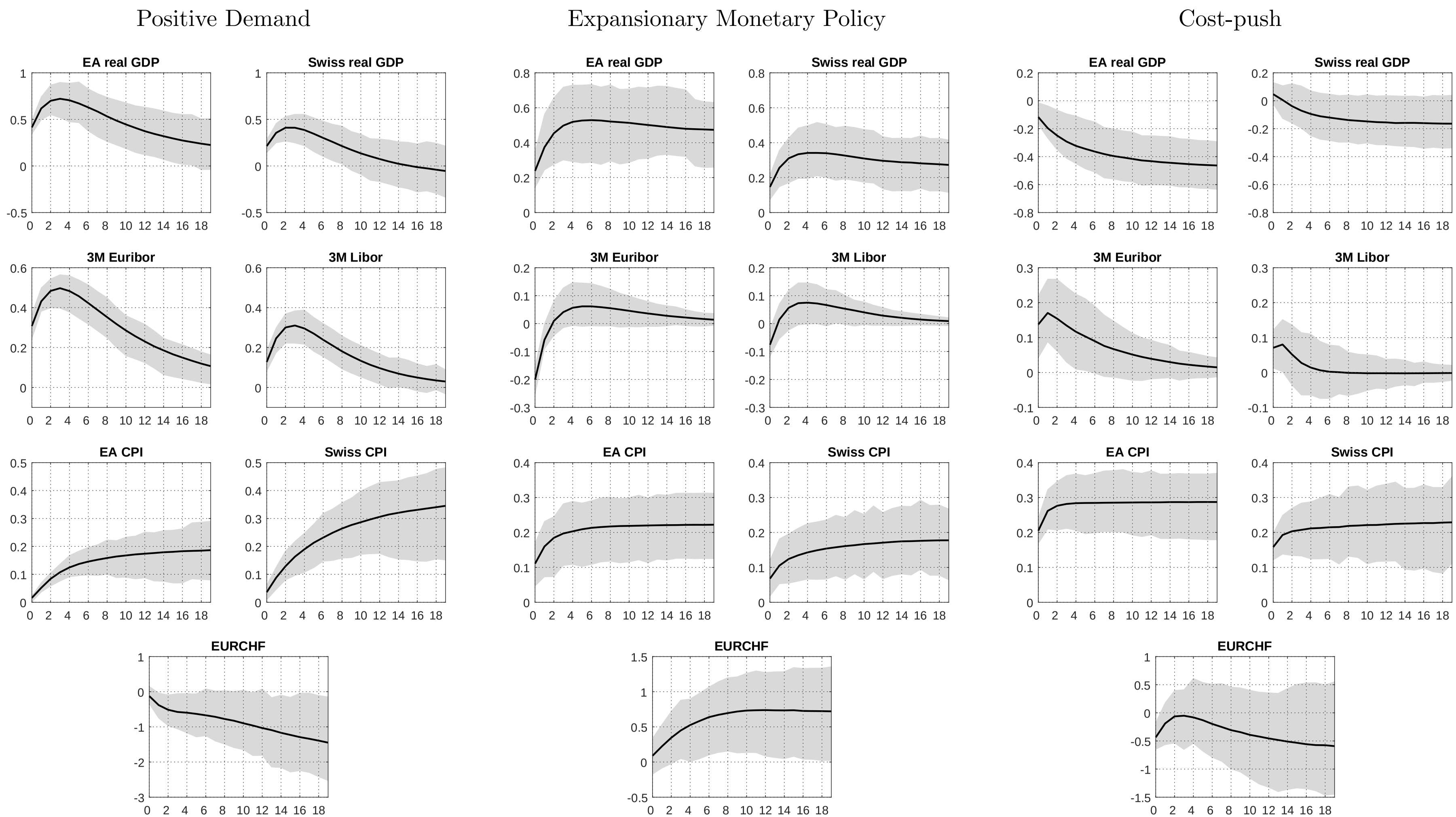
Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

Figure D.12 – Variance decomposition of Swiss variables and different price categories for the model with 2 unobserved factors and with 2 lag in the state equation and 0 lags in the observation equation



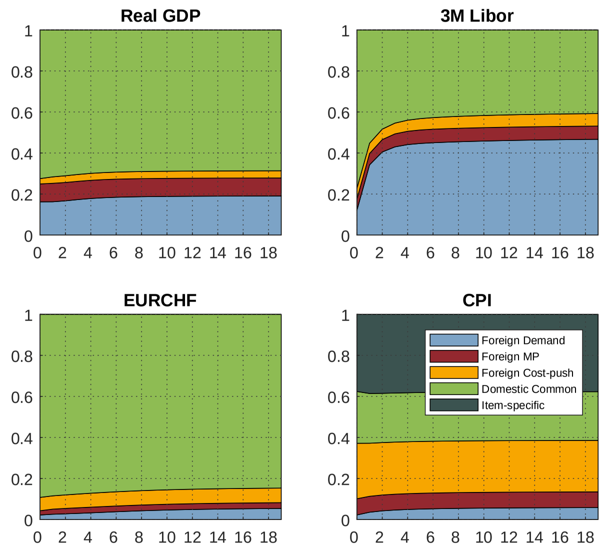
Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

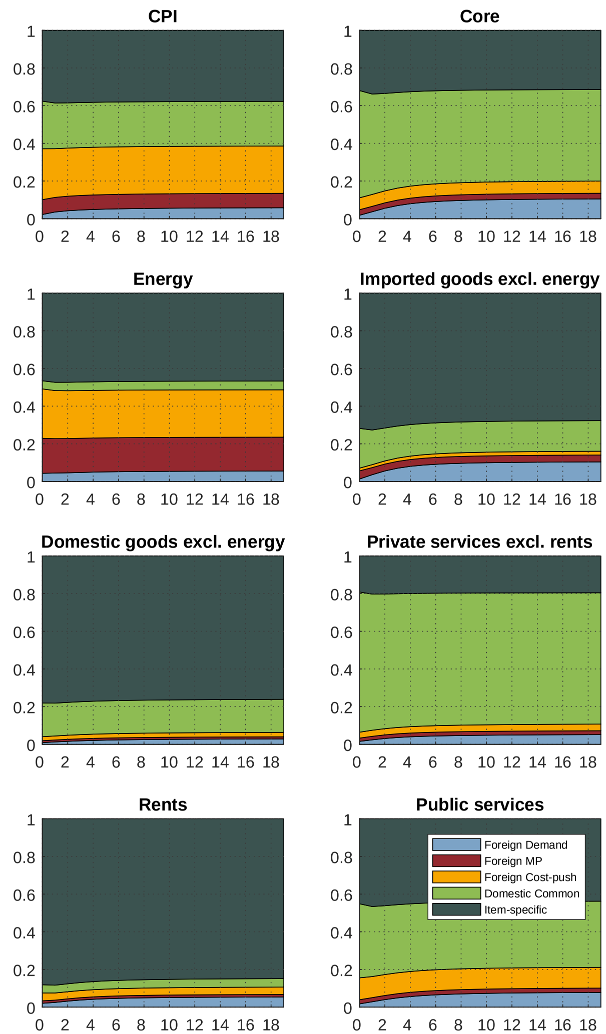
Figure D.13 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model with 1 lag in the state equation and 0 lags in the observation equation



Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

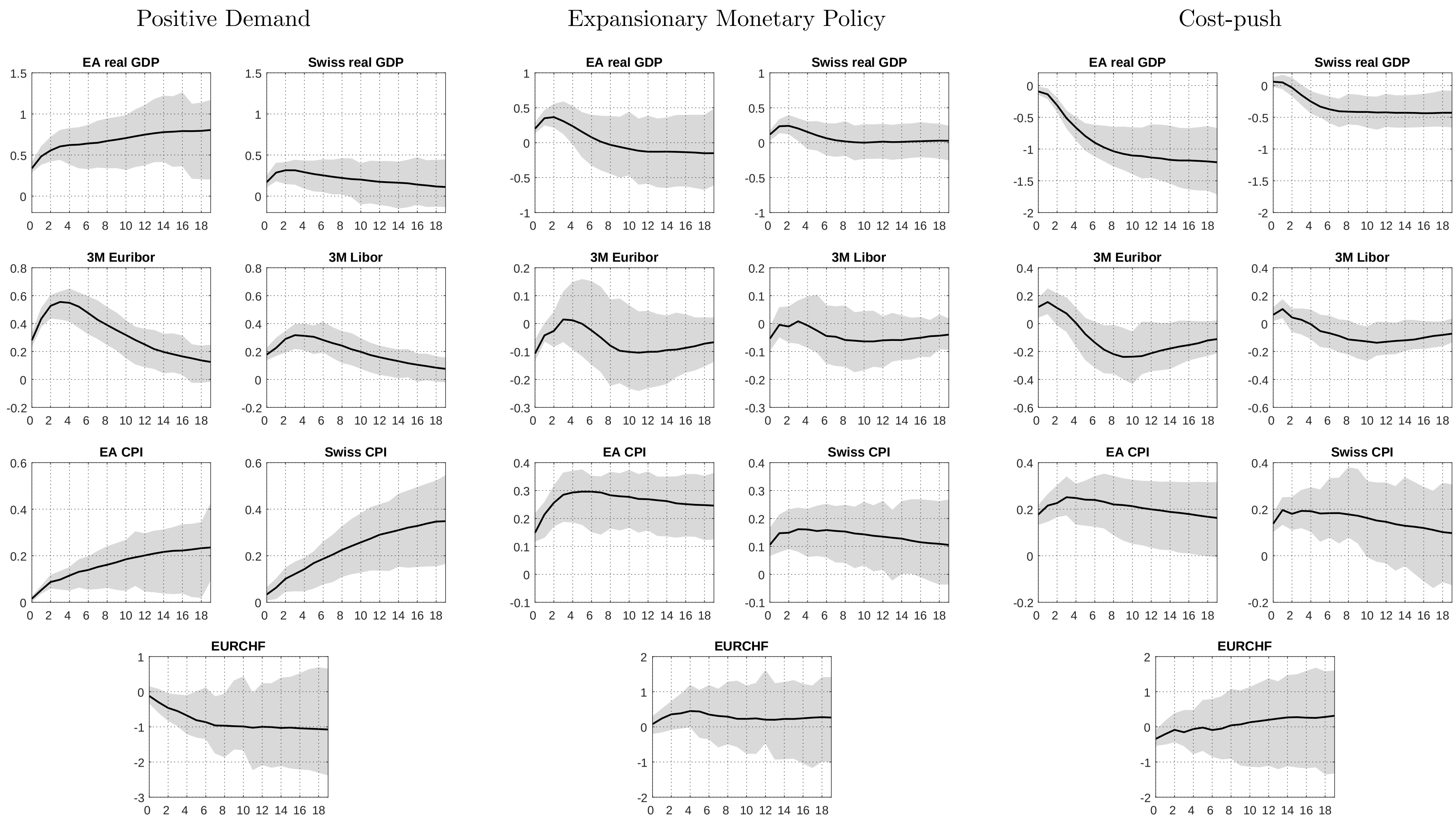
Figure D.14 – Variance decomposition of Swiss variables and different price categories for the model with 1 lag in the state equation and 0 lags in the observation equation





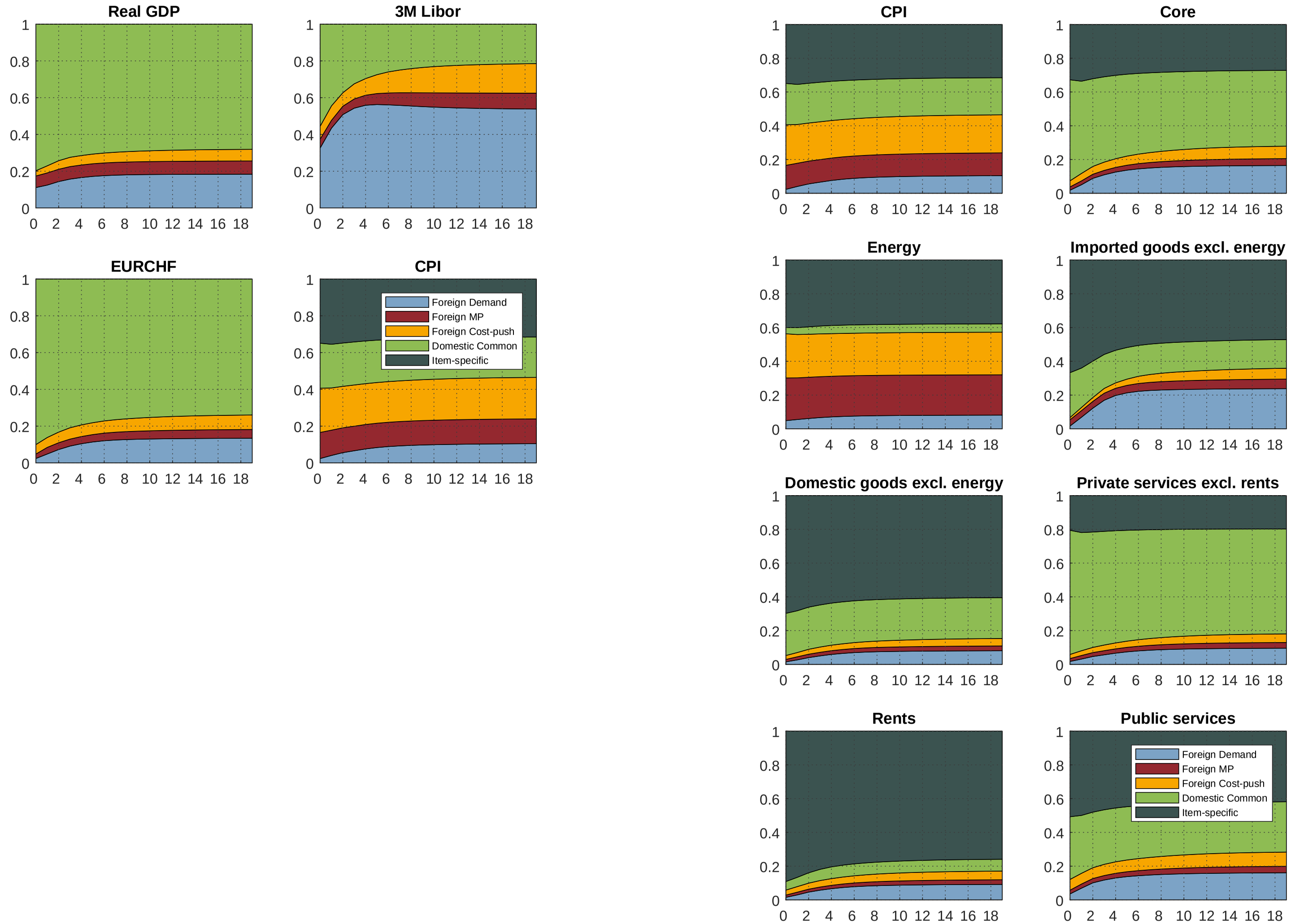
Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

Figure D.15 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model with 3 lags in the state equation and 2 lags in the observation equation



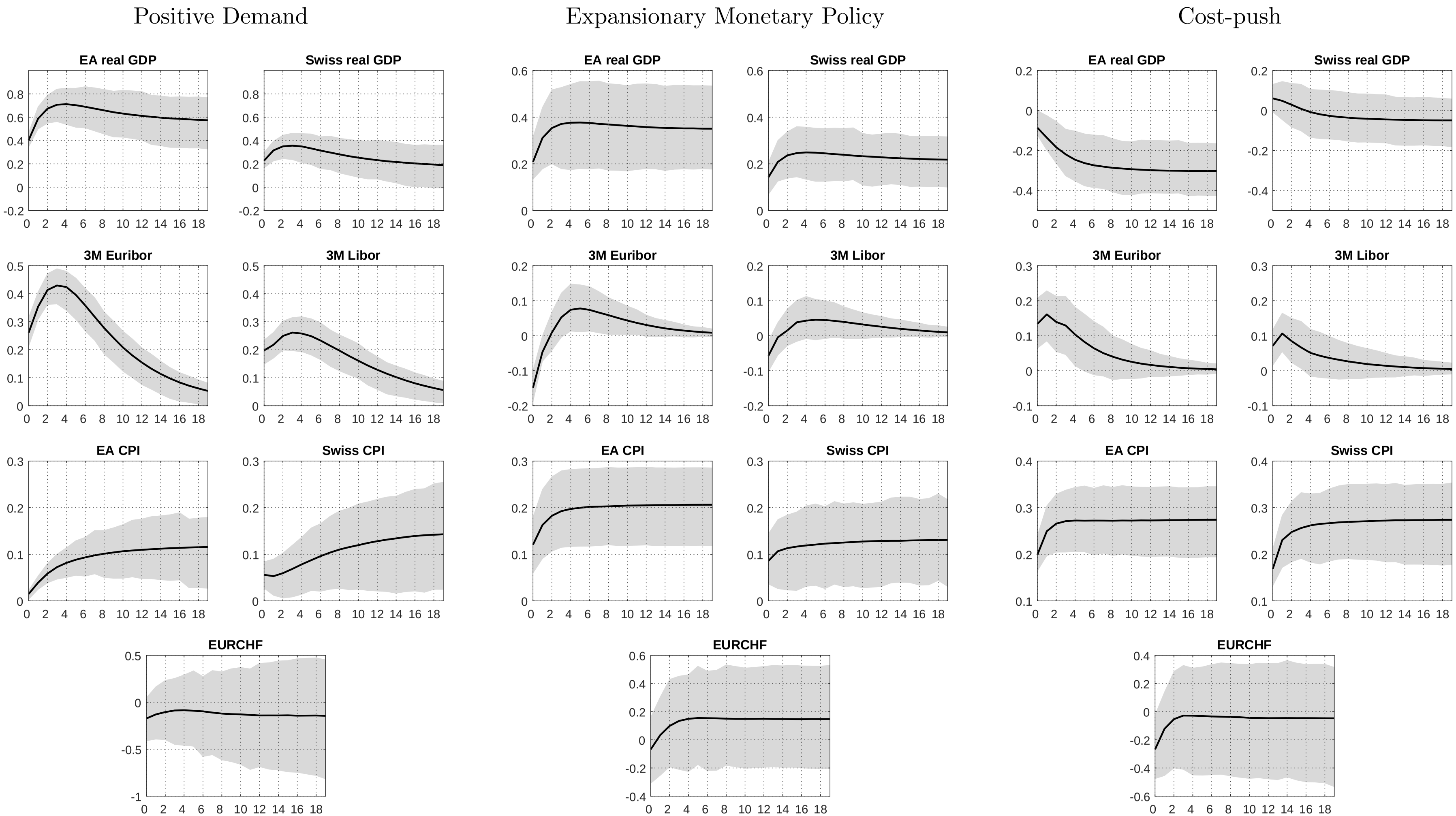
Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

Figure D.16 – Variance decomposition of Swiss variables and different price categories for the model with 3 lags in the state equation and 2 lags in the observation equation



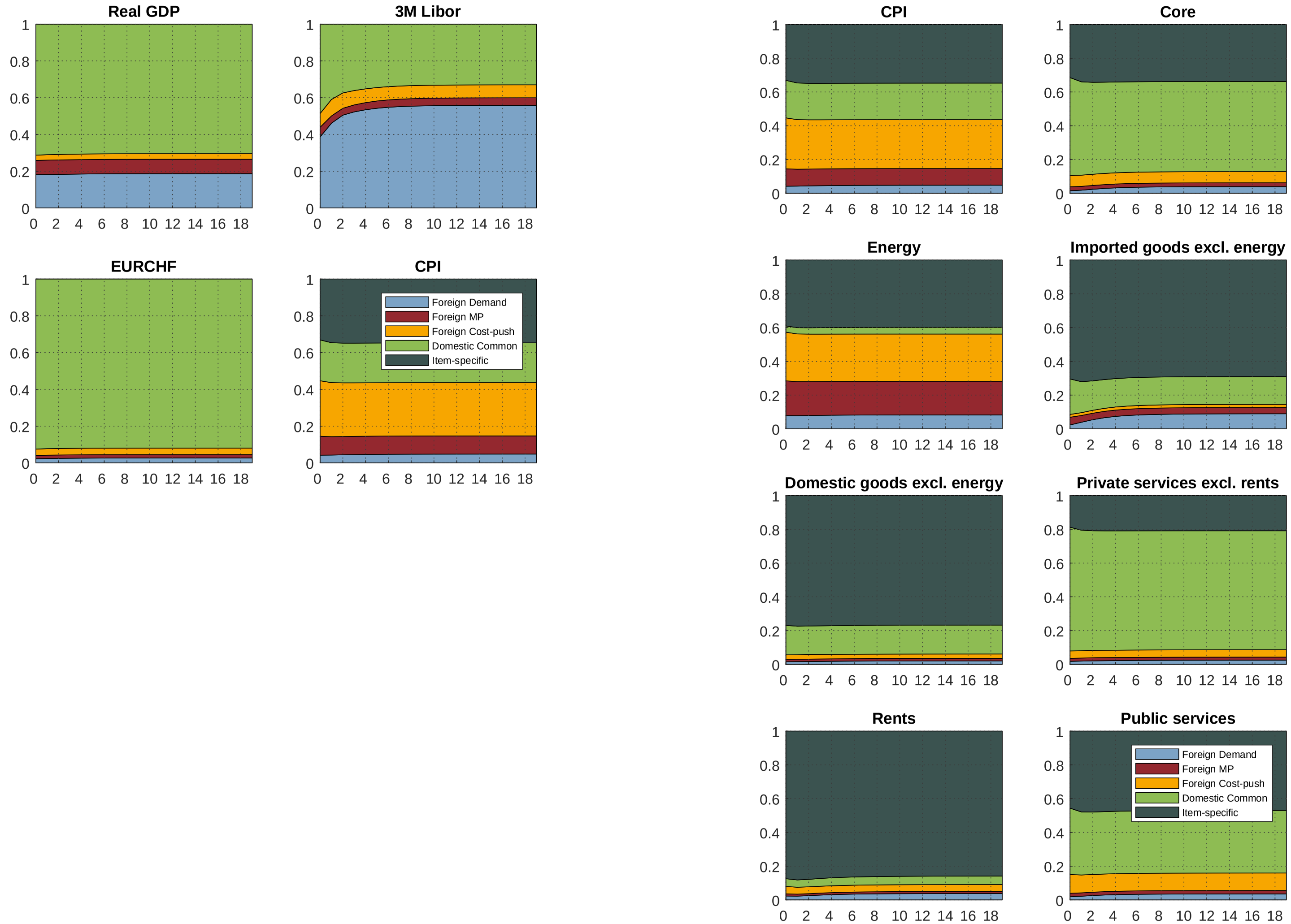
Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

Figure D.17 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model with prior parameters $\pi_1 = 0.2, \pi_2 = 0.7, \pi_3 = 2$ and 4 lags in the state equation and 1 lag in the observation equation



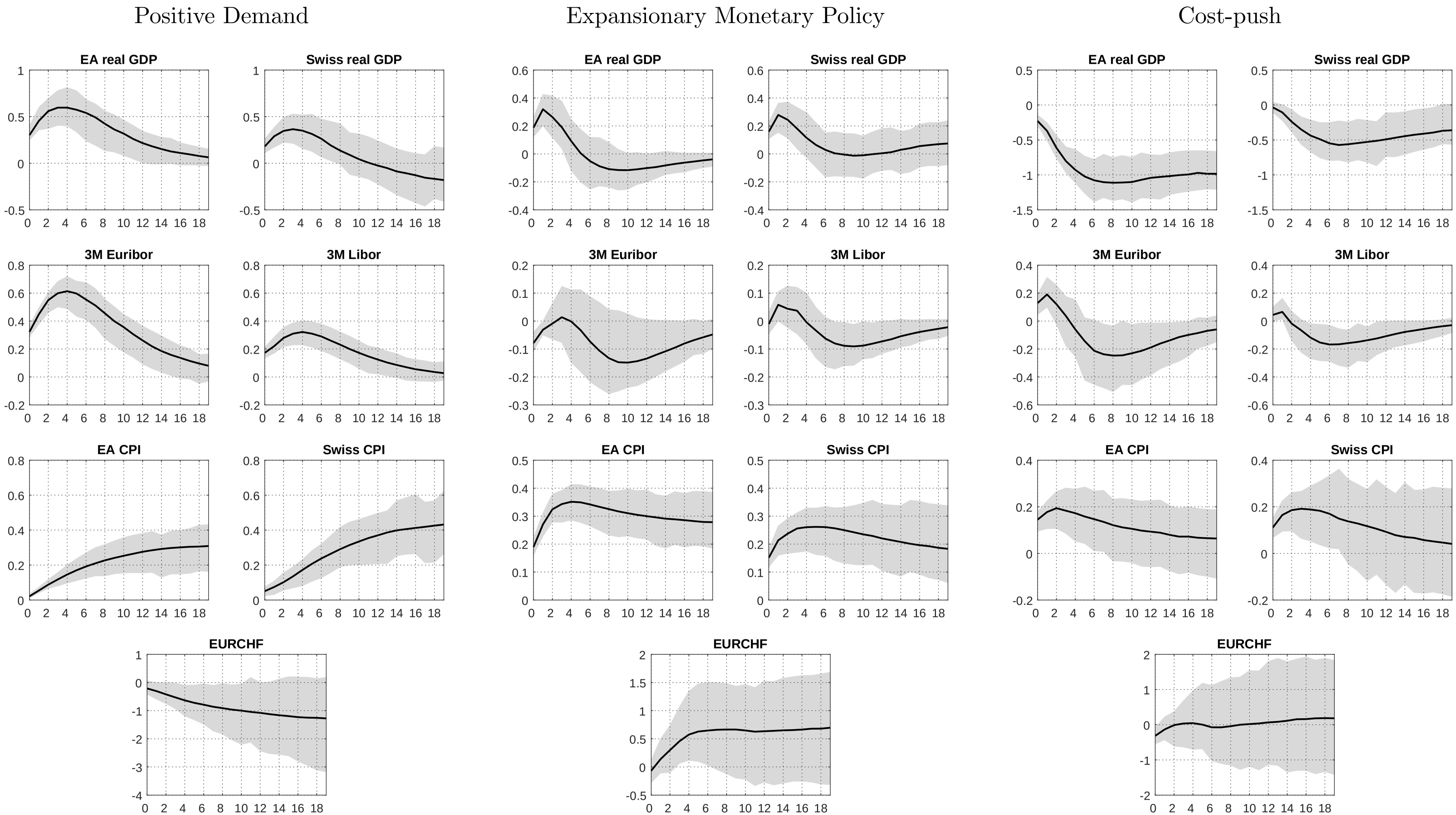
Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

Figure D.18 – Variance decomposition of Swiss variables and different price categories for the model with prior parameters $\pi_1 = 0.2, \pi_2 = 0.7, \pi_3 = 2$ and 4 lags in the state equation and 1 lag in the observation equation



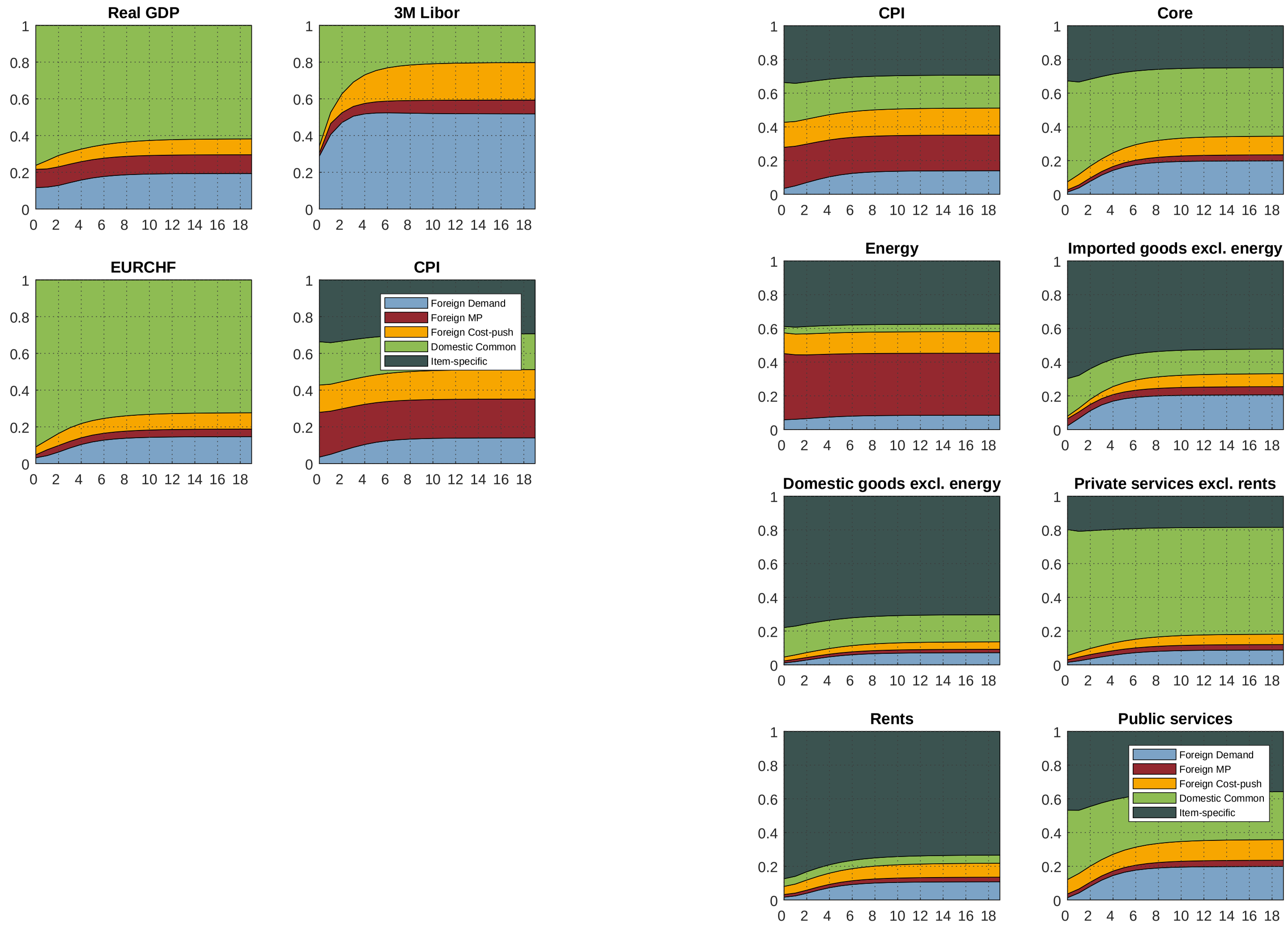
Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

Figure D.19 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model with long-run zero restrictions



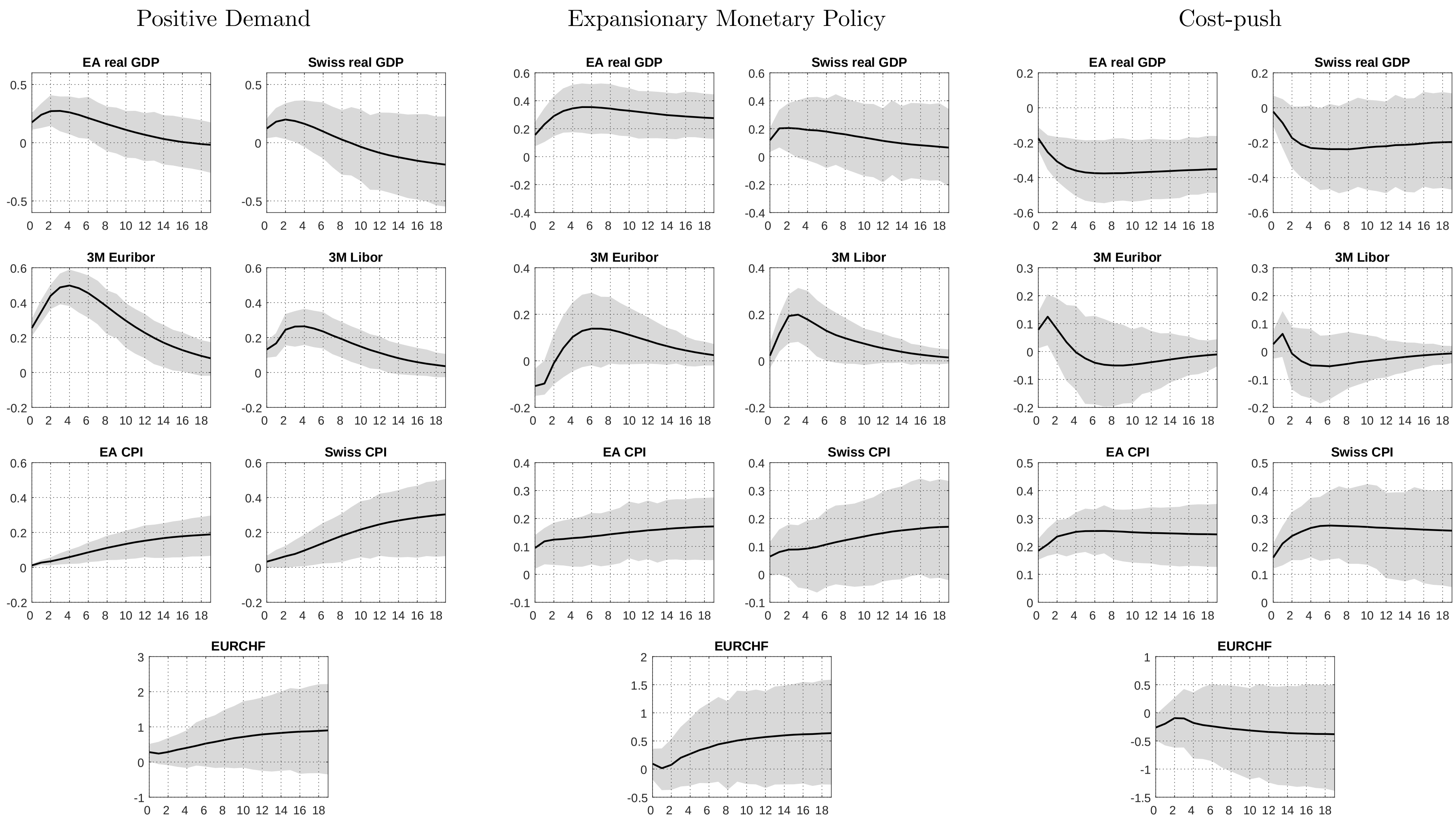
Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

Figure D.20 – Variance decomposition of Swiss variables and different price categories for the model with long-run zero restrictions



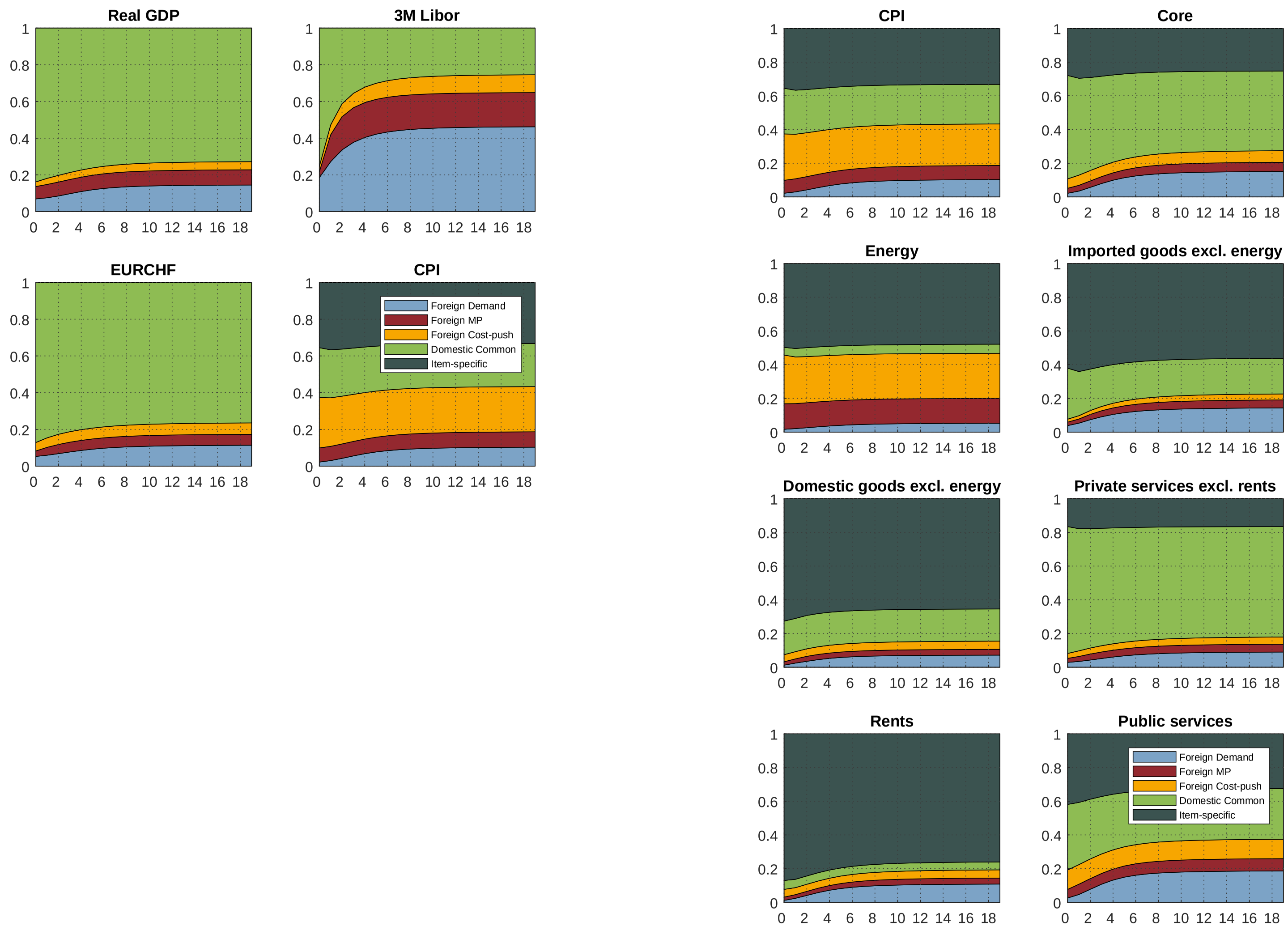
Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

Figure D.21 – Impact of foreign inflationary shocks on common factors and aggregate Swiss CPI for the model estimated on data for 1992Q1 to 2007Q4



Note: The figure illustrates the impulse responses to one standard deviation structural shocks at horizons up to 20 quarters (along the x-axis). The median response is depicted by the bold black line. The light gray shaded area represents the 68% HPD interval. For all variables, the cumulative responses are shown except for the interest rates. The response of the interest rates along the y-axis can be interpreted as the annualized quarter-on-quarter change in percentage points. All other responses along the y-axis denote percentage changes.

Figure D.22 – Variance decomposition of Swiss variables and different price categories for the model estimated on data for 1992Q1 to 2007Q4



Note: The figure illustrates the posterior mean of the forecast error variance decomposition of shocks (along the y-axis) at horizons up to 20 quarters (along the x-axis).

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