Demand Side Hysteresis in Finland - What Can We Learn from SVARs?*

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Abstract

We study whether aggregate demand shocks have long-run effects on output and employment using data for Finland and a number of other European economies. We use a recently proposed identification strategy that combines sign and long-run restrictions to estimate a SVAR model that allows for demand shocks with potentially permanent effects on output. In contrast to the results previously documented for the US, we fail to find convincing evidence of demand shock hysteresis in Finland. Our hysteresis results for other European countries are mixed. We also propose a simple generalization of the original identification strategy and find that allowing for the possibility of several distinct long-run supply shocks considerably reduces the estimated long-run relevance of demand shocks in the US economy.

Keywords: hysteresis, structural vector autoregressions, sign restrictions

JEL Codes: C32, E24, E32

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1 Introduction

The path of aggregate output is generally embodied by cyclical variation around a growing trend. Traditionally, cyclical variation—which can be explained by both supply and demand side factors—is seen as independent of economic growth. However, a growing literature makes a link between the cycle and the trend through so-called hysteresis effects (Cerra et al., forthcoming). Notably, the hysteresis view highlights the possibility that demand shocks in the present can have permanent effects on the long-run level of output via macroeconomic scarring effects. Future economic potential might be hampered, for example, by reduced investment—a phenomenon Summers (2015) dubs as inverse Say's Law: "Lack of demand creates lack of supply potential". Indeed, the finding of Anzoategui et al. (2019) that a substantial part of the slowdown in productivity growth since the Financial crisis can be attributed to an endogenous response of economic agents to the initial contraction in demand suggests that one channel of hysteresis is through the endogeneity of economic growth.[1]

Roots to the current interest in the hysteresis hypothesis arguably lie in recent macroeconomic experiences. Following the Financial crisis of 2007–2008, many countries saw a period of lackluster growth that was not strong enough to fill the gap between current output and its pre-crisis trend. Given that, as documented by Blanchard et al. (2015), a high proportion of recessions are followed by persistently lower levels of output, one may be led to ask whether demand shocks potentially leave permanent scars to the economy. Relatedly many papers, including Cerra and Saxena (2008), find that financial crises are associated with larger and more persistent output losses than other types of recessions and in a recent paper Benguria and Taylor (2020) provide evidence suggesting that financial crises are predominantly negative demand shocks.

Figure 1 plots the path of GDP per capita (15-64 y/o) for USA and Finland before and after the Financial crisis of 2007–2008. In both countries we can see a clear deviation from

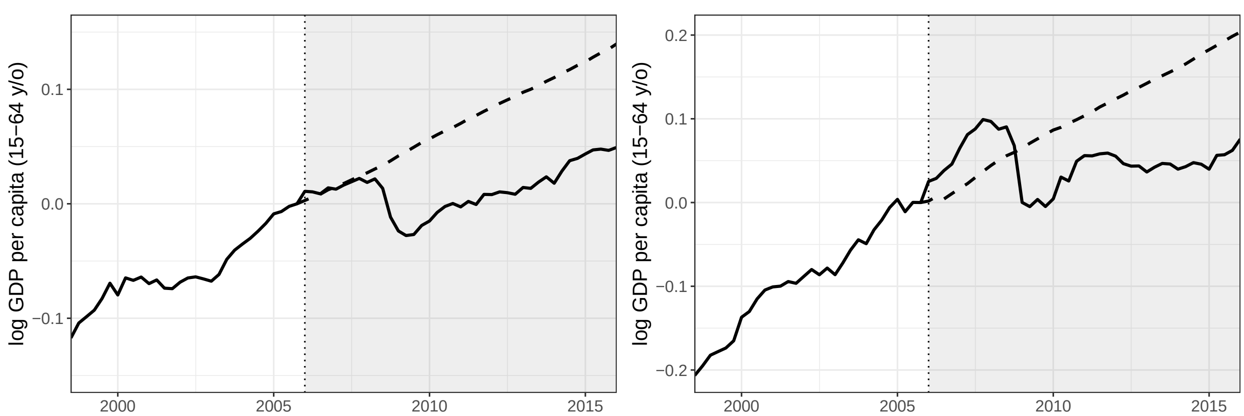
[1] Early references to hysteresis in economics, like Blanchard and Summers (1986), often highlight unemployment and scarring in the labour market as channels of hysteresis.

the trend that prevailed before the crisis. This figure however does not by itself imply that there are hysteresis effects at play. The drop in the level of GDP could conceivably be driven by supply side factors rather than the demand side. In order to answer the question of what drove this divergence of GDP from its prior trend, one needs to use some empirical approach that is able to distinguish between supply and demand side factors that are behind changes in GDP.

The aim of this paper is to address whether one-off demand shocks can have a long-term effect on levels of real economic variables, generating trend shifts similar those observed after the Financial Crisis (Figure 1). Our main focus here is on Finland, where references to the importance of hysteresis effects have recently been made in multiple instances.[2]

Figure 1: Log of GDP per capita and its model implied trend in the absence of shocks.

(a) USA **(b)** Finland



Notes: This figure plots logarithm of GDP per 15-64 year old population (solid line) and the median path for the same variable (dashed line) implied by the VAR model in section 2 in the absence of shocks following 2005Q4 (shaded area).

Our empirical approach builds on the recent work of Furlanetto et al. (2021), who propose a four-variable SVAR model for growth in output, price level, investment and employment. The model is portrayed as an extension of Blanchard and Quah (1989). Separation of demand

[2]At the time of preparing this paper, the economic effects of the Covid-19 pandemic are feared to persist long after the public health situation gets better. In relation to the current situation, multiple references to potential hysteresis effects have been made, for instance by Tervala (2020) and Lainà (2021) (both in Finnish). Up to this point, the Finnish discussion around hysteresis has been driven by theoretical and descriptive analyses due to a lack of rigorous empirical evidence specific to Finland.

and supply shocks in the Furlanetto et al. (2021) model is achieved with sign-restrictions, assuming that supply shocks move output and prices in opposite directions while demand shocks move them in the same direction. Their model then uses long-run restrictions to impose that one supply and one demand shock only have transitory effects on output. Thus, their model identifies 4 distinct shocks: demand and supply shocks with transitory effects, in addition to demand and supply shocks with *potentially* permanent effects on aggregate output. Main interest lies in the potentially permanent effects of demand shocks.

We manage to replicate the main results of Furlanetto et al. (2021) for the US economy, and use their identification strategy as our baseline across the paper.[3] We then estimate the Furlanetto et al. (2021) model using data for Finland and other European economies. For Finland, we fail to find evidence of strong hysteresis comparable to that found in the US. Evidence of hysteresis from other European countries is mixed, with a number of countries sharing the inconclusive hysteresis result found for Finland. However, our results for other European countries are partly work in progress, and should be regarded as preliminary.

The possible presence of demand side hysteresis implies that cost of demand driven output shortfalls would be higher and this has implications also for economic policy. Arguably, the welfare gains from counter-cyclical policy that aims to fill the output gap created by insufficient demand are greater if there are scarring effects to the long-run level of GDP from current lack of demand (see for example Tervala, 2021). In the case of hysteresis, counter-cyclical policy that supports current demand may thus not only dampen the current cycle but also support living standards permanently if it counters the permanent effects of hysteresis. The costs of fiscal policy might also be lower. DeLong and Summers (2012) even suggest that fiscal policy in recessions can be self-financing if hysteresis effects are accounted for.

Our paper is related to several recent empirical studies on hysteresis. Furlanetto et al.

[3] To be exact, the analysis for this paper was done before the publication of Furlanetto et al. (2021), with the aim of replicating an earlier version of the study (Furlanetto et al., 2020). While the main results are similar, there are differences regarding e.g. the choice of lag order between the two versions.

(2021) find that demand shocks have a permanent effect on real output in the US and are an important driver of it accounting for much of its long-run variation. Maffei-Faccioli (2021) finds using SVAR with common trends that demand-side factors are important drivers of not only long-run GDP levels but growth as well (*super-hysteresis*). In contrast to these papers, Benati and Lubik (2021) find no evidence of hysteresis effects using cointegrated SVARs for US, UK or the Euro area—unless researcher is willing to impose them upon the data. Relatedly from a perspective of policy, Jordà et al. (2020) find that monetary policy shocks have long-term effects on output while the results of Fatás and Summers (2018) suggest the same for fiscal consolidations.

This paper is structured as follows. In section 2, we describe the SVAR framework and the identifying assumptions used in this study. Section 3 provides details on the data used for estimation. Section 4 reports the results from our analysis. Section 5 briefly discusses the implications of our results and possible directions for future work, before section 6 concludes.

2 Methodology

In this section we outline the empirical methodology and identification strategies behind SVAR models that are use throughout this paper to study the presence of demand side hysteresis effects.

2.1 Empirical Framework

Following Furlanetto et al. (2021), our baseline empirical model is a stationary SVAR in first differences

$$\Delta y_t' A_0 = \sum_{j=1}^{p} \Delta y_{t-j}' A_j + c' + \epsilon_t', \tag{1}$$

where y_t and c are $(n \times 1)$ real vectors, and A_j is an invertible $(n \times n)$ matrix for all $j = 0, ..., p$. Conditional on the parameters, shocks ϵ_t are assumed to be independent across t and identically distributed as multivariate normal with mean zero and a unitary covariance matrix. The associated reduced-form is

$$\Delta y_t' = \sum_{j=1}^{p} \Delta y_{t-j}' B_j + d' + u_t', \tag{2}$$

such that $B_j = A_j A_0^{-1}$, $d' = c' A_0^{-1}$ and $u_t = \epsilon_t' A_0^{-1}$.

Structural shocks, ϵ_t, are identified using a combination of contemporaneous sign restrictions and zero restrictions on the long-run effects. In other words, we impose signs onto A_0^{-1} (impact matrix) and zeros on $(A_0 - \sum_{j=1}^{p} A_j)^{-1}$ (long-run effects matrix). We use the Bayesian algorithm of Arias et al. (2018) to draw from the posterior distribution over the structural parameters. All of our specifications use an improper uniform prior over the (orthogonalised) reduced-form parameterisations that are compatible with a stationarity. This deviates from Furlanetto et al. (2021), who use a combination of informative Minnesota and sum of coefficient priors. Note, however, that we are able to replicate the Furlanetto et al. (2021) results for the USA very accurately using our non-informative prior, suggesting that prior choice should not be driving the lack of demand shock hysteresis we find for Finland.

Within this framework, we evaluate the presence of hysteresis effects in several ways. First, we can look at the posterior probability at which a negative demand shock has a negative impulse effect on a given real variable. A high probability of negative impulse effects is interpreted as evidence in favour of hysteresis. Second, we can use a forecast error variance decomposition (FEVD) to compare the relative importance of identified shocks at different horizons. A large demand shock share in FEVDs at long horizons speaks in favour of the practical relevance of demand shocks for long-run outcomes. Finally, historical decompositions can be used to evaluate how specific historical periods, such as the Financial Crisis of 2008, coincide with shocks identified from the model.

2.2 Baseline Identification

Our baseline model is that of Furlanetto et al. (2021), which considers a four-variable SVAR with real GDP per capita, prices measured by the PCE deflator, real investments per capita, and employment-to-population. In addition, responses of output per worker to identified shocks can be backed out from the model as a difference between output and employment impulse responses. We interpret output per worker as a coarse measure of productivity, as is done in the original paper.

Identifying assumptions in the baseline model are summarised in Table 1. The model includes two demand shocks and two supply shocks. Sign restrictions on contemporaneous output and prices are used to distinguish between demand and supply shocks. The contemporaneous effect of a demand shock on output and prices are assumed to have the same sign while a supply shock is assumed to have output and price effects of opposite signs. Such an identification scheme follows from the simple logic of upward-sloping aggregate supply and downward-sloping aggregate demand curves that featured already in elementary economics. Using them is common practice in the literature.

Zero restrictions on the long-run multiplier matrix are used to separate temporary shocks from those with potentially permanent effects á la Blanchard and Quah (1989). Note that as all variables enter the model in first-differences in the Furlanetto et al. (2021) model and no cointegrating relations are specified, we cannot have shocks with no long-run effects on all of the modeled variables. Furthermore, in the considered four variable setting, it is not even possible to have two shocks restricted to have only price effects in the long run. Instead, the temporary and permanent shocks are distinguished by constraining temporary shocks to no long-run effects on the level of output and employment. It should be noted that a stationary specification in log-differences automatically rules out any shock having a permanent effect on the growth rate of the modeled variables.

Table 1: Furlanetto et al. (2021) Identifying Restrictions

	Demand 1		Supply 1		Demand 2		Supply 2	
	Impact	LR	Impact	LR	Impact	LR	Impact	LR
GDP	-	0	-	0	-		-	
PCE deflator	-		+		-		+	
Investment								
Employment		0		0				

Notes: "Impact" stands for contemporaneous restrictions. "LR" stands for long-run restrictions.

2.3 Alternative Identification

As an alternative identification scheme, we consider a simple modification of the Furlanetto et al. (2021) model in Table 2. Our alternative model can be thought of as a relaxation of the identifying restrictions outlined above. In the alternative identification scheme we allow—without imposing—for the possibility of multiple long-run supply shocks. This is in contrast to the model Furlanetto et al. (2021) that imposes only one supply shock to have permanent effects on the level of GDP. The generalization is achieved by, rather than imposing that both output and employment responses are zero in the long-run, imposing that they are equal. In practice, this amounts to assuming that the response of output per worker to a Supply 1 shock is zero in the long-run.

Table 2: Alternative Identifying Restrictions

	Demand 1		Supply 1		Demand 2		Supply 2	
	Impact	LR	Impact	LR	Impact	LR	Impact	LR
GDP	-	0	-		-		-	
PCE Deflator	-		+		-		+	
Investment								
Employment		0						
Output Per Worker				0				

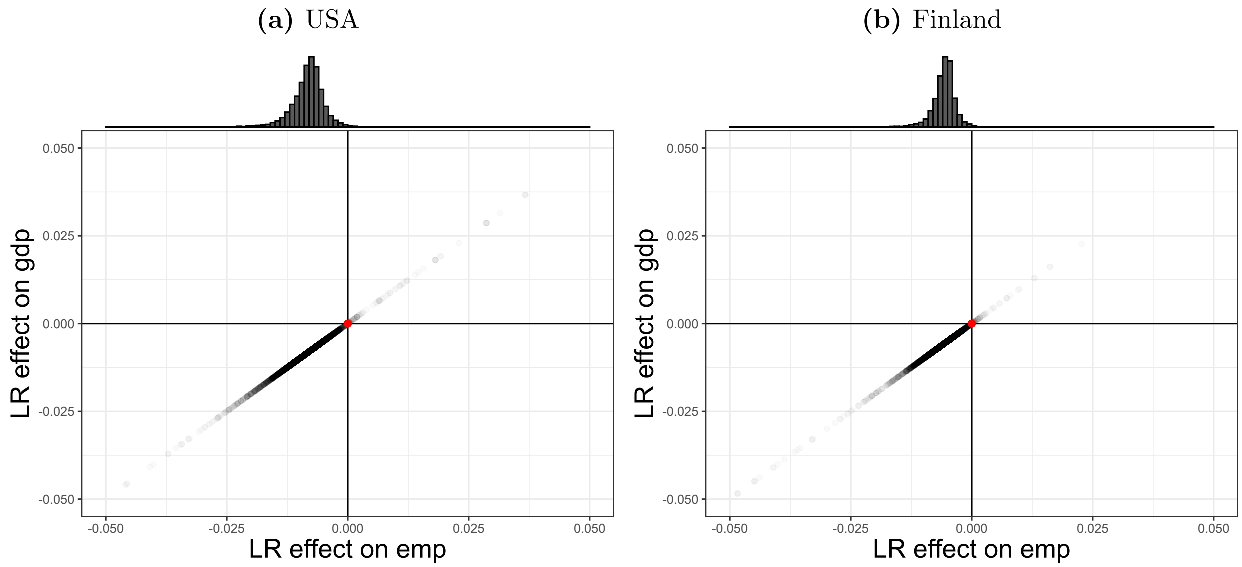
Notes: "Impact" stands for contemporaneous restrictions. "LR" stands for long-run restrictions.

Having several *distinct* supply shocks with long-run effects on real variables is a feature shared by several prominent theoretical models. For example, Shapiro and Watson (1988), Smets and Wouters (2007), and Galí et al. (2012) have productivity and labour supply shocks as two distinct determinants of long-run outcomes. As the Furlanetto et al. (2021) identification only allows for one permanent supply shock, we are interested in whether their results are robust for our proposed generalization and how the result of strong demand side hysteresis effects in the US data might be affected.

As said, our alternative identification strategy is summarised in Table 2. We relax the identifying restrictions on Supply 1 shocks from that in Furlanetto et al. (2021), requiring only that Supply 1 shocks have no effect on output per worker in the long run. Whereas in Furlanetto et al. (2021), Demand 1 and Supply 1 shocks are both interpreted as temporary shocks, our alternative identification allows for the possibility of both Supply 1 and Supply 2 shocks to have long-run effects. While, as we shall see, it turns out that Supply 1 shocks could perhaps be interpreted more as employment shocks and Supply 2 more as "productivity" shocks, this result is not imposed on the data. Either of the supply shocks could, for example, have had no long-run effects on both output and employment, which would take us back to the Furlanetto et al. (2021) model. Our alternative identification strategy is thus a generalization of the original model that nests it as a special case.

Figure 2 illustrates this point. It plots the long-run effects of negative Supply 1 shocks on output and employment across the estimated models for the US and Finland that are discussed in later sections. Alternative identification allows for permanent effects on output as far as this effect comes only from changes in employment, not affecting output per worker in the long-run. All models that are consistent with the restrictions of the alternative identification fall on the identity line ($y = x$) in Figure 2 whereas the baseline identification only allows for the long-run responses to be zero, as illustrated by a red dot at the origin ($y = x = 0$). From Figure 2 we also see that most of the mass for the alternative identification is left of zero (the baseline restriction) suggesting that on average Supply 1 shock now has some explanatory power over long-run employment. Distribution of the long-run effects of a unit Supply 1 shock is given by a histogram on top of the xy-plane.

Figure 2: Long-run effects of negative Supply 1 shocks on GDP and employment.



Notes: This figure plots the distribution of the long-run effects of Supply 1 shocks on output (*gdp*, y-axis) and employment (*emp*, x-axis) based on 10000 draws from the model posterior for the alternative identification. Red dot at the origin represents the restriction imposed by baseline identification that Supply 1 shock have no long-run effect on either *gdp* or *emp*.

The proposed alternative identification strategy also relates to the idea of separating productivity and non-productivity shocks using a long-run zero restriction on total factor productivity (Galí, 1999). While there are obvious issues with using output per worker instead of TFP for productivity shock identification, we limit ourselves to output per worker here keep the framework of analysis close to that of Furlanetto et al. (2021). The current approach should therefore been seen more as an interesting robustness check to the Furlanetto et al. (2021) model than as a complete standalone empirical model. Future work should look into a more complete and rigorous implementation of the ideas suggested here.

3 Data

The SVAR models outlined in the previous section all contain four variables: output (real GDP), price level (PCE deflator), investment and employment. These variables enter the model in (first-differenced) logarithms and we regularly refer to these logarithmic variables as *gdp*, *p*, *inv* and *emp* across the paper. Output per worker in logarithms is then given by $gdp - emp$. This section outlines data sources for US, Finland and other European economies.

United States

For the US, data is retrieved through FRED. Similar to Furlanetto et al. (2021), we use quarterly data from 1983-Q1 to 2019-Q4. Seasonally adjusted rates were used for private investment (GPDIC1), real GDP (GDPC1), and employment (CE16OV). PCE deflator (DPCERD3Q086SBEA) was used as the price series. Population was measured by a series excluding armed forces (CNP16OV).

Finland

Data for Finland are retrieved through Statistics Finland. Seasonally and working day adjusted series were available for all real series except employment. Employment and prices were seasonally adjusted using X-13ARIMA-SEATS included in the IRIS Toolbox.[4] The basis year for price adjustments is 2015. We use real gross domestic product (B1GMH) to measure output, the price deflator to private consumption (P3KS14S15) for price levels, gross fixed capital formation in real terms (P51K) as a measure of investments, and employment to population aged 15 to 64 (ER1564) as the employment measure. Investment and gdp were transformed to per capita terms relative to the population aged 15 to 64.

Quarterly data was available from between the years 1990 and 2021. We chose to limit our analysis to between 1995-Q1 and 2019-Q4. The choice of the starting period was made to exclude the recessionary period in the earlier part of the 1990s, which was difficult to analyse without preceding data. Finnish accession to the EU in 1995 also makes this a natural starting point for our analysis. The end date was chosen to exclude periods affected by the COVID-19 pandemic.

[4] IRIS Toolbox Release 20210824. Available for download from: https://github.com/IRIS-Solutions-Team/IRIS-Toolbox.

Other European economies

For data on European countries, we retrieve data through Eurostat. The measures used are identical to those above. Differences in data vintages and corrections mean that results for Finland differ slightly when using data from Eurostat instead of domestic data sources. For most countries data is available from 1995-Q1. The exceptions are Baltic countries (Estonia, Latvia, Lithuania) where data starts from 1997-Q1, Italy and the Netherlands where data starts from 1996-Q1, and Sweden, Norway, and Finland where data begins form 1995-Q2.

4 Results

This section reports main results from our SVAR analysis. First for the US, then for Finland, and finally for other European economies.

4.1 Summary of results for the US

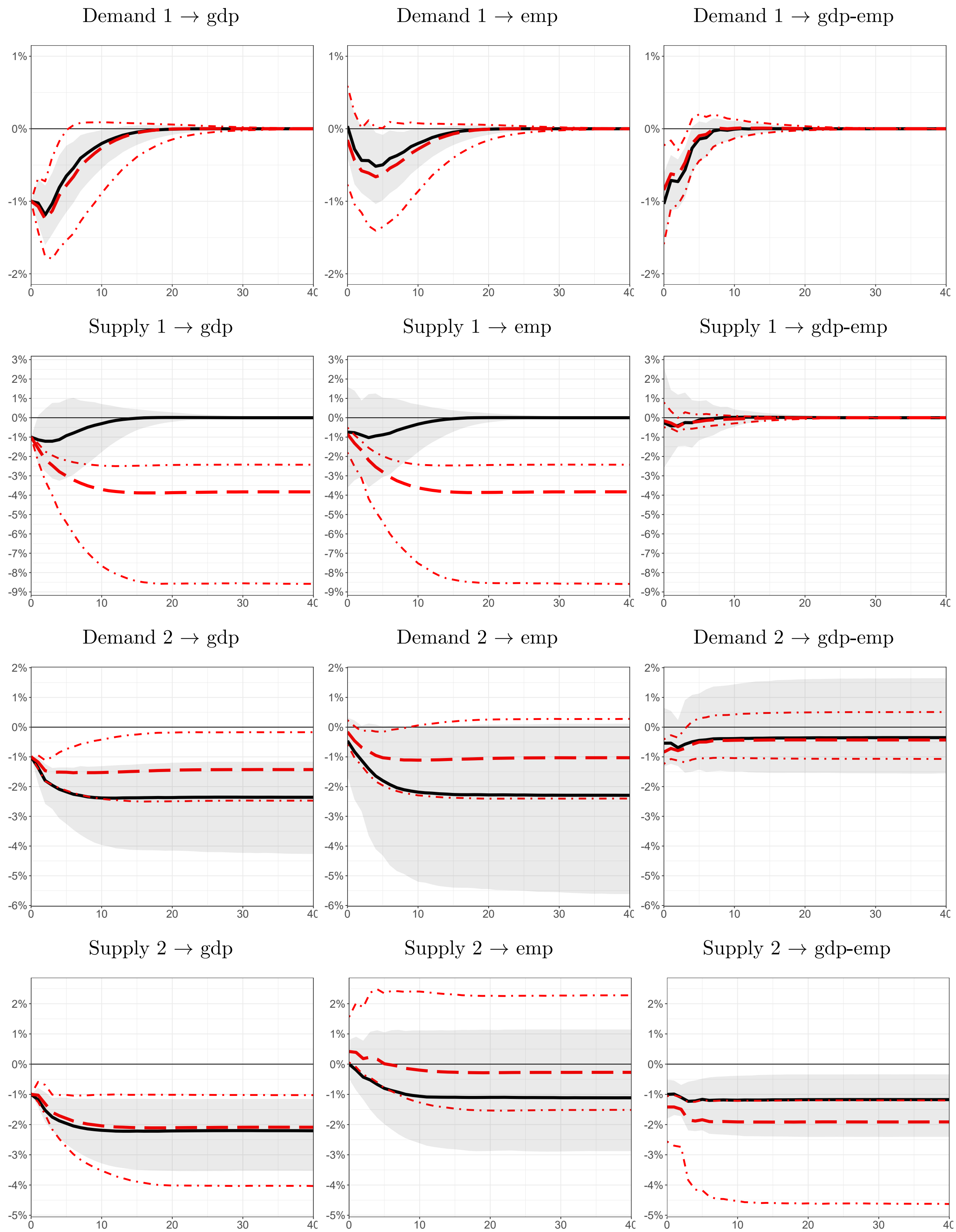
This subsection provides results for the US. We first replicate the results of Furlanetto et al. (2021) but we also provide results using our proposed alternative identification scheme. To better help compare the differences in results, Figure 3 plots impulse responses of output (gdp), employment (emp) and output per worker ($gdp - emp$) to identified shocks using either the baseline identification (solid line) or alternative identification (red longdashed line). To facilitate comparison across models, impulse responses have been normalized such that the initial reaction using both identification schemes.[5] In addition, Figure 4 provides forecast error variance decompositions (FEVDs) for both models.

Baseline Identification

We successfully replicate the results of Furlanetto et al. (2021) using US data. We summarise their main findings here but some of our replication results are relegated to the Appendix.

[5] Normalization is done for all 10000 draws from the posterior.

Figure 3: Impulse responses to a normalized shock that moves gdp initially by −1%, US.



Notes: This figure plots pointwise median impulse responses and associated 68% credible intervals for models that use baseline (solid line, shaded area) and alternative (red longdashed line, red dotdashed lines) identifications based on 10000 draws from the posterior. Initial shock is normalized to move gdp by −1% in each draw from the posterior.

The headline result of Furlanetto et al. (2021) is that demand shocks have permanent effects on output and that demand side hysteresis effects seem to be an important driver of US GDP. They find that a negative Demand 2 shock has a permanent negative effect on both output and employment with high posterior probability. Demand 2 shocks' long-run effects are sizeable. Figure 3 shows that much of this long-run effect on output is explained by the permanent response in employment. Output per worker is not significantly affected by Demand 2 shocks in the long-run.

Demand 2 shocks also account for a major share of the output and employment forecast error variance at the 10-year horizon. In the FEVD that is calculated from median impulse responses (see Figure 4a), replicated from Furlanetto et al. (2021), we see that Demand 2 shocks account for roughly 50% of output fluctuations and close to 80% of employment variation at forecast horizons up to 10 years.[6] At the same time, demand shocks do not seem to have a permanent effect on output per worker in the US data.

Meanwhile, the effects of temporary shocks on real variables, even at short horizons, are quite limited in the US data. Demand 1 shocks can be characterised almost as purely inflationary shocks, while Supply 2 shocks do not seem to have economically meaningful effects on either output or employment at any horizon.

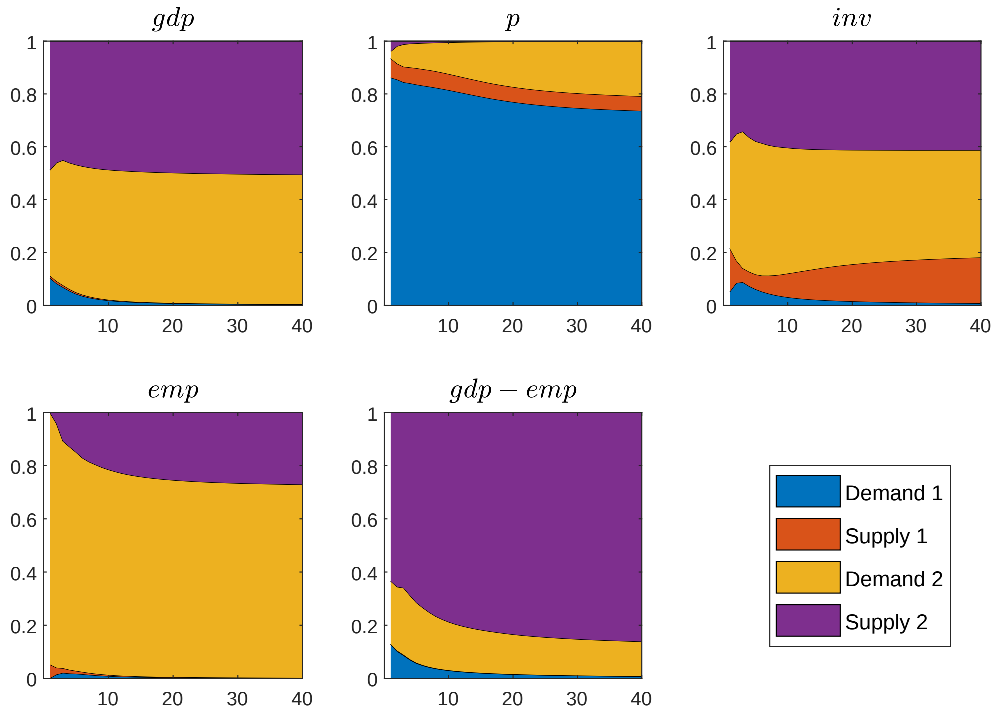
Alternative Identification

Estimating the alternative model for US data, we find that the share of demand shocks in employment fluctuations reduces from over 80% in the baseline model to less than 20% in the alternative identification. Figure 4b shows the FEVD based on median impulse responses obtained from the alternative identification. The role of demand shocks in output and employment fluctuations in the US economy is reduced considerably relative to the Furlanetto et al. (2021) model. Instead, Supply 1 shocks now account for the majority of employment

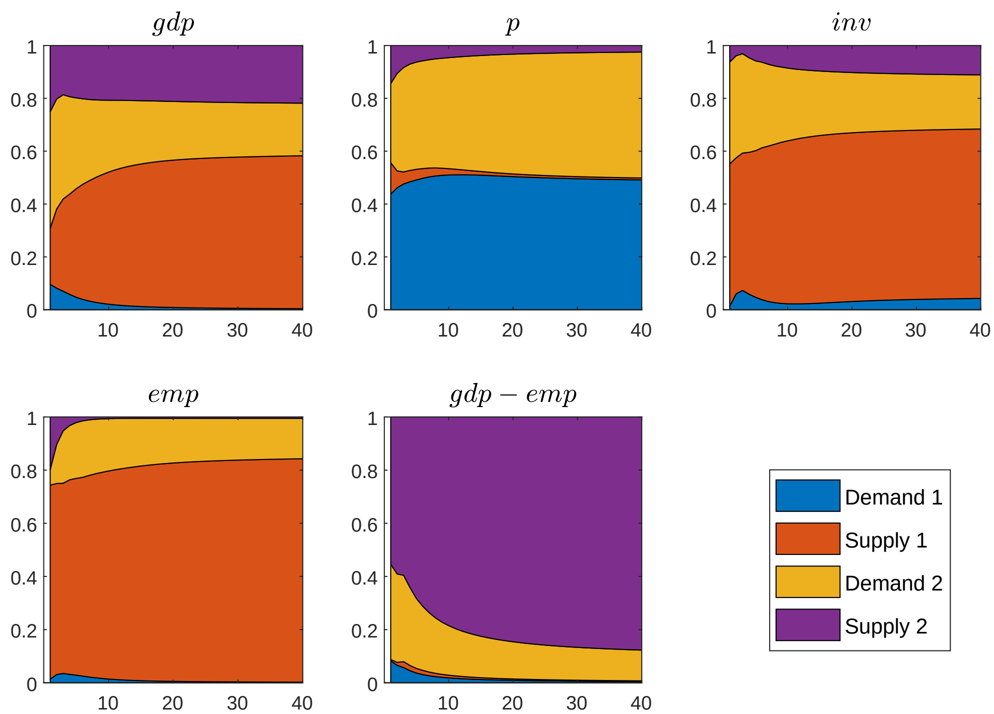
[6] As a caveat to this result, we find in our replication that dispersion of FEVD shares around their median is large in the posterior distribution. For example, the 68% credible interval for Demand 2 shocks' share in employment variance at a ten-year horizon ranges from 20% to 90%. See Figure A2 in the Appendix.

Figure 4: FEVDs, US.

(a) Baseline identification



(b) Alternative identification



Notes: Decompositions are based on pointwise median impulse responses on the levels of the variables. X-axis has the forecast horizon in quarters starting from 0.

and output fluctuations. Given the large role of Supply 1 shocks in employment fluctuations, and the role of Supply 2 shocks in output per worker fluctuations, we could give them interpretations of employment and productivity shocks, respectively.

Despite of the reduced relative effect, negative Demand 2 shocks continue to have a permanent negative effect on output and employment with high posterior probability (see Figure 3). However, the median size of the impulse response is smaller in absolute terms than in the baseline identification for both of these variables. In common with the baseline model, demand shocks do not have long-term effects on output per worker.

Supply 2 shock's long-run effect on output per worker is increased whereas the effect on employment diminishes as is evident from Figure 3. At the same time, as Supply 1 shock is allowed to have a long-run effect on output through employment, it seems to also depress the effect that Demand 2 shocks have on employment in the baseline model while Supply 1 shock has a relatively large effect on employment. This speaks to our interpretation of them as supply shocks with different long-run characteristics: one more of a labour supply shock and one more of a productivity shock.

Historical decompositions for the US using the alternative identification (Figures A6 and A7 in the Appendix) suggest that while demand shocks were driving the sharpest decline in output and employment in 2008-2009, supply shocks were responsible for the more persistent negative pressure on real variables around this period.

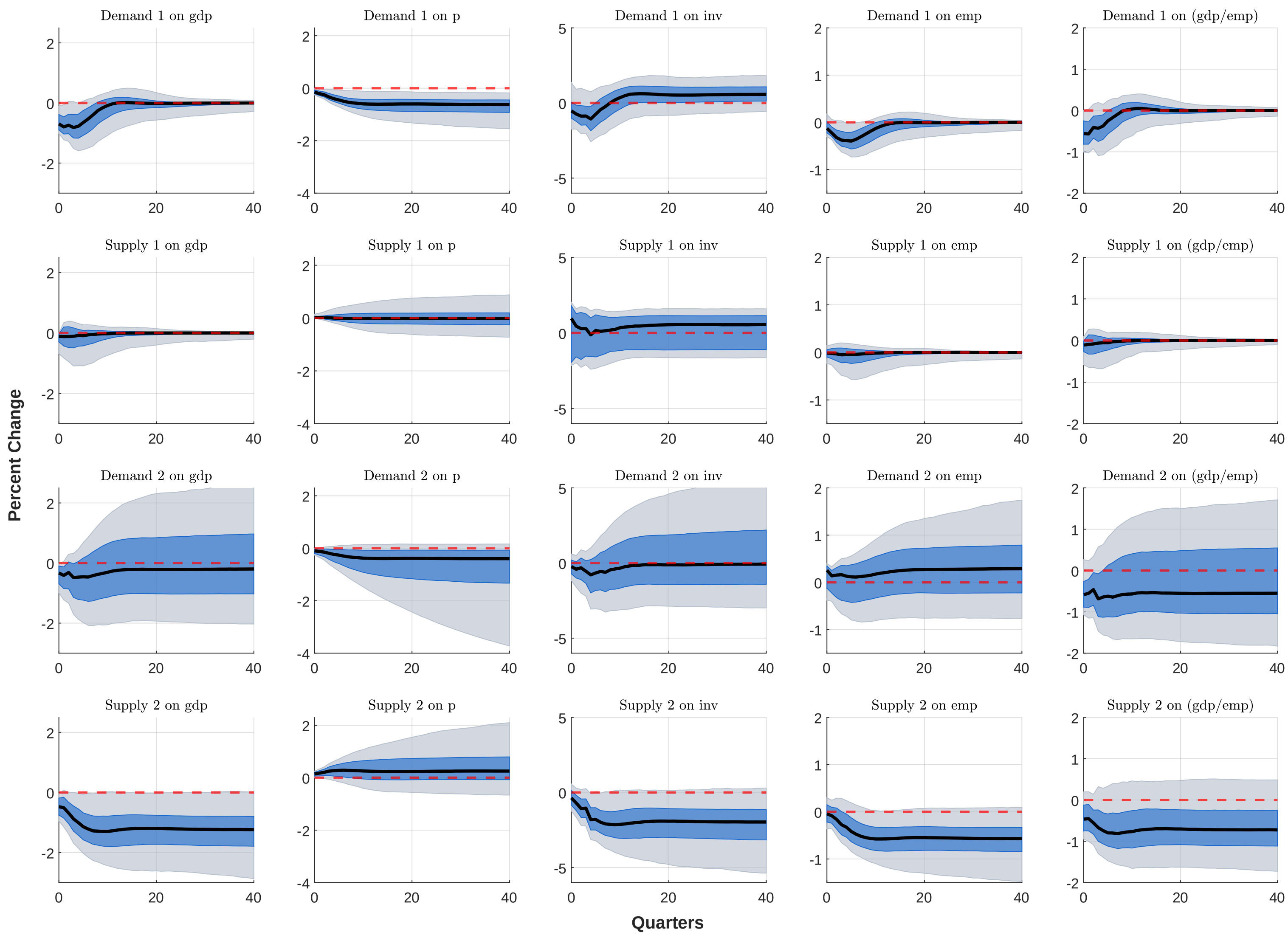
4.2 Results for Finland

Baseline Identification

Using the Furlanetto et al. (2021) empirical model, we fail to find evidence of strong demand side hysteresis in the Finnish data.

Figure 5 shows impulse responses of the modeled variables (in levels) to identified shocks. We see that forecast horizons longer than two years the 68% posterior credible intervals for impulse responses of real variables to Demand 2 shocks all include zero. This null result also

Figure 5: IRFs on Levels, Finland Baseline identification



Notes: Plots show percent changes in levels (based on log-difference approximation) after unit-sized shocks at period zero. Y-axes are scaled by 100. Figures are based on 10000 draws from the posterior distribution. Dark lines denote pointwise posterior medians. Inner bands denote pointwise 68% posterior credible intervals. Outer bands denote pointwise 95% posterior credible intervals.

holds at horizon infinity (see Table A1 and Figure A9 in the Appendix). Even though the credible intervals for Demand 2 impulse effects on output per worker include zero at longer horizons, the median effect is economically sizeable and of a similar magnitude as that of Supply 2 shocks. However, this median effect on output per worker is associated with a median *rise* in employment, as most clearly seen from Figure A8.

In contrast to the effects of demand shocks, and in line with the US results, impulse responses of real variables to a negative Supply 2 shock are negative with a high probability in the posterior distribution. The median impulse effect of a negative Supply 2 shock leaves output 1.2%, investment 2%, employment 0.6%, and output-per-worker 0.7% lower ten years after the shock has passed.

In the FEVD based on median impulse responses, Supply 2 shocks account for most of the variation in in output, investment, and employment. At a 10-year horizon, the shares of Demand 2 shocks in output and investment forecast error variance are negligible, and Demand 2 shocks' share in employment variation is below 20%. However, Demand 2 shocks do explain a large share of short-run variation in employment, and sizeable proportion of the long-run variation in output per worker. However, as noted above, the median impulse effect of Demand 2 shocks on employment has a counter-intuitive sign.

Compared to the US, Demand 1 shocks account for a much larger share of short-run fluctuations in real economic variables in the Finnish data. In the Finnish context, Figure 5 suggests that Demand 1 shocks are the dominant drivers of short-run fluctuations in output, while having mainly price effects in the long-run, and together with Demand 2 shocks account for almost all of employment variation at short horizons. At the same time, a commonality between the US and Finnish economies is that the importance of Supply 1 shocks is limited in the median FEVDs of all variables apart from investment at short horizons. A plot of the historical decomposition (Figure A11) suggests that the documented lackluster growth performance in the Finnish economy post-2008 was mainly driven by supply shocks. Although the sharpest decline in growth around 2008 coincides with large negative demand shocks (of both types 1 and 2), the contribution of Supply 2 shocks is more persistently negative around this time.

Alternative Identification

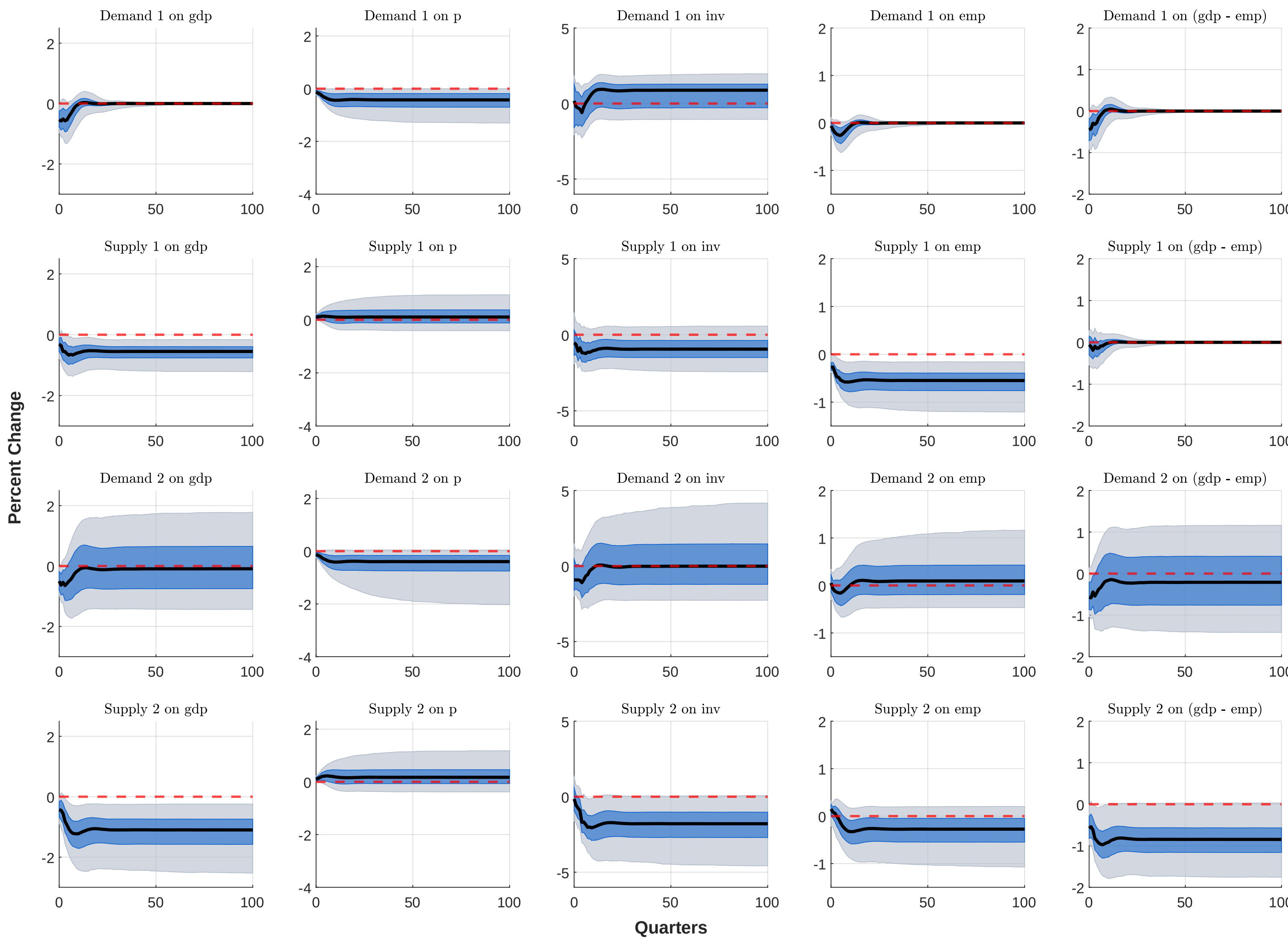
Similar to the Finnish baseline results, we fail to find convincing evidence of demand shock hysteresis in the Finnish economy using our model with alternative identification scheme.

Impulse responses of real variables to Demand 2 shocks remain qualitatively similar to those from the Finnish baseline model (Figure 6). The 68% credible intervals all include zero, while median long-run effects are shrunk towards zero relative to the baseline model. Both supply shocks are found to have a permanent effect on real variables with high posterior probability. In common with the alternative identification model estimated using US data, FEVDs from the Finnish alternative identification suggest an employment shock interpretation for Supply 1 and a permanent productivity shock interpretation for Supply 2.

Robustness Checks for Finnish Baseline Model

We check robustness of the Finnish no-hysteresis result to the choice of variables and lag order. We also also check the robustness of our results to minor changes in the identifying assumptions. The results of this exercise summarised in Table A2 in the Appendix. The patterns of output responses to Demand 2 shocks are similar across all of our robustness checks (Figure A14). In all of the robustness checks, we fail to find clear evidence of demand shock output hysteresis, with Supply 2 shocks having the dominant role in long-run output fluctuations across all the models. This result coincides with demand shocks account for around 50% of short-run output fluctuations across most models. Meanwhile, there is more variation in the long-run employment effects of demand shocks across our robustness checks, with 10-year demand shares in employment fluctuations ranging from 0% to close to 50%.

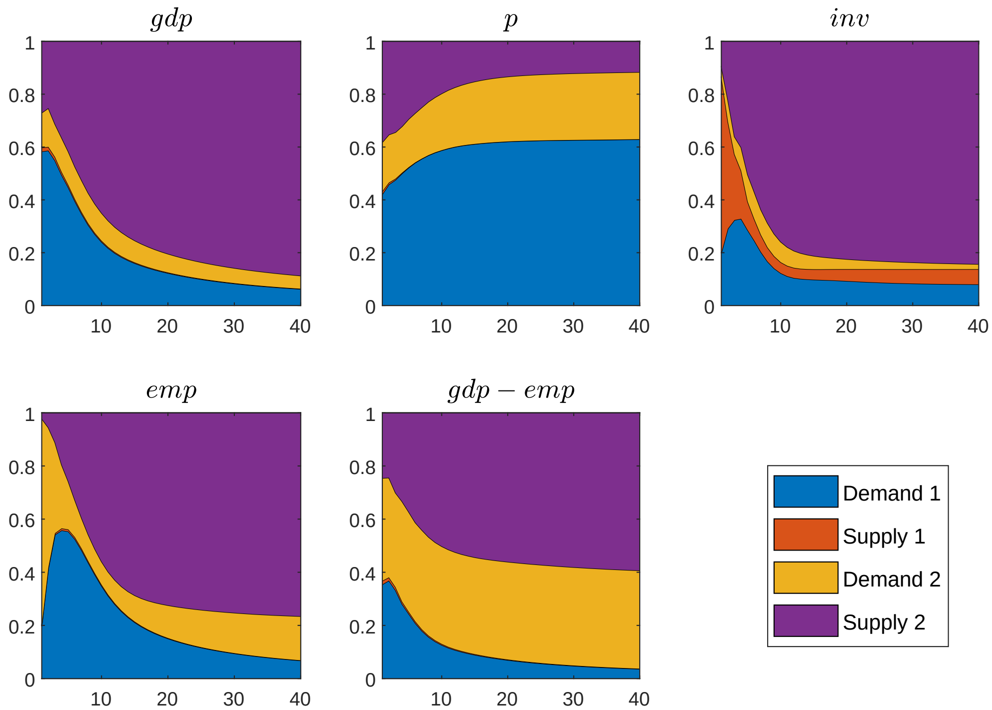
Figure 6: IRFs on Levels, Finland Alternative identification



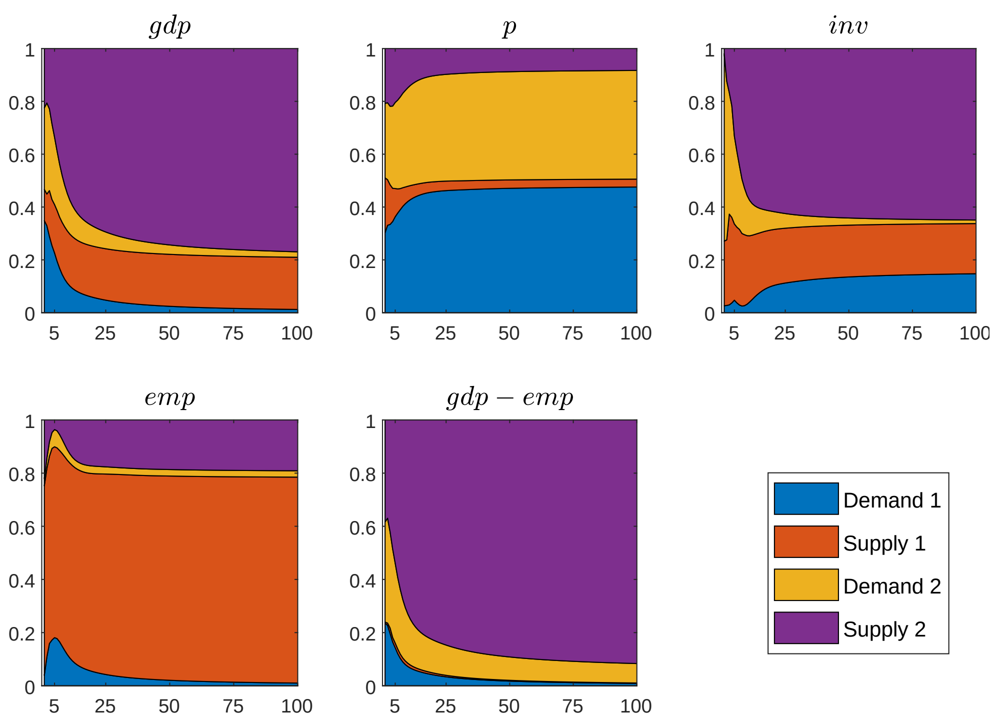
Notes: Plots show percent changes in levels (based on log-difference approximation) after unit-sized shocks at period zero. Y-axes are scaled by 100. Figures are based on 10000 draws from the posterior distribution. Dark lines denote pointwise posterior medians. Inner bands denote pointwise 68% posterior credible intervals. Outer bands denote pointwise 95% posterior credible intervals.

Figure 7: FEVDs, Finland.

(a) Baseline identification



(b) Alternative identification



Notes: Decompositions are based on pointwise median impulse responses on the levels of the variables. X-axis has the forecast horizon in quarters.

4.3 Results for Other European Countries

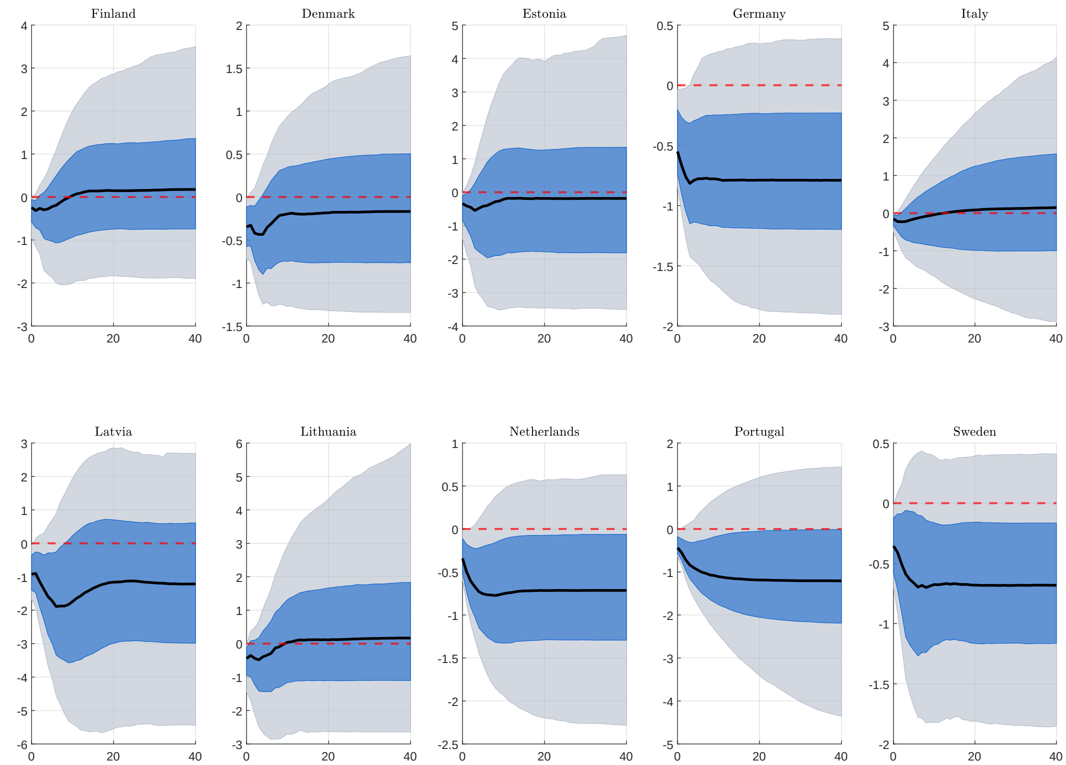
We only use the baseline Furlanetto et al. (2021) identification in this subsection. Obtaining results for other European economies with the alternative model is left for future work.

We find a substantial amount of heterogeneity in demand shock hysteresis across European countries using the baseline Furlanetto et al. (2021) identification. Impulse responses of output and employment (in levels) are reported in Figure 8. A negative Demand 2 shock is found to have permanent negative effects on output with high posterior probability in Germany, the Netherlands, Portugal, and Sweden. However, in three of out these four countries this hysteresis in output is associated with no permanent negative effect on output, suggesting a different hysteresis channel to that in the US.

Overall, the results from the European cross-country analysis gives us confidence that the Finnish no-hysteresis is not an aberrance. Across the countries without hysteresis, the patterns in FEVDs closely resemble each other, with demand shocks driving short run fluctuations, and supply shocks accounting for long-run outcomes (see Figure 9).

Figure 8: Impulse responses of output and employment to Demand 2 shocks (baseline identification) for selected European countries.

(a) Output



(b) Employment

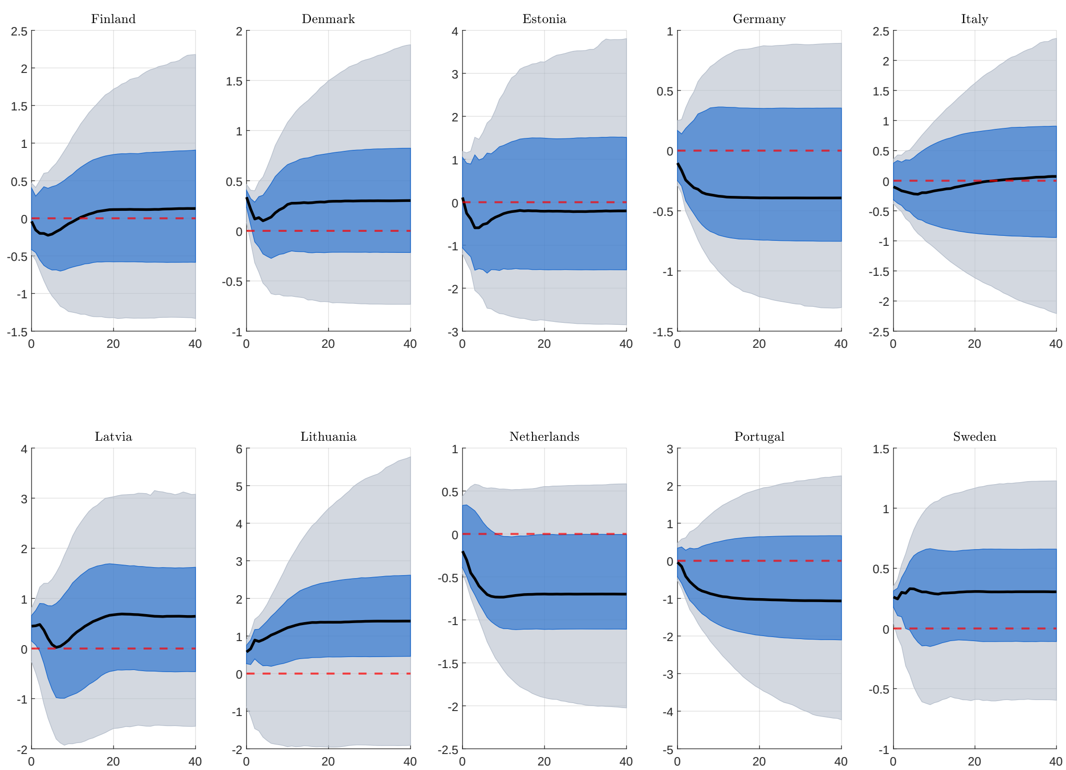
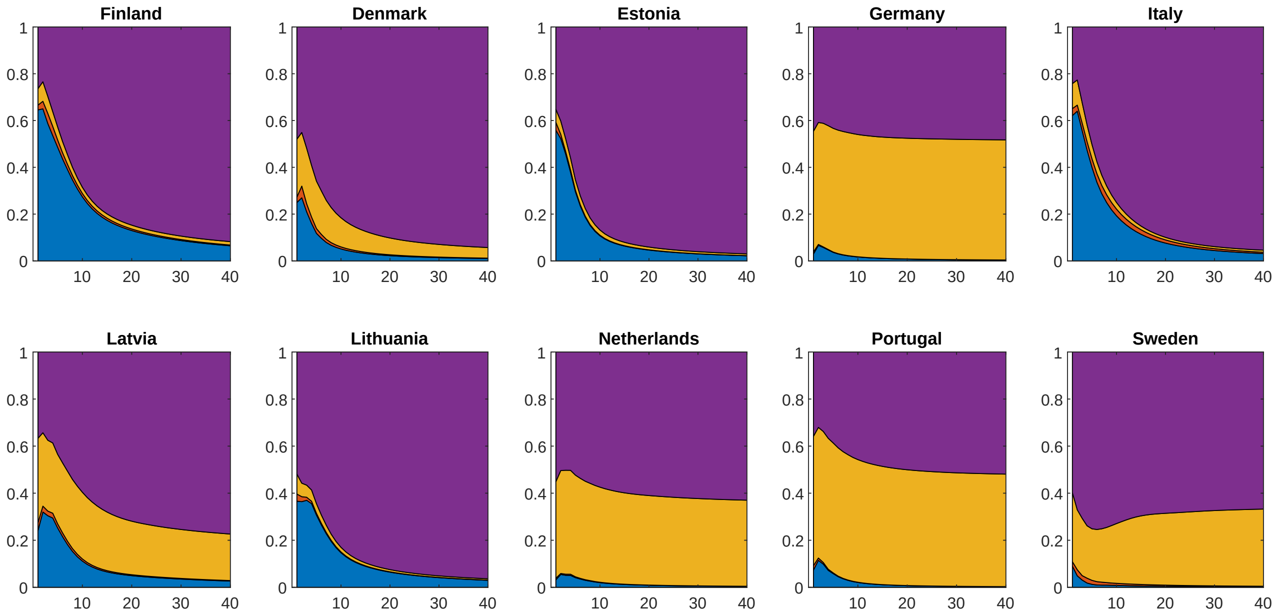
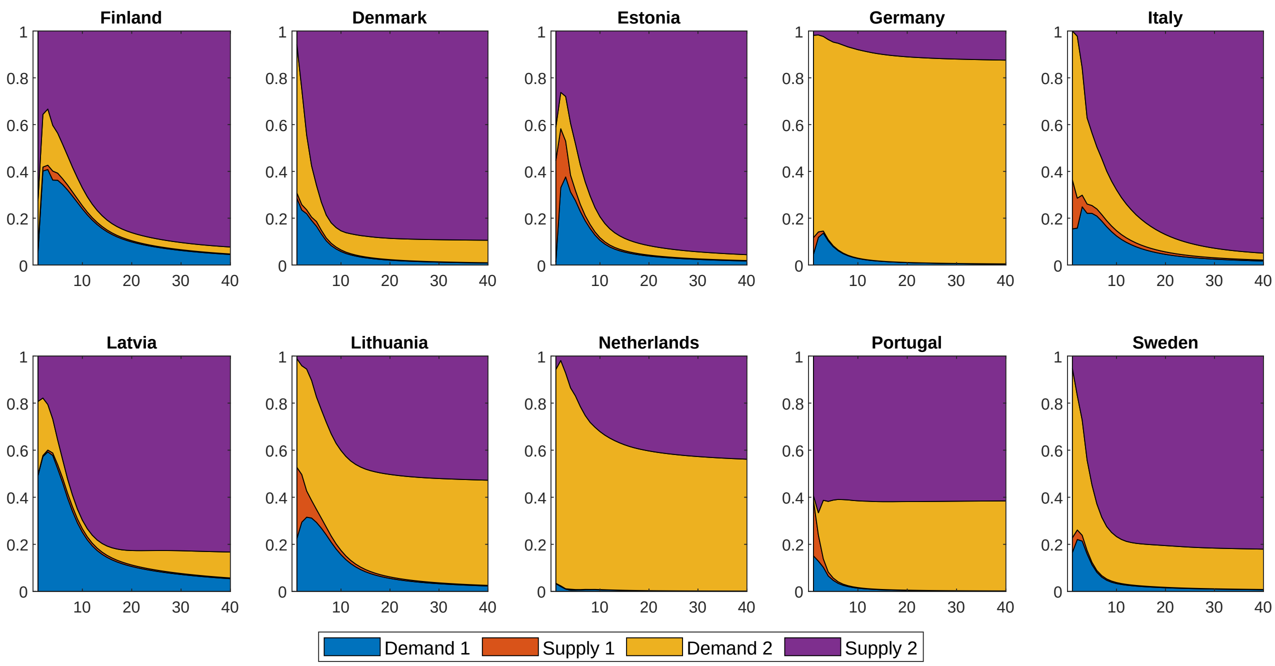


Figure 9: FEVDs for selected European countries using the baseline identification.

(a) Output



(b) Employment



Notes: Decompositions are based on pointwise median impulse responses on the levels of the variables. X-axis has the forecast horizon in quarters.

5 Discussion

Previous section outlined results from our empirical analysis of hysteresis effects in the US, Finland and a number of European economies. This section briefly discusses the results on demand side hysteresis and how should we interpret them. What can we learn from SVARs?

In some papers, including DeLong and Summers (2012) or Rawdanowicz et al. (2014), hysteresis effects are discussed in terms of the long-term effect on potential output that is caused by a 1%-point output gap in the present period. Naturally, the SVAR-model we use does not directly yield an estimate of the output gap and it is not straightforward to provide a corresponding estimate in the SVAR context.

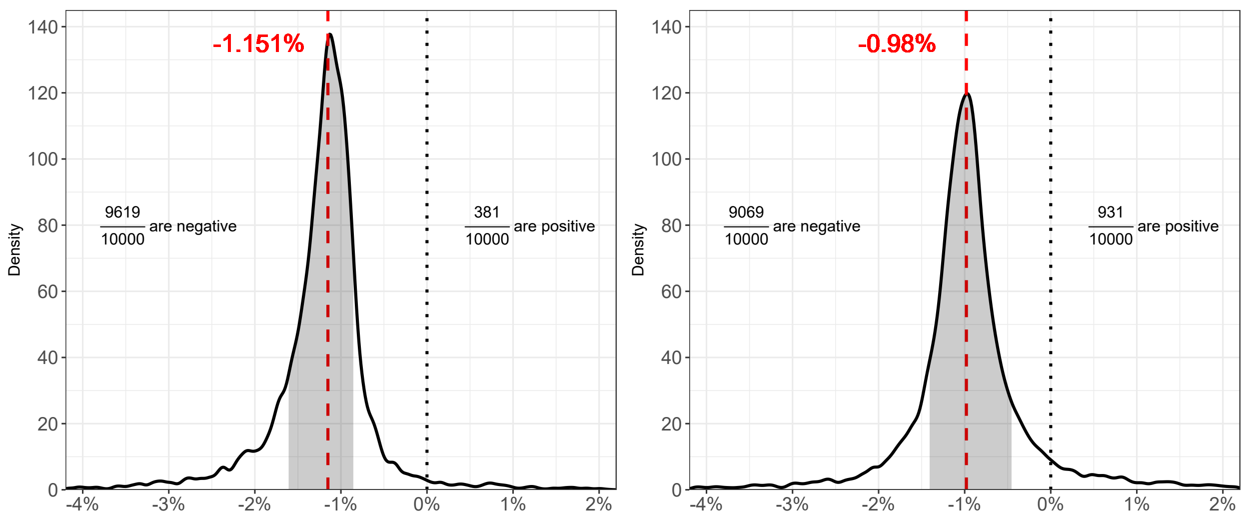
We suggest that, in the SVAR context, one way to normalize results on the size of hysteresis effects is to consider the size of permanent effects on output that are the result of a demand shock that moves output by 1% in absolute terms at some horizon of choice. Here we choose to consider horizon $t + 4$, that is, one year from the shock.[7] Although this type of an normalization of results is not strictly equivalent to definitions used in some of the hysteresis literature, we consider it to share approximately the same idea.

In Figure 10 we plot the posterior distribution of permanent effects of Demand 2 shocks on *gdp* implied by our estimated model for the US economy. Figure 10a gives the distribution in the case of baseline identification while Figure 10b does so for the alternative identification. Using the baseline identification we find a large hysteresis effect on average: median long-run effect of a Demand 2 shock that moves *gdp* by -1% in 4 quarters time is -1.15% is for the baseline identification and -0.98% for the alternative identification. Hysteresis effect is (two-sided) significant at the 0.68-level (shaded area) for the alternative identification and at the 0.9-level for the baseline identification. The plot contains also shares of the draws with positive and negative outcomes. For both identifications, more than $\frac{9}{10}$ are negative.

[7] This is in contrast to Figure 3 where normalization is done using period $t = 0$. Increasing the horizon would naturally make the distribution approach negative unity. Notice, however, that given the median shape of impulse responses of *gdp* in most of the models, smaller horizons would yield larger median values. For a normalization using the impact ($t = 0$) effect, see the Appendix.

Figure 10: Posterior distributions of the long-run ($t+\infty$) response of output to a Demand 2 shock at time t that moves US *gdp* at $t+4$ by -1%.

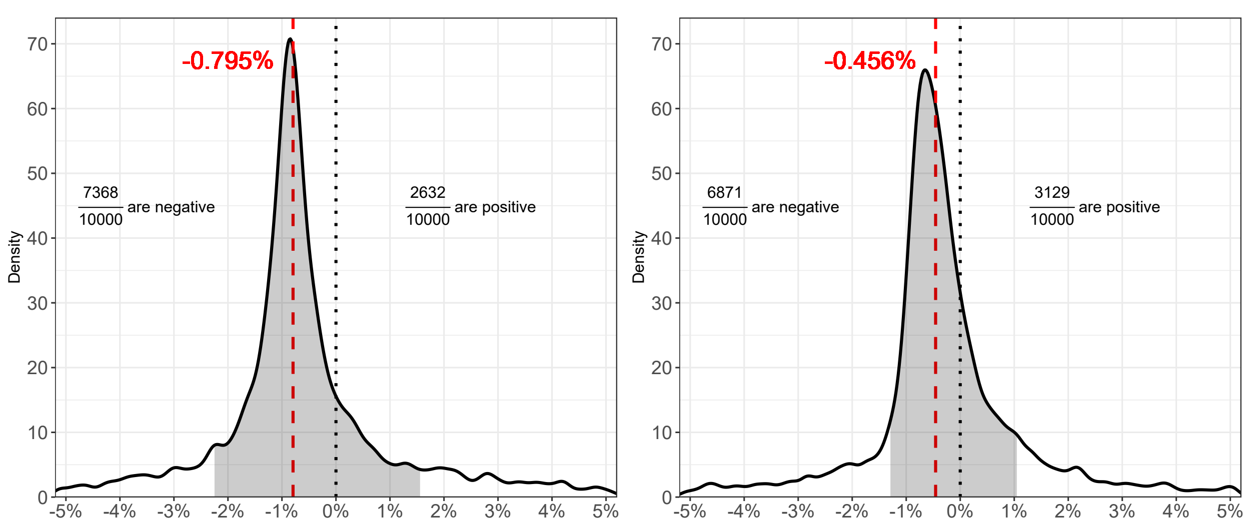
(a) Baseline identification **(b)** Alternative identification



Notes: This figure plots kernel density estimates on the distribution of the permanent effects of Demand 2 shocks on output that is implied by a sample of 10000 draws from the model posterior. Median draw is highlighted with a red dashed line. Shaded area represents 68% credible set. X-axis is truncated and thus 348 and 531 observations out of 10000 lie outside the plot area for panels (a) and (b) respectively.

Figure 11: Posterior distributions of the long-run ($t+\infty$) response of output to a Demand 2 shock at time t that moves Finnish *gdp* at $t+4$ by -1%.

(a) Baseline identification **(b)** Alternative identification



Notes: This figure plots kernel density estimates on the distribution of the permanent effects of Demand 2 shocks on output that is implied by a sample of 10000 draws from the model posterior. Median draw is highlighted with a red dashed line. Shaded area represents 68% credible set. X-axis is truncated and thus 1630 and 1090 observations out of 10000 lie outside the plot area for panels (a) and (b) respectively.

As a reference, DeLong and Summers (2012) consider a parameter space $0 - 0.2$ for their hypothetical hysteresis effect while Rawdanowicz et al. (2014) end up with hysteresis parameters ranging from 0.1 to 1.2 with an average of 0.4 in OECD countries in their analysis of hysteresis effects associated with the Financial crisis.[8] For US they find hysteresis parameter of 0.1 and for Finland 0.5.

For Finland, Figure 11 provides corresponding results. For neither the baseline identification nor the alternative identification do we find statistically significant hysteresis effects using this normalization. The point estimate given by posterior median is however rather large when compared to the examples in previous paragraph. But again, the results given by this normalization are not entirely comparable to those cited before. Results for Finland are also not as tightly distributed as corresponding results for the US. Relative shares of positive and negative estimates in Figure 11 are markedly different from those in Figure 10. There is more uncertainty surrounding the estimates.

The lack of demand side hysteresis effects in the Finnish data using the Furlanetto et al. (2021) model might reflect a few things. It can be due to a fundamental difference in economic fundamentals: there being no hysteresis in Finland unlike in the US. Alternatively, it may be that the identification strategy for the US is not appropriate for Finland and produces unreliable results. For instance, Finland can be considered to be a small open economy whereas the US economy is among the largest in the world. It is also possible that the shorter sample for Finland could be too unreliable and erratic to draw any strong conclusions using the SVAR methodology. However, the similarity of results between Finnish and other European countries could give us some confidence that the no-hysteresis result in Finland is not only driven by a data quirk.

[8] Rawdanowicz et al. (2014) calculate their hysteresis parameters by dividing the hit to potential output from the Financial crisis by the cumulative output gaps over 2009-2014.

6 Conclusion

We use a recently proposed SVAR methodology to evaluate the extent of demand side hysteresis in Finland. Contrary to the results reported for the US economy using the same methodology (Furlanetto et al., 2021), we fail to find convincing evidence of demand shock hysteresis in Finland. Finnish long-run outcomes are found to be mostly driven by supply shocks, which account for close to 80% of long-run fluctuations in both output and employment. We find that this inconclusive hysteresis result is shared by several other European countries. Further, we find that allowing for two potentially permanent supply shocks considerably reduces the long-run relevance of demand shocks in the US data.

The findings presented here leave room for further research. Our preliminary finding of cross-country differences in demand shock hysteresis warrants a closer investigation. Our choice of using a using a one-size-fits-all identification strategy for several countries may carry issues, and should be adjusted to account for different economic structures. If the cross-country heterogeneity in demand shock hysteresis is indeed a robust feature of SVAR models, the attention should be shifted to the mechanisms behind these differences. In lockstep with the cross-country research, we should also aim to gain a better understanding of whether a misspecification of the long-run supply component can bias hysteresis estimates in SVARs and elsewhere. Likewise, we think future work should address how endogenous policy responses and forward-looking expectations might confound the SVAR identification used here. For example, fiscal and monetary policy systematically offsetting demand shocks could lead us to understate the extent of demand shock hysteresis, while news of future economic conditions *causing* aggregate demand fluctuations today could trick us into inferring causality in the wrong direction.

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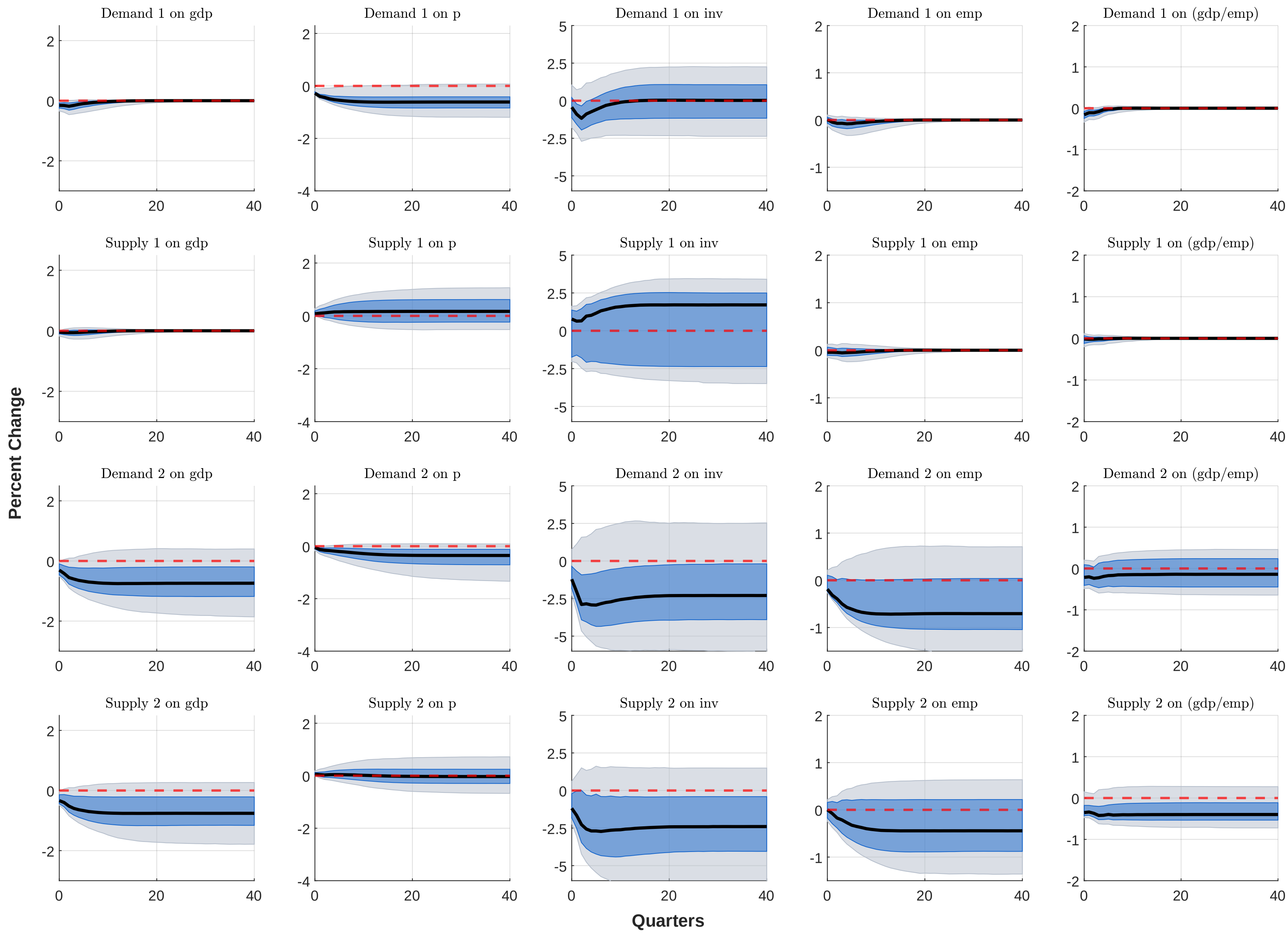
A Appendix

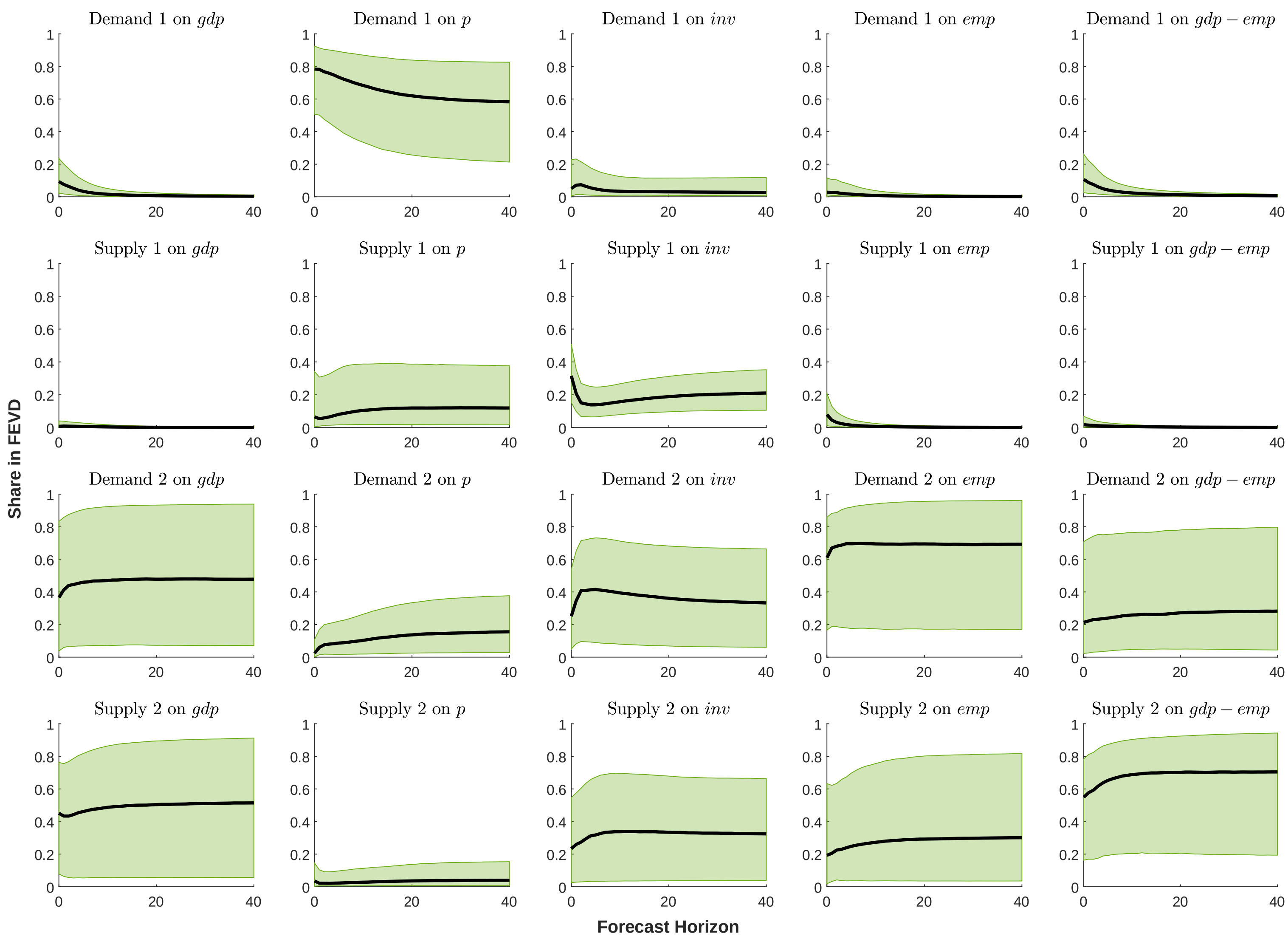
A.1 Replication of Furlanetto et al. (2021)

Figure A1: US Baseline Model: IRFs on Levels



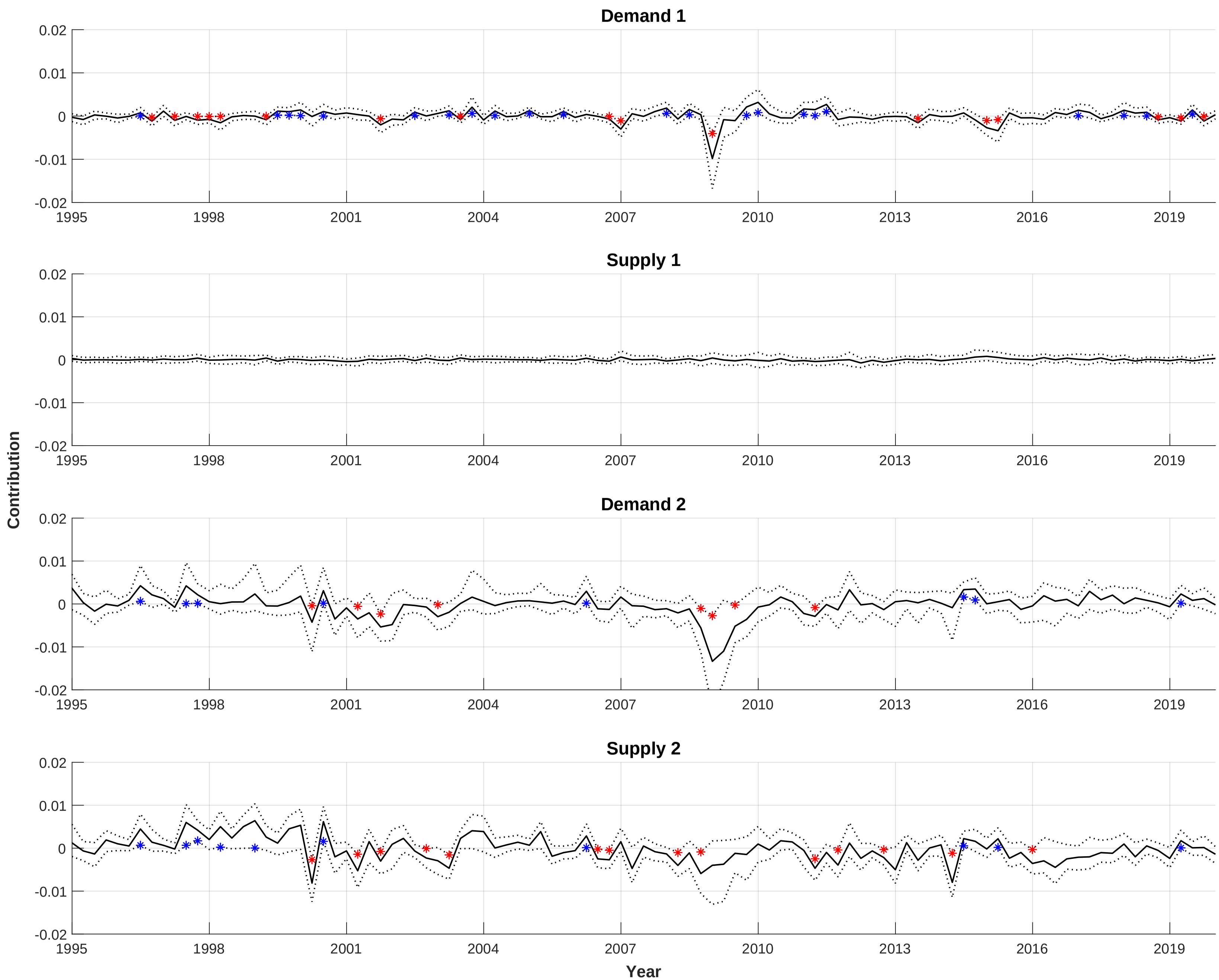
Notes: Plots show percent changes in levels (based on log-difference approximation) after unit-sized shocks at period zero. Y-axes are scaled by 100. Figures are based on 10000 draws from the posterior distribution. Dark lines denote pointwise posterior medians. Inner bands denote pointwise 68% posterior credible intervals. Outer bands denote pointwise 95% posterior credible intervals.

Figure A2: US Baseline Model – Distribution of FEVD Shares



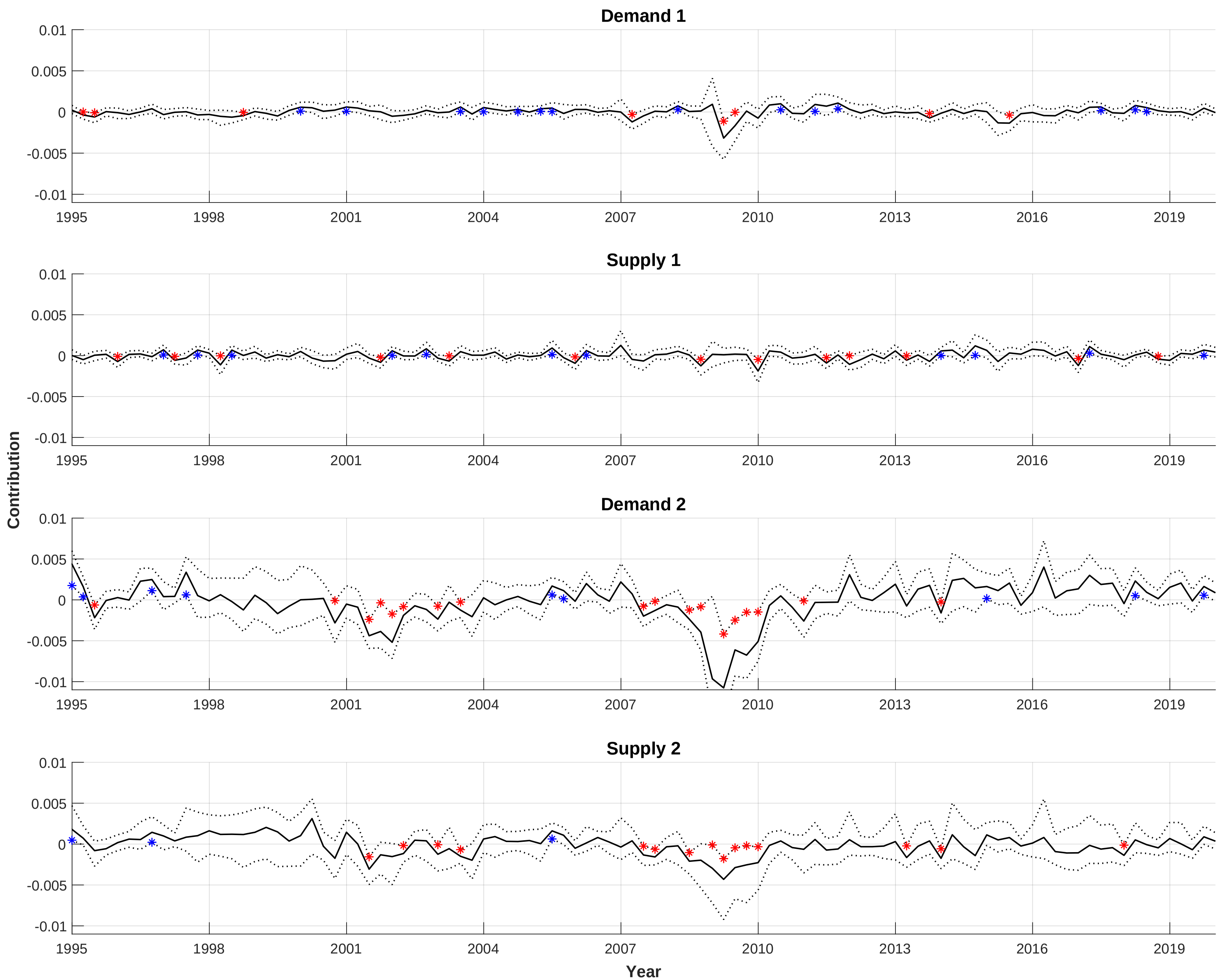
Notes: Figures show the pointwise distribution of FEVD shares for each shock-variable pair based on 10000 draws from the posterior distribution. Pointwise median is captured by the dark solid line, while shaded areas (in green) denote 68% credible intervals around the median.

Figure A3: US Baseline Model – Historical Decomposition of GDP Growth



Notes: Figure shows pointwise distribution of contributions to the stochastic component in GDP growth based on 10000 draws from the posterior. Solid line denotes the pointwise median, while 16th and 84th quantiles are denoted by the dotted lines. Red (blue) asterisks are used to highlight periods where the 84th (16th) quantile is below (above) zero.

Figure A4: US Baseline Model – Historical Decomposition of Employment Growth



Notes: Figure shows pointwise distribution of contributions to the stochastic component in employment growth based on 10000 draws from the posterior. Solid line denotes the pointwise median, while 16th and 84th quantiles are denoted by the dotted lines. Red (blue) asterisks are used to highlight periods where the 84th (16th) quantile is below (above) zero.

A.2 US Alternative Identification

Figure A5: IRFs on Levels for US Alternative Identification

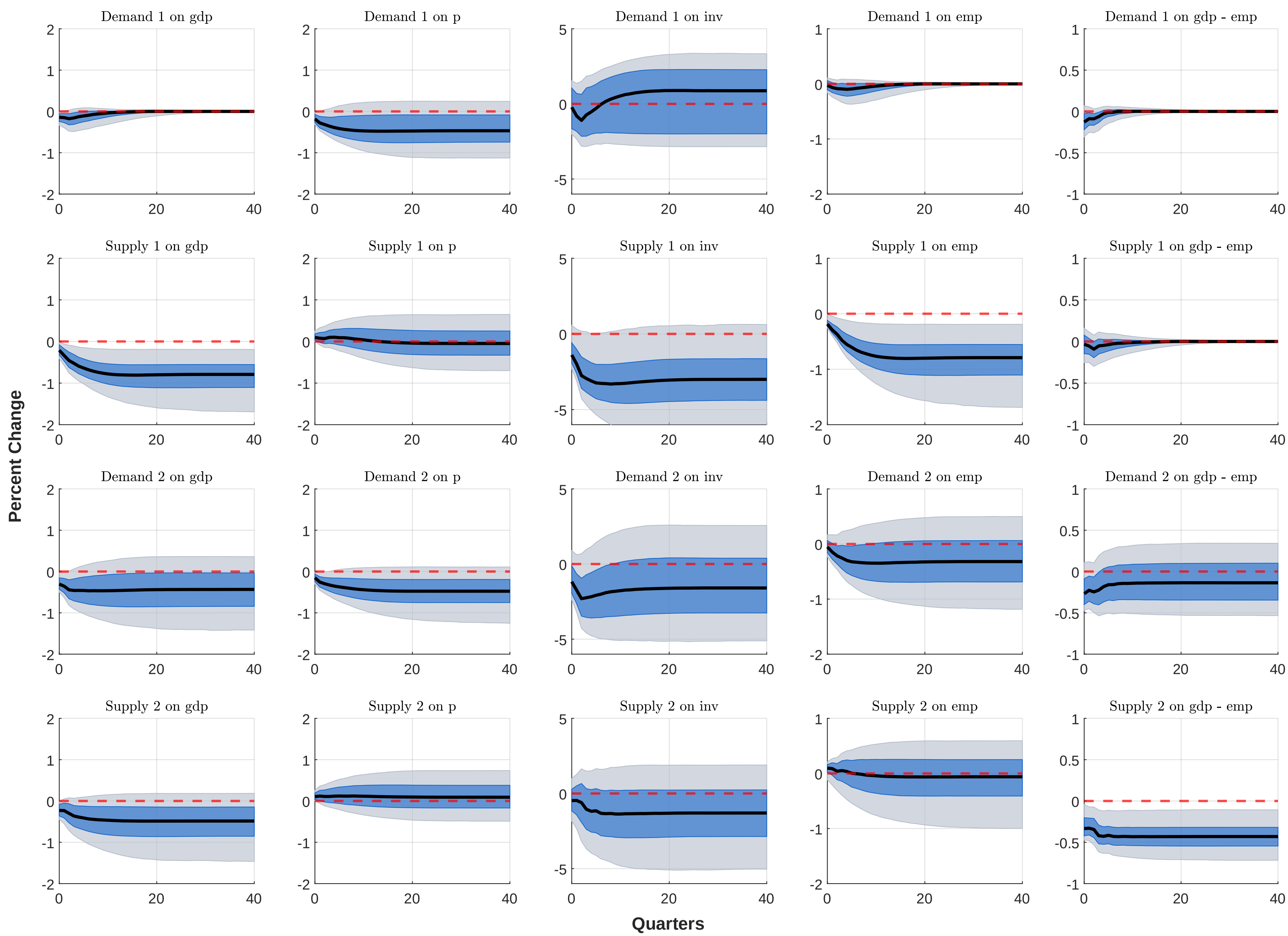
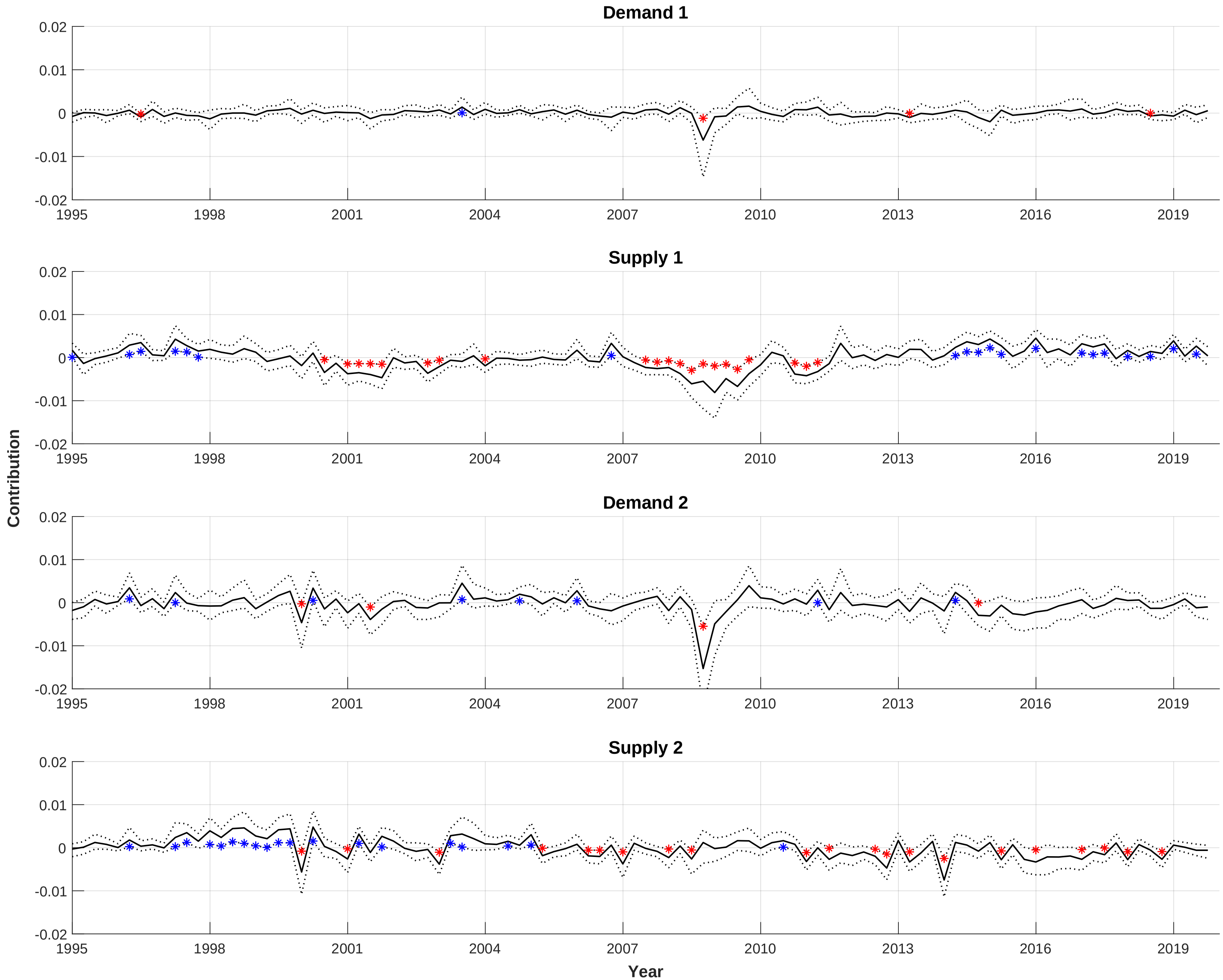
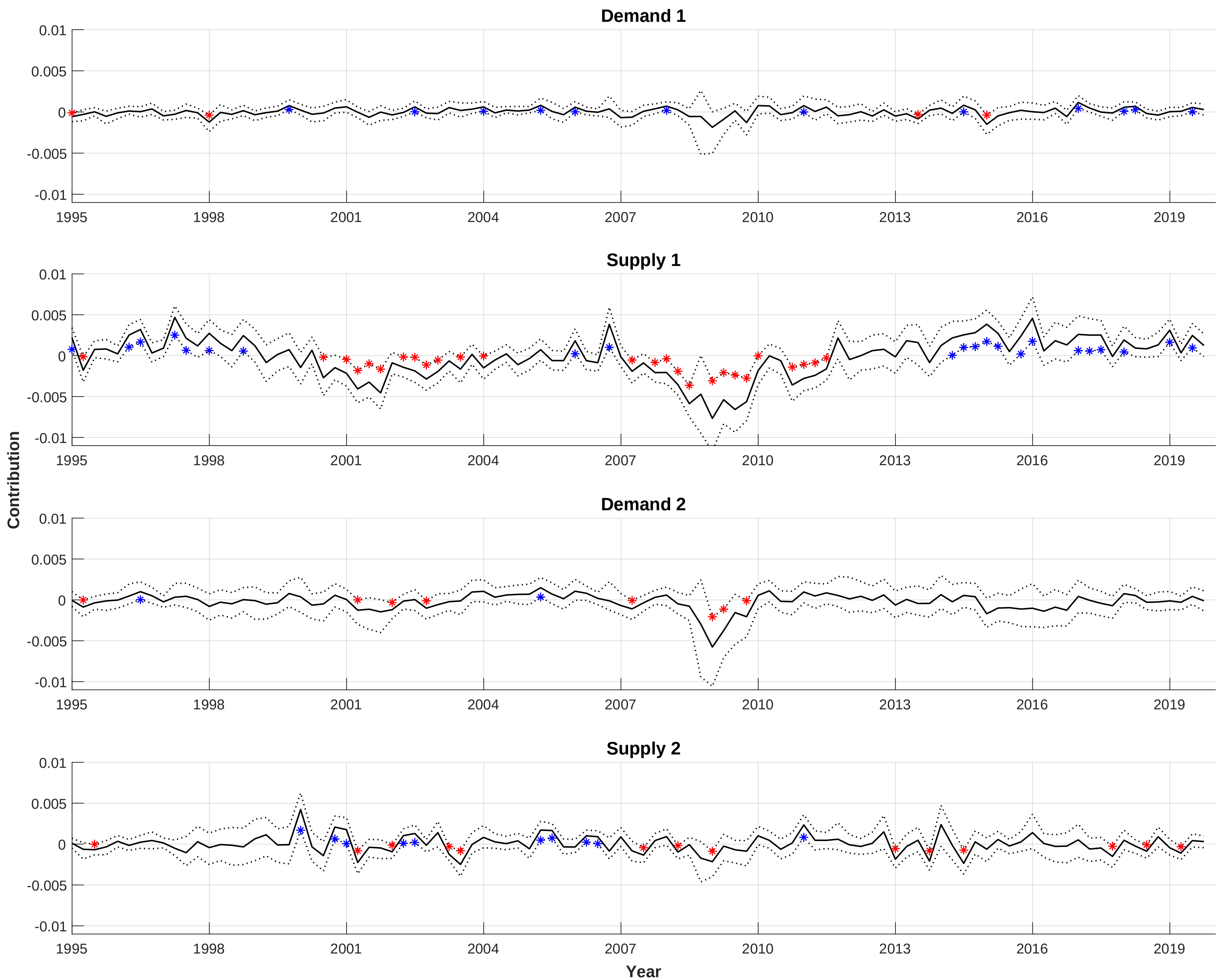


Figure A6: US Alternative Identification – Historical Decomposition of GDP Growth



Notes: Figure shows pointwise distribution of historical decomposition shares. Solid line denotes the pointwise median, while 16th and 84th quantiles are denoted by the dotted lines. Red (blue) asterisks are used to highlight periods where 84th (16th) quantile is below (above) zero.

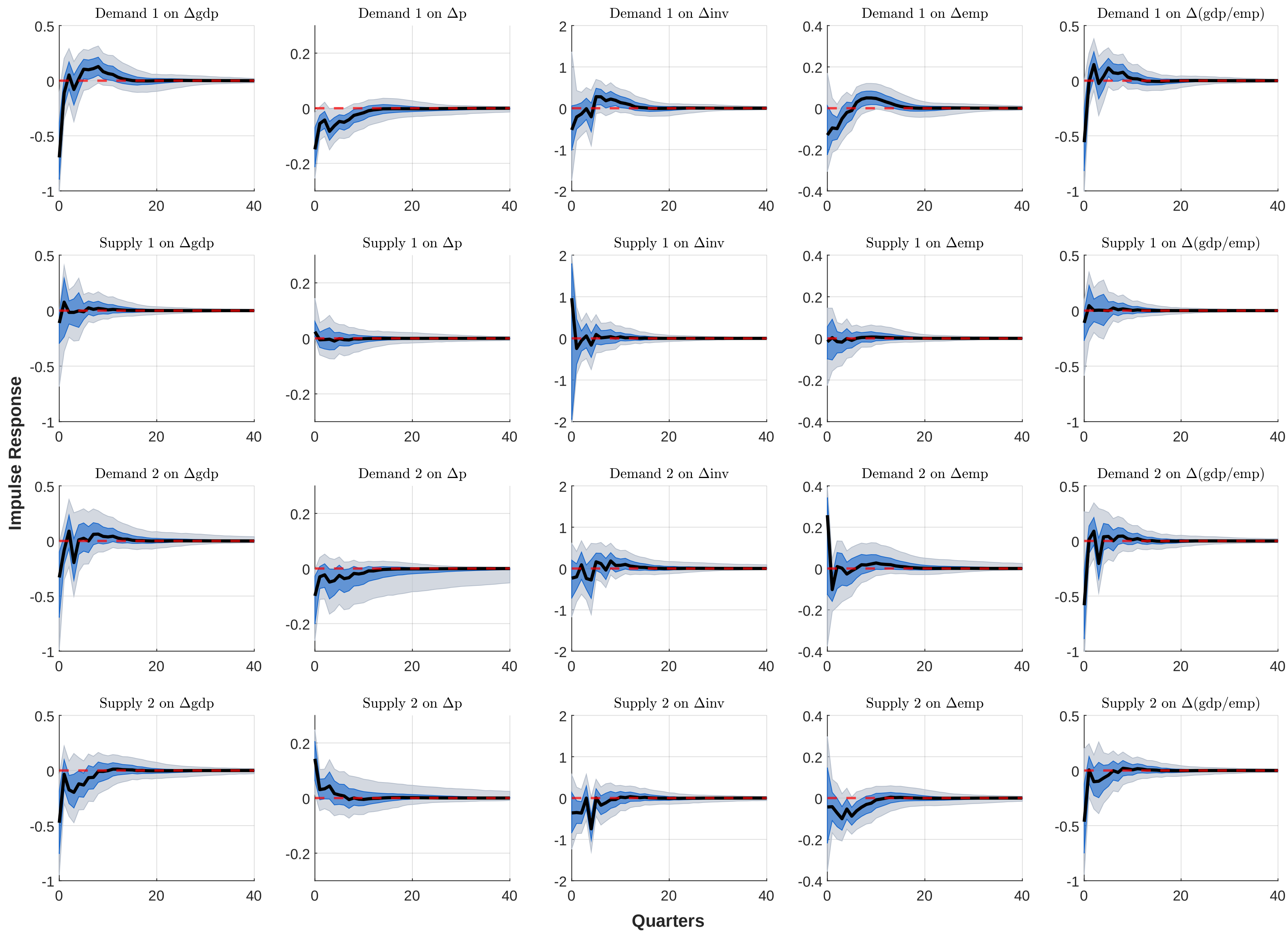
Figure A7: US Alternative Model – Historical Decomposition of Employment Growth



Notes: Figure shows pointwise distribution of historical decomposition shares. Solid line denotes the pointwise median, while 16th and 84th quantiles are denoted by the dotted lines. Red (blue) asterisks are used to highlight periods where 84th (16th) quantile is below (above) zero.

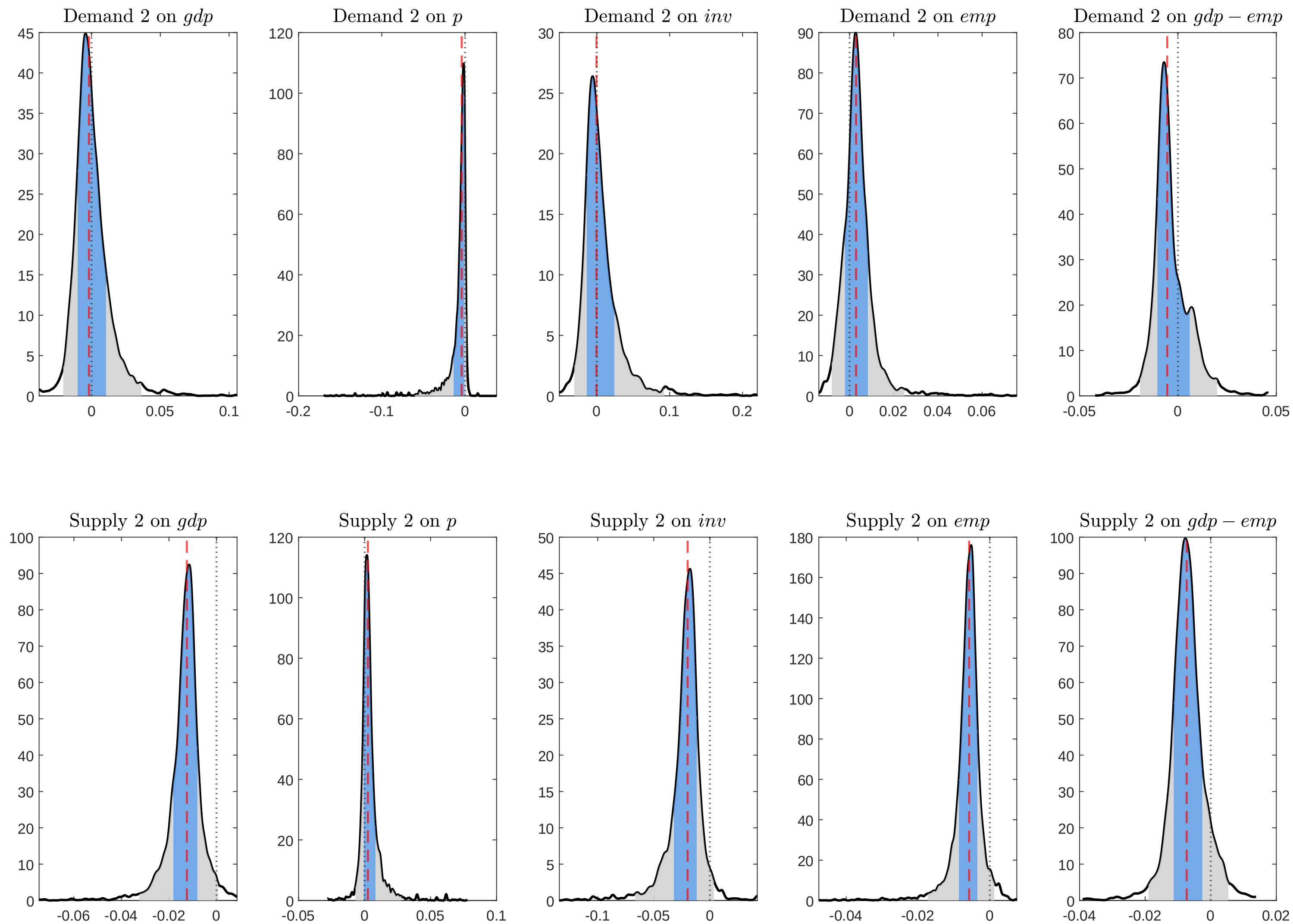
A.3 Finland Baseline Model

Figure A8: FIN Baseline Model – IRFs on First Differences



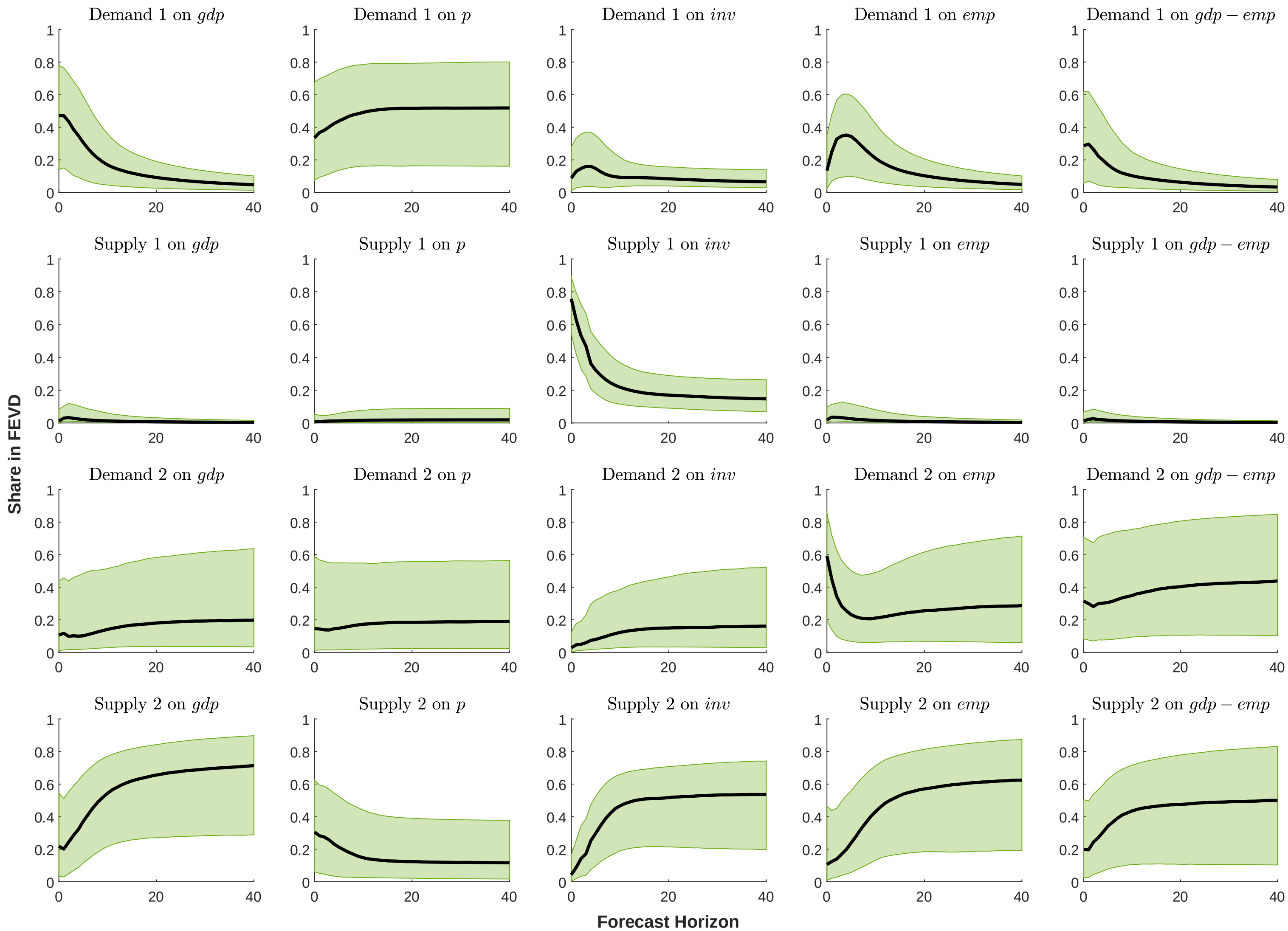
Notes: Plots show responses to unit-sized shocks in period zero. Y-axes are scaled by 100. Figures are based on 10000 draws from the posterior distribution. Dark lines denote pointwise posterior medians. Inner bands denote pointwise 68% posterior credible intervals. Outer bands denote pointwise 95% posterior credible intervals.

Figure A9: FIN Baseline Model – Distributions of Long-Run Effects



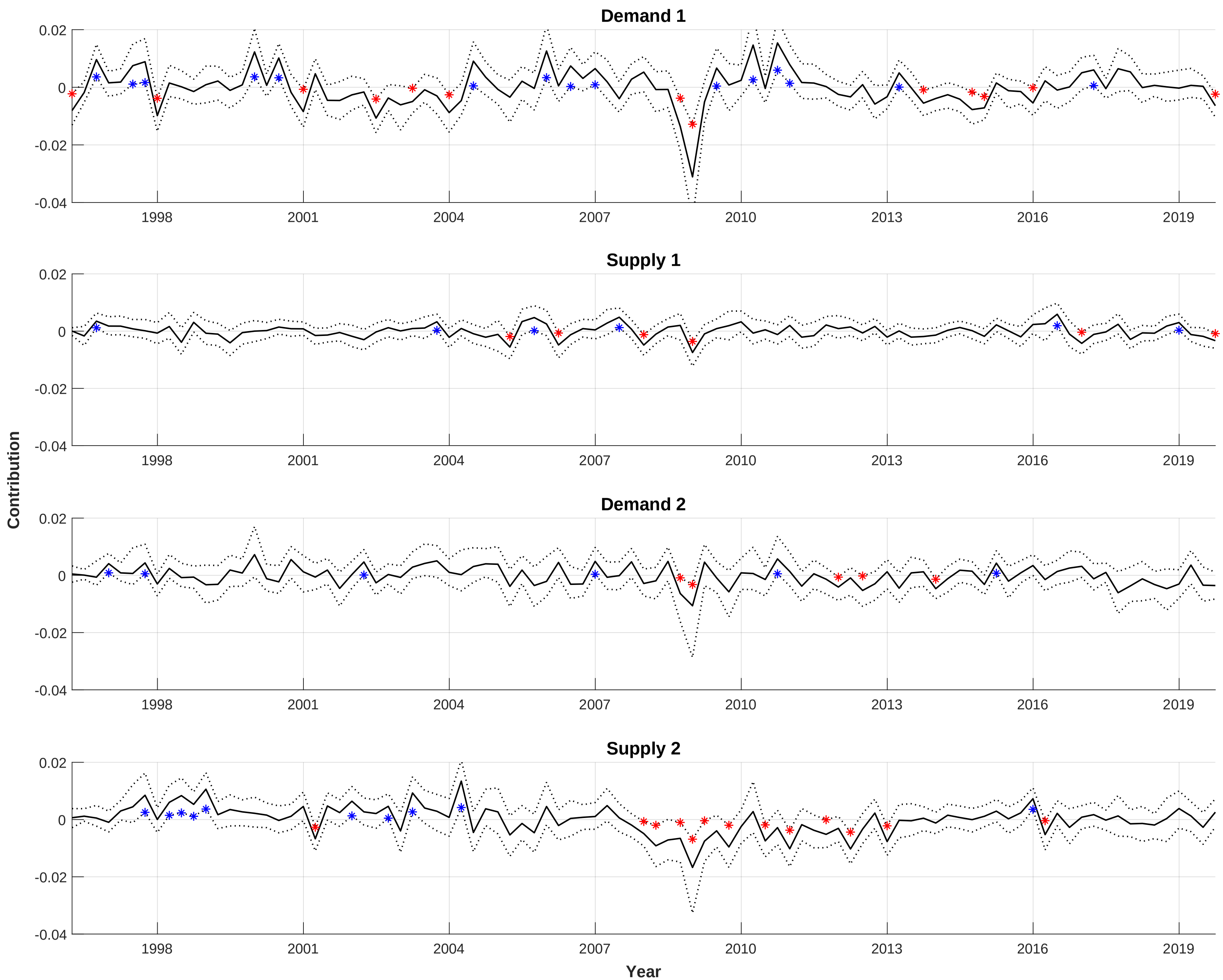
Notes: Plots show kernel density estimates for long-run effects for the potentially permanent shocks. Gaussian kernel and the optimal bandwidth for Gaussian distribution is used. Inner shaded areas (in blue) denote 68% posterior credible intervals, while outer shaded areas (in gray) denote 95% posterior credible intervals. Median is marked by a dashed red line, and zero on the x-axis is highlighted with dark dotted line.

Figure A10: FIN Baseline - Distribution of FEVD Shares



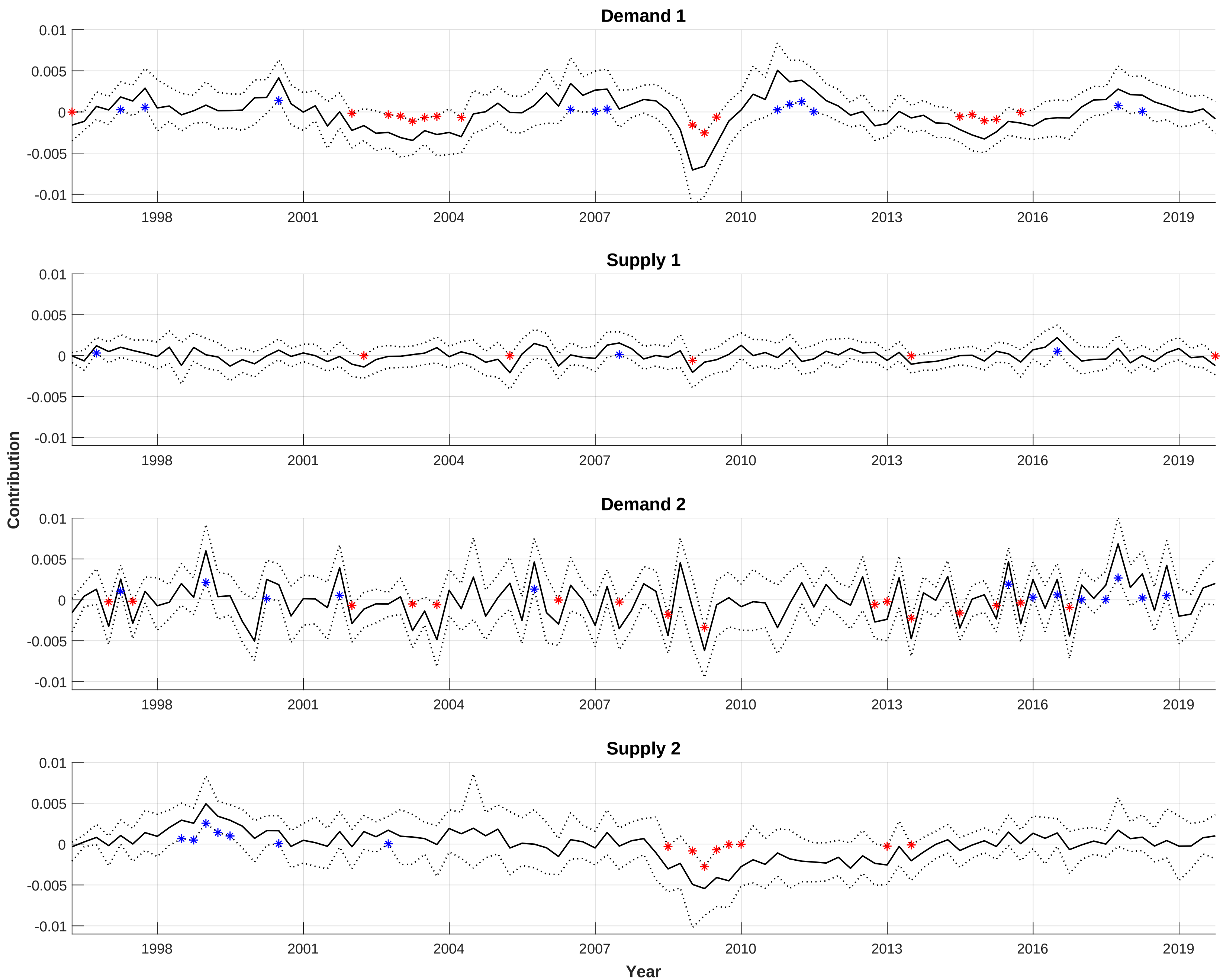
Notes: Figures show the pointwise distribution of FEVD shares for each shock-variable pair based on 10000 draws from the posterior distribution. Pointwise median is captured by the dark solid line, while shaded areas (in green) denote 68% credible intervals around the median.

Figure A11: FIN Baseline Model – Historical Decomposition of GDP Growth



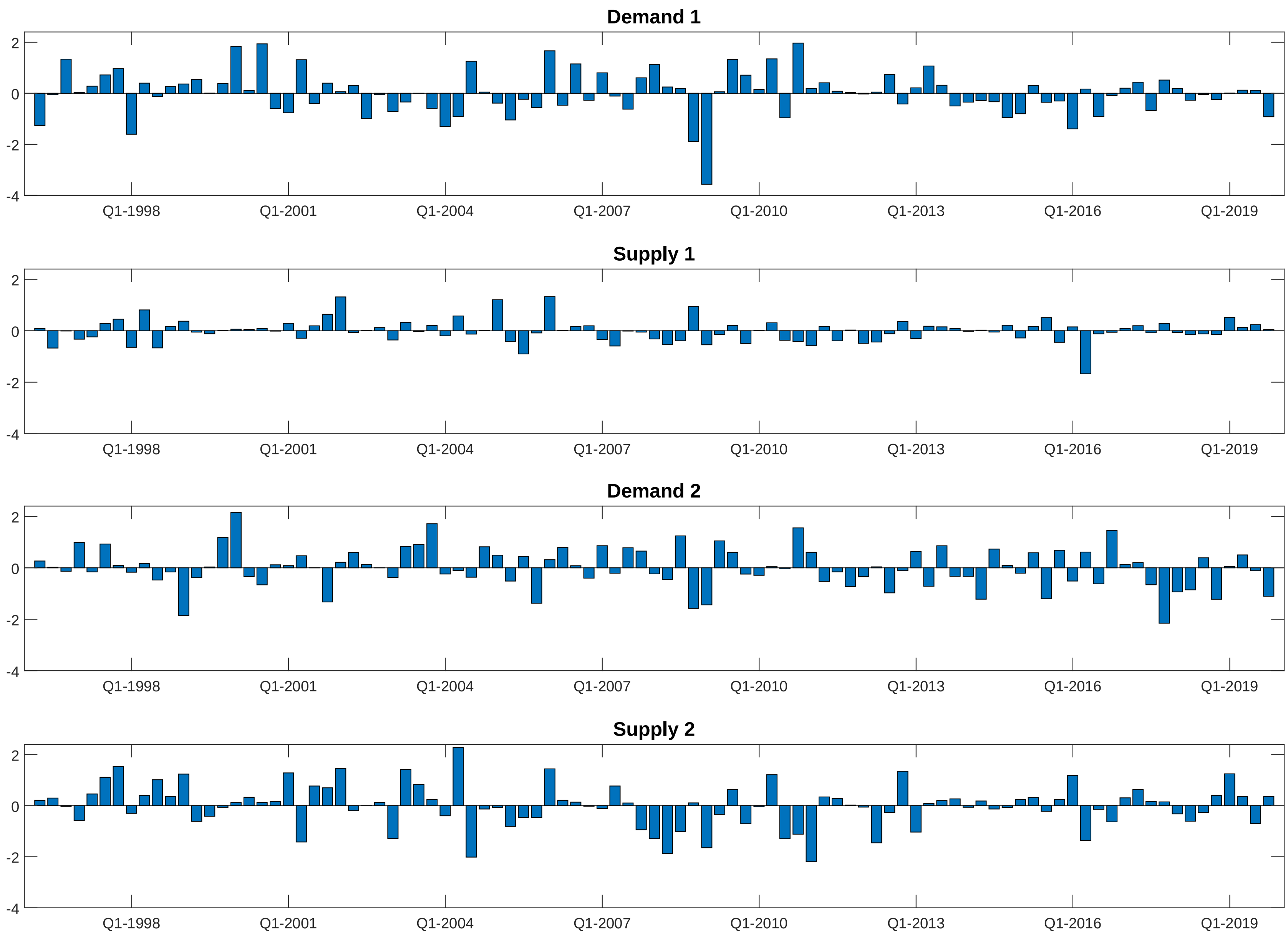
Notes: Figure shows pointwise distribution of contributions to the stochastic component in GDP growth. based on 10000 draws from the posterior. Solid line denotes the pointwise median, while 16th and 84th quantiles are denoted by the dotted lines. Red (blue) asterisks are used to highlight periods where the 84th (16th) quantile is below (above) zero.

Figure A12: FIN Baseline Model – Historical Decomposition of Employment Growth



Notes: Figure shows pointwise distribution of historical decomposition shares. Solid line denotes the pointwise median, while 16th and 84th quantiles are denoted by the dotted lines. Red (blue) asterisks are used to highlight periods where 84th (16th) quantile is below (above) zero.

Figure A13: FIN Baseline - Time Path of Structural Shocks



Notes: Figure shows median shock sizes based on 10000 draws from the posterior distribution.

Table A1: FIN Baseline - Summary Statistics on Long-Run Effects

(a) LR effects of Demand Shock 1 on...

	gdp	**p**	**inv**	**emp**	**(gdp/emp)**
Mean	0	-0.73	0.65	0	0
Median	0	-0.64	0.59	0	0
Max	0	1.4	5.06	0	0
Min	0	-3.5	-1.87	0	0
Decile 1	0	-1.14	0.02	0	0
Decile 2	0	-0.89	0.23	0	0
Decile 3	0	-0.78	0.36	0	0
Decile 4	0	-0.7	0.48	0	0
Decile 5	0	-0.64	0.59	0	0
Decile 6	0	-0.58	0.71	0	0
Decile 7	0	-0.53	0.85	0	0
Decile 8	0	-0.48	1.04	0	0
Decile 9	0	-0.42	1.3	0	0
F(0)	0.5	0.99	0.09	0.51	0.49

(c) LR effects of Supply Shock 1 on...

	gdp	**p**	**inv**	**emp**	**(gdp/emp)**
Mean	0	0	0.08	0	0
Median	0	-0.02	0.59	0	0
Max	0	5.79	4.11	0	0
Min	0	-2.38	-7.59	0	0
Decile 1	0	-0.4	-1.21	0	0
Decile 2	0	-0.21	-1.02	0	0
Decile 3	0	-0.13	-0.89	0	0
Decile 4	0	-0.07	-0.69	0	0
Decile 5	0	-0.02	0.59	0	0
Decile 6	0	0.03	0.86	0	0
Decile 7	0	0.08	0.98	0	0
Decile 8	0	0.15	1.1	0	0
Decile 9	0	0.3	1.28	0	0
F(0)	0.46	0.54	0.46	0.46	0.47

(b) LR effects of Demand Shock 2 on...

	gdp	**p**	**inv**	**emp**	**(gdp/emp)**
Mean	0.75	-3.36	2.39	1.11	-0.36
Median	-0.19	-0.4	-0.04	0.3	-0.54
Max	2413.09	1.54	6425.61	2786.09	117.18
Min	-51.58	-10509.03	-111.56	-8.02	-372.99
Decile 1	-1.29	-2.1	-1.81	-0.39	-1.23
Decile 2	-0.89	-1.11	-1.19	-0.13	-0.96
Decile 3	-0.62	-0.74	-0.8	0.06	-0.81
Decile 4	-0.42	-0.54	-0.43	0.19	-0.68
Decile 5	-0.19	-0.4	-0.04	0.3	-0.54
Decile 6	0.07	-0.28	0.42	0.41	-0.38
Decile 7	0.39	-0.19	1.01	0.55	-0.07
Decile 8	0.83	-0.11	1.89	0.74	0.37
Decile 9	1.58	-0.01	3.49	1.07	0.9
F(0)	0.58	0.9	0.51	0.26	0.72

(d) LR effects of Supply Shock 2 on...

	gdp	**p**	**inv**	**emp**	**(gdp/emp)**
Mean	-3.09	7.78	-6.78	-2.59	-0.5
Median	-1.25	0.25	-1.99	-0.58	-0.73
Max	10.25	36140.53	100.81	11.05	1279.86
Min	-8302.61	-66.1	-22103.42	-9582.48	-60.18
Decile 1	-2.09	-0.2	-3.89	-1.01	-1.28
Decile 2	-1.71	-0.02	-2.95	-0.81	-1.06
Decile 3	-1.5	0.08	-2.5	-0.7	-0.93
Decile 4	-1.36	0.17	-2.22	-0.63	-0.83
Decile 5	-1.25	0.25	-1.99	-0.58	-0.73
Decile 6	-1.14	0.35	-1.77	-0.52	-0.63
Decile 7	-1.03	0.47	-1.55	-0.46	-0.52
Decile 8	-0.89	0.69	-1.28	-0.38	-0.35
Decile 9	-0.59	1.16	-0.82	-0.24	-0.04
F(0)	0.97	0.22	0.96	0.96	0.91

Notes: Tables show long-run effects on (log-)levels of variables in response to a unit-sized shock at period 0. Statistics are based on 10000 draws from the posterior distribution. F(0) stands for the value of the cumulative distribution function $F(t) = P(X \leq t)$ at $t = 0$.

A.4 Robustness Checks to Finnish Baseline Model

Table A2: Robustness Checks to Finnish Baseline Identification

Model	**Description**
(a)	Three lags in VAR
(b)	Five lags in VAR
(c)	Consumer price index instead of private consumption deflator.
(d)	GDP deflator instead of private consumption deflator.
(e)	Private investment instead of gross fixed capital formation.
(f)	Apply sign restrictions to horizons 0 and 1.
(g)	No long-run zero restrictions on employment.
(h)	Restrict demand 2 to have neg. horizon 0 effect on employment.
(i)	Restrict both demand shocks to have neg. horizon 0 effect on employment.

Figure A14: FIN Baseline Robustness - IRFs of Output to Demand 2 Shocks

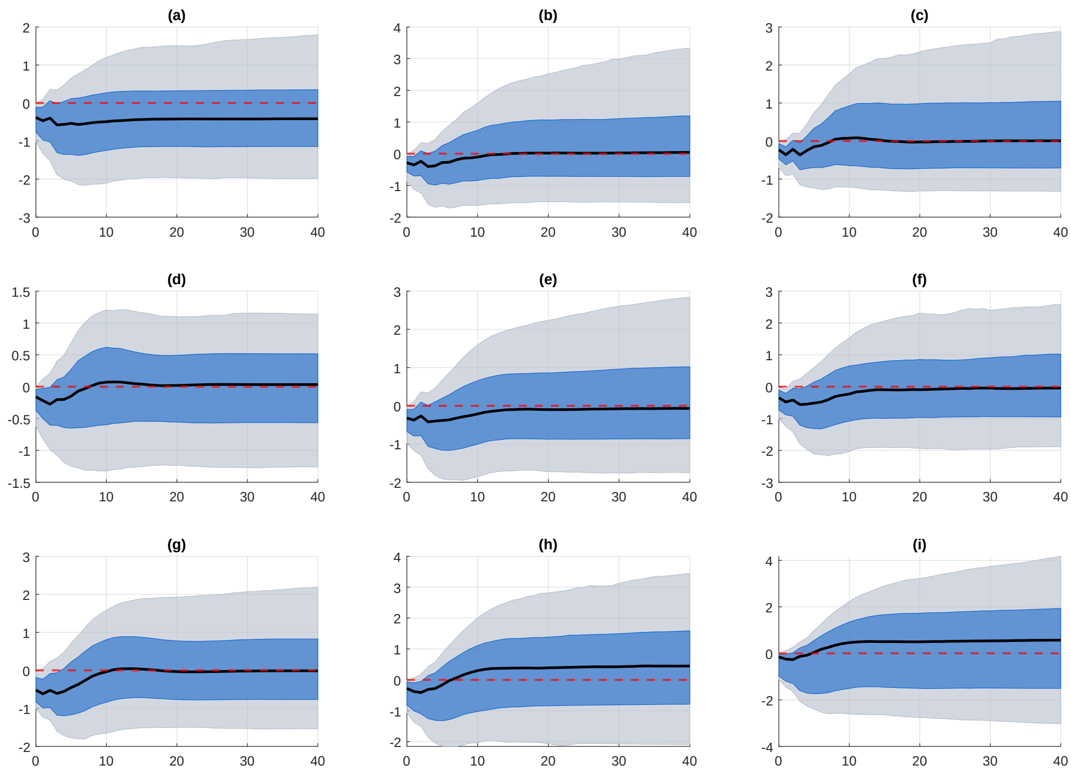


Figure A15: FIN Baseline Robustness - FEVDs for Output Across Models

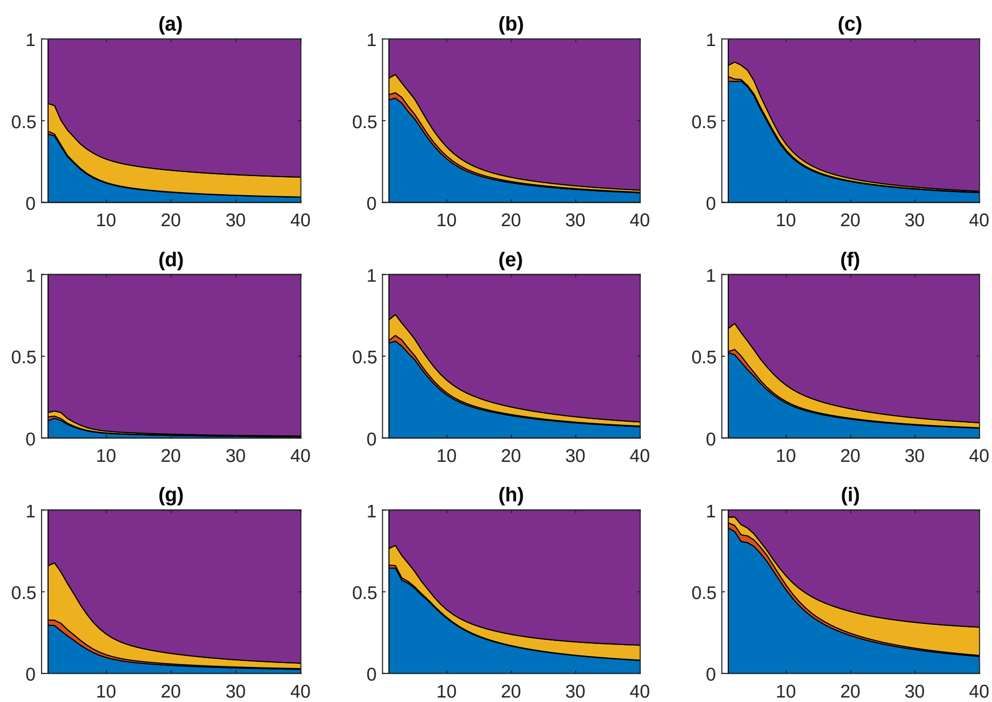


Figure A16: FIN Baseline Robustness - IRFs of Employment to Demand 2 Shocks

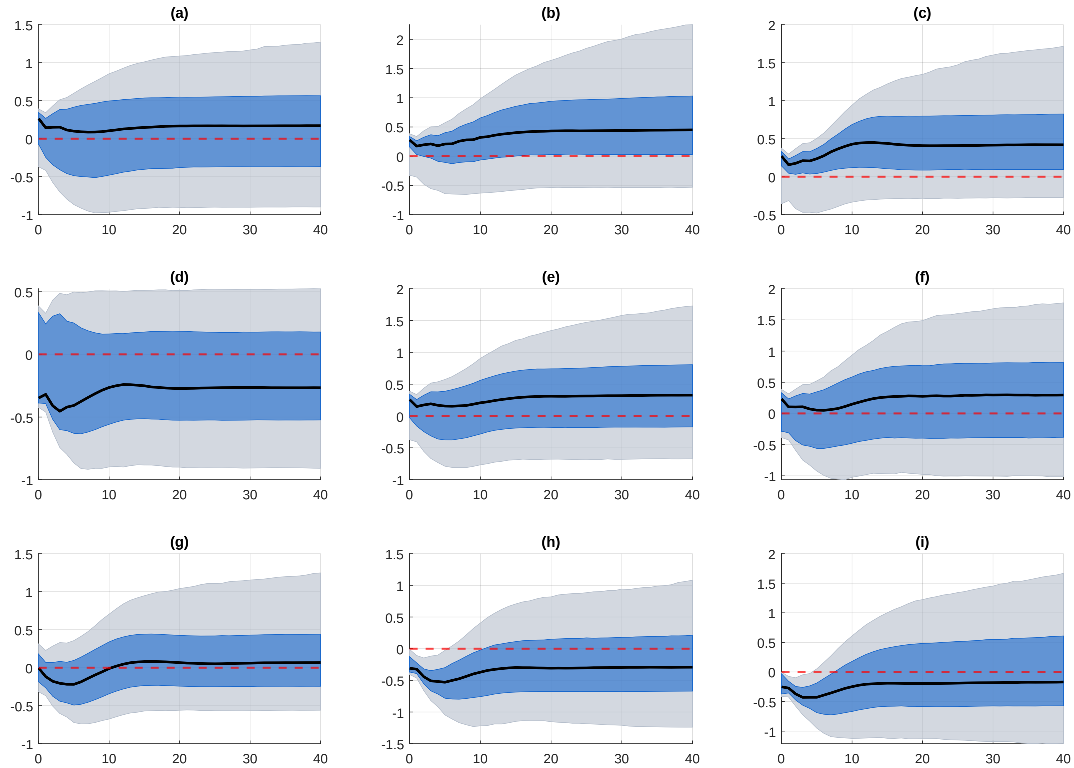
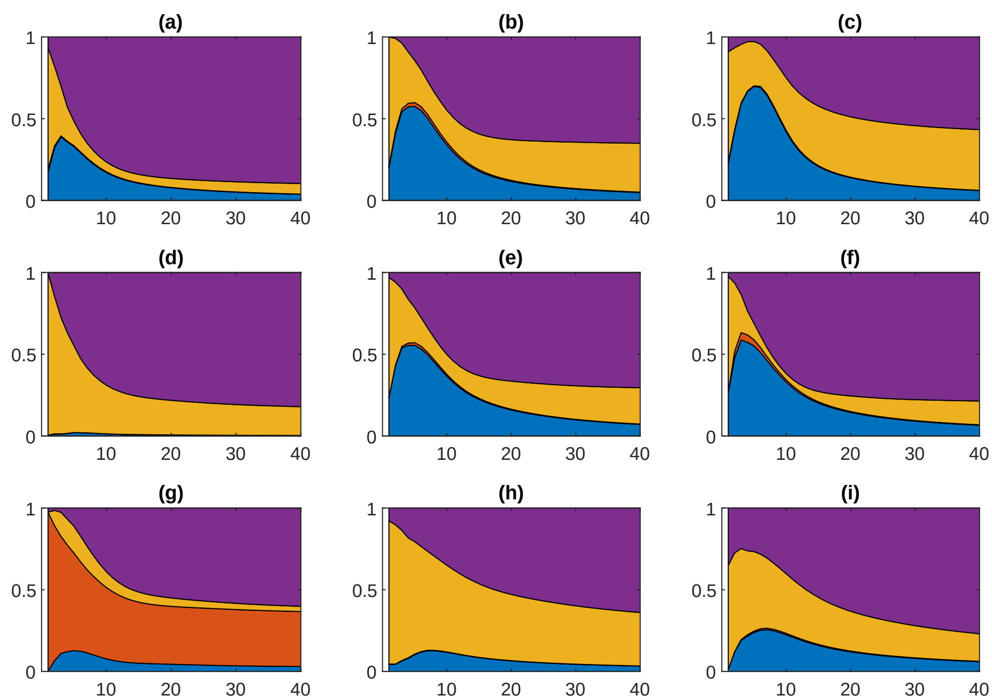


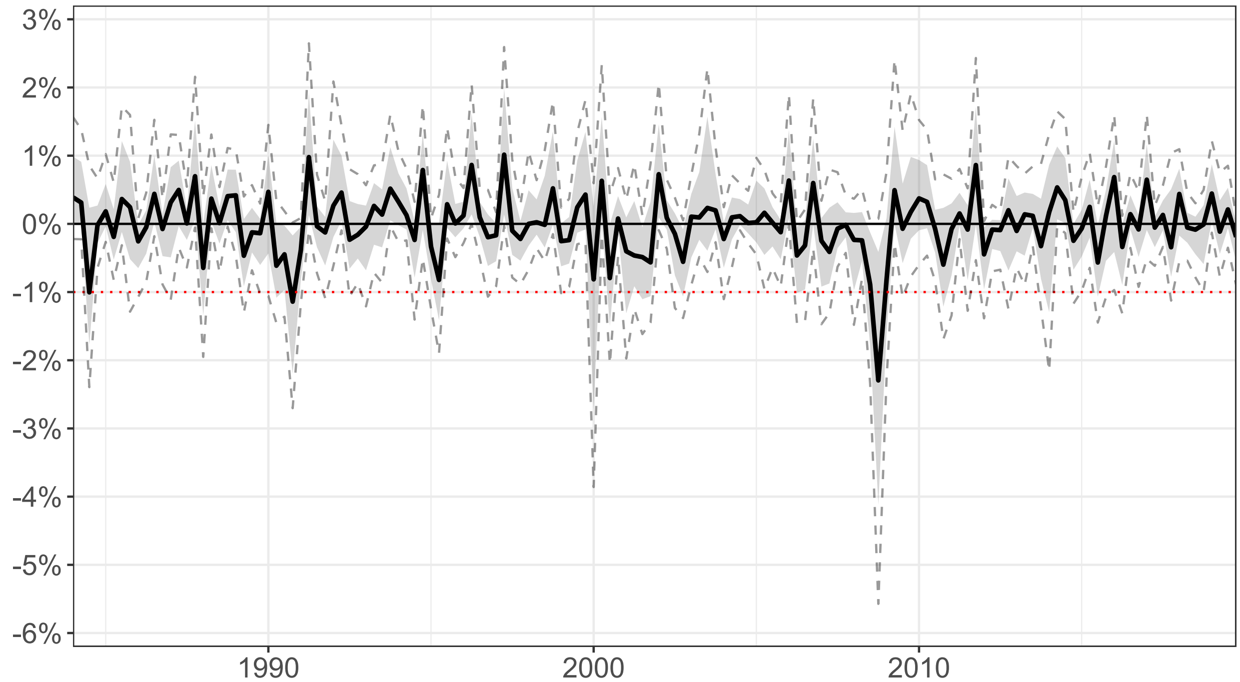
Figure A17: FIN Baseline Robustness - FEVDs for Employment Across Models



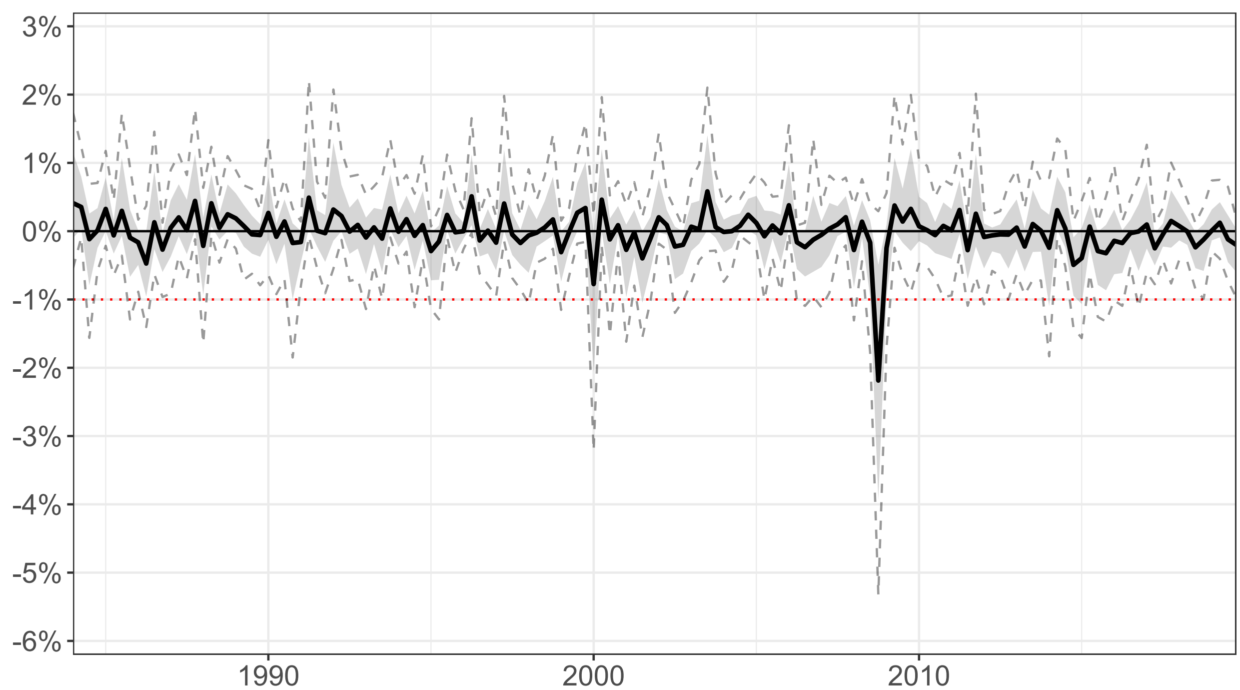
A.5 Additional Figures

Figure A18: Contributions of Demand 2 shocks at time t to gdp at time $t + 4$ in the US sample.

(a) Baseline identification



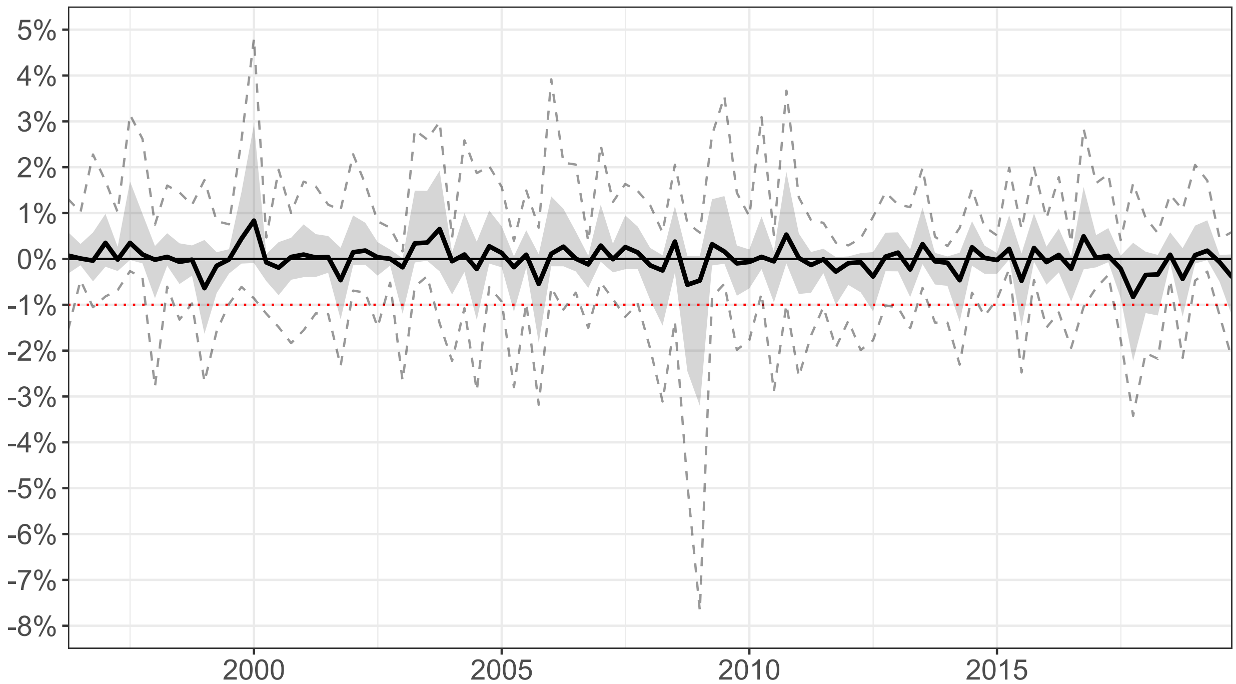
(b) Alternative identification



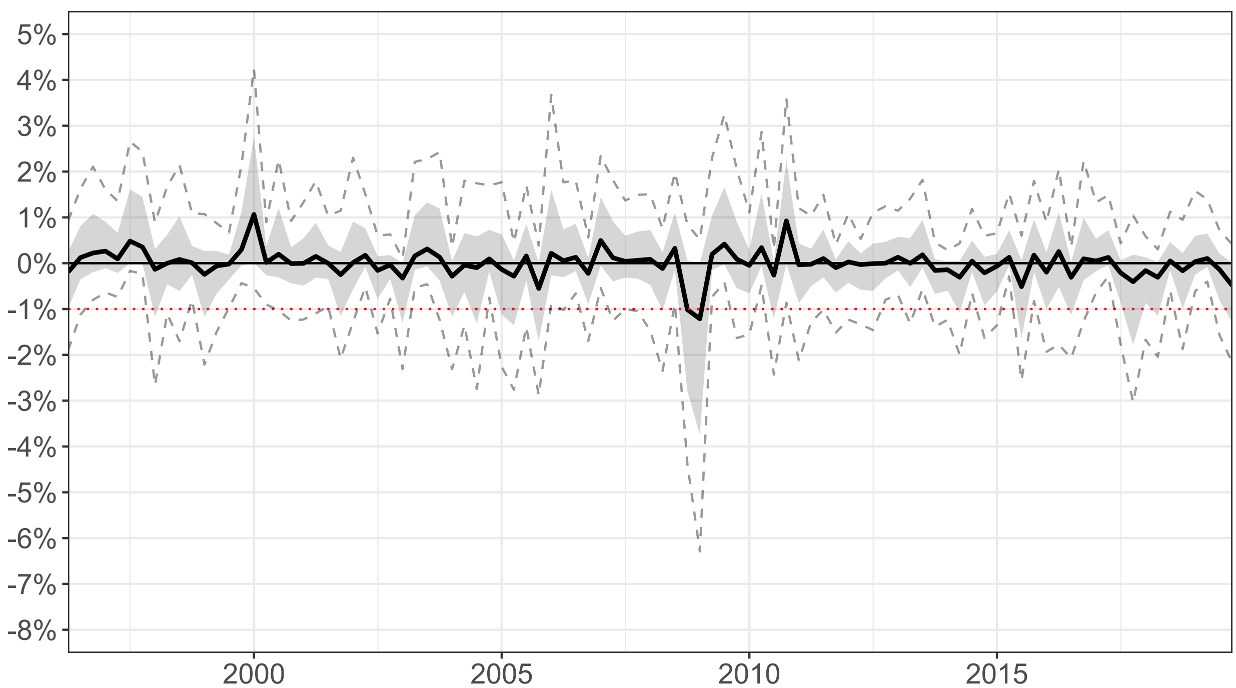
Notes: Solid line represents the median from 10000 draws of the model posterior. Shaded area is the 68% and the area between dashed lines the 95% credible set.

Figure A19: Contributions of Demand 2 shocks at time t to gdp at time $t+4$ in the Finnish sample.

(a) Baseline identification



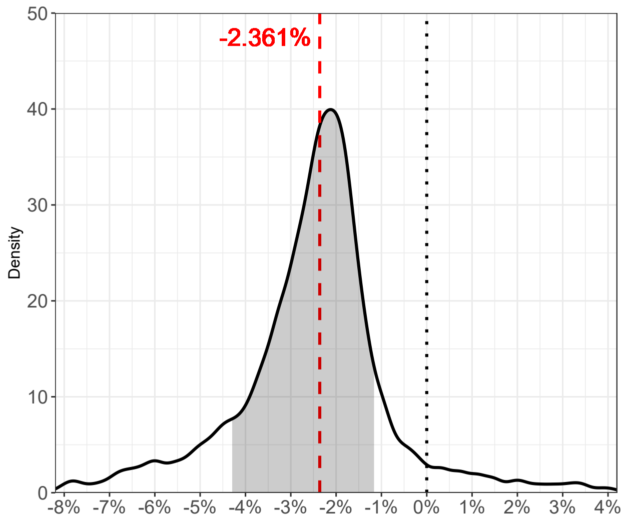
(b) Alternative identification



Notes: Solid line represents the median from 10000 draws of the model posterior. Shaded area is the 68% and the area between dashed lines the 95% credible set.

Figure A20: Posterior distributions of the long-run response of output to a Demand 2 shock that moves current US output by -1%.

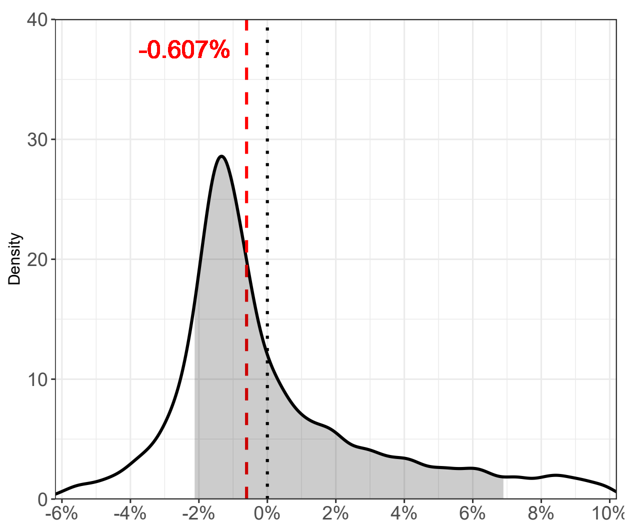
(a) Baseline identification | **(b)** Alternative identification



Notes: This figure plots kernel density estimates on the distribution of the permanent effects of Demand 2 shocks on output that is implied by a sample of 10000 draws from the model posterior. Median draw is highlighted with a red dashed line. Shaded area represents 68% credible set.

Figure A21: Posterior distributions of the long-run response of output to a Demand 2 shock that moves current Finnish output by -1%.

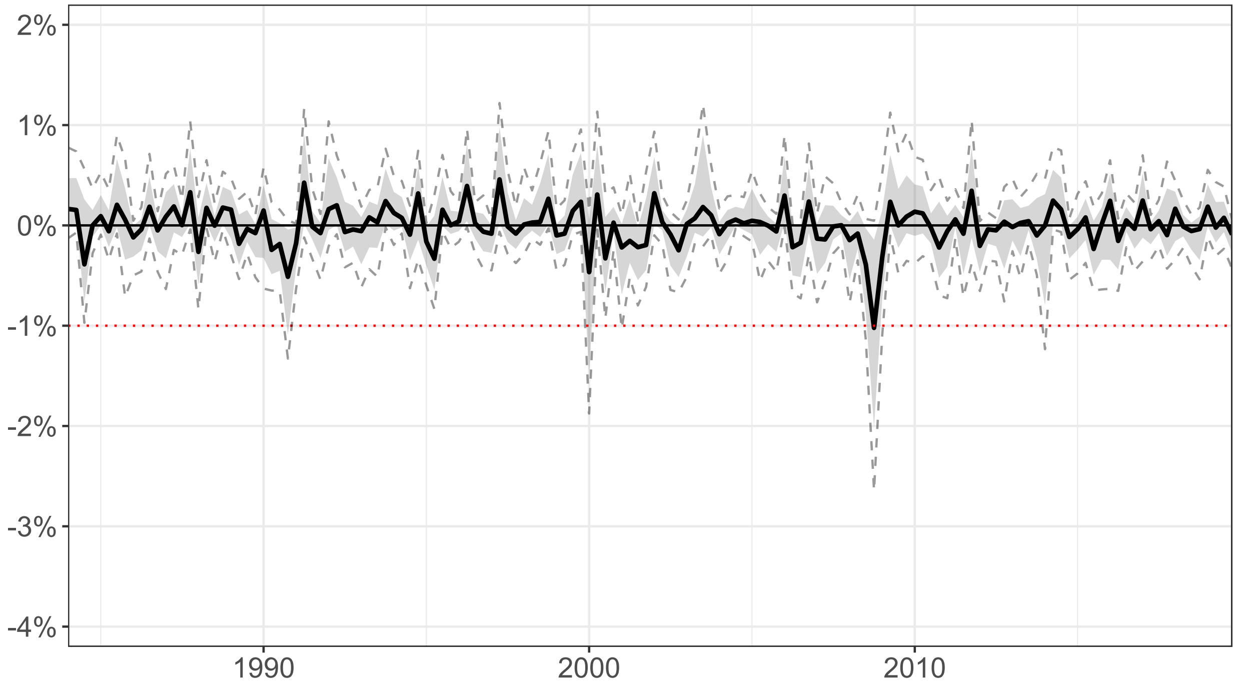
(a) Baseline identification | **(b)** Alternative identification



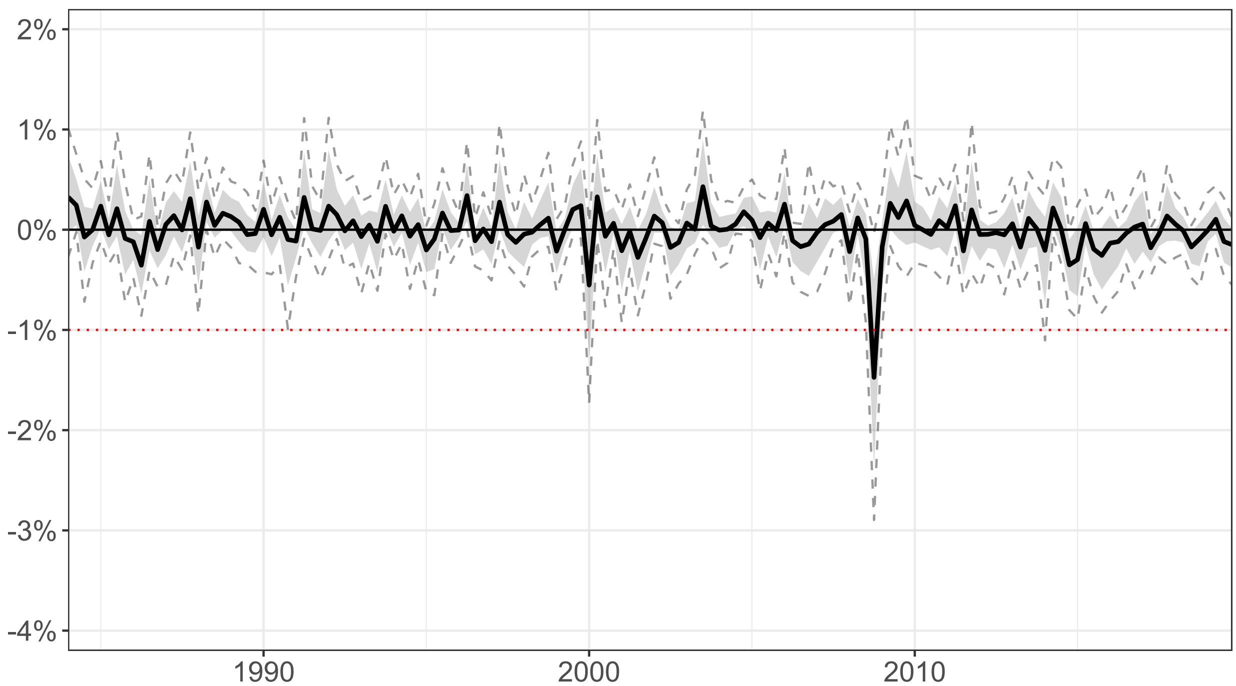
Notes: This figure plots kernel density estimates on the distribution of the permanent effects of Demand 2 shocks on output that is implied by a sample of 10000 draws from the model posterior. Median draw is highlighted with a red dashed line. Shaded area represents 68% credible set.

Figure A22: Contributions of Demand 2 shocks to the stochastic component of *gdp* in the sample, US.

(a) Baseline identification



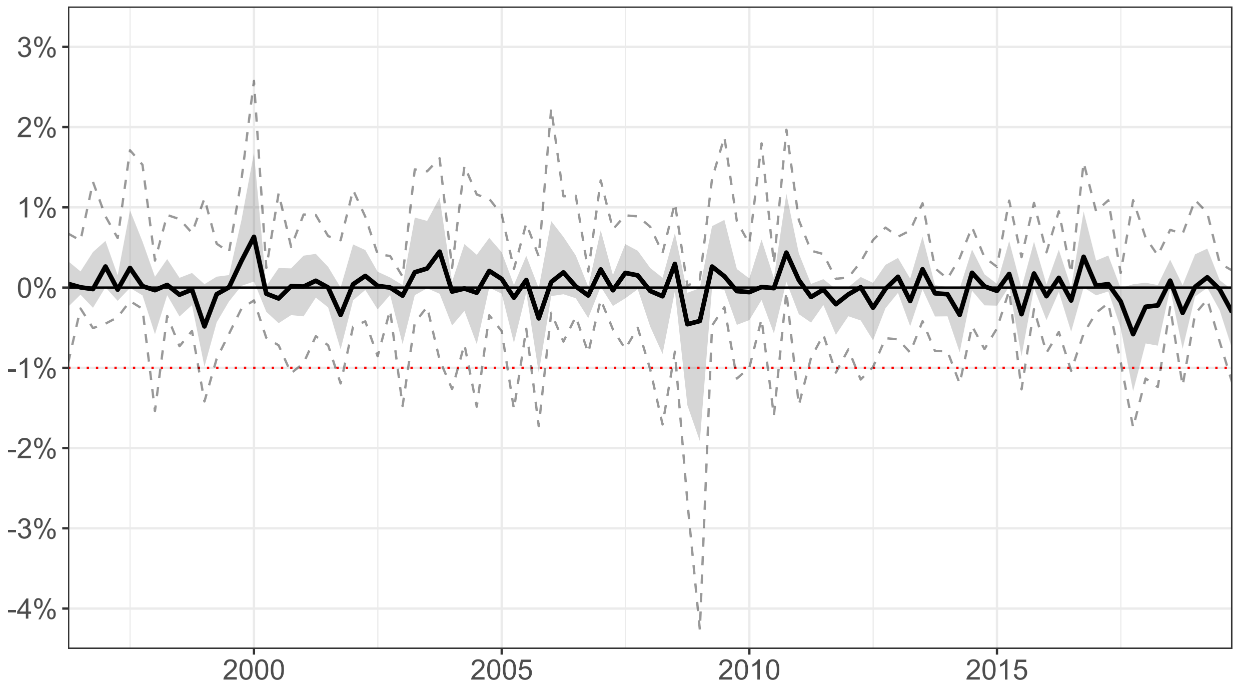
(b) Alternative identification



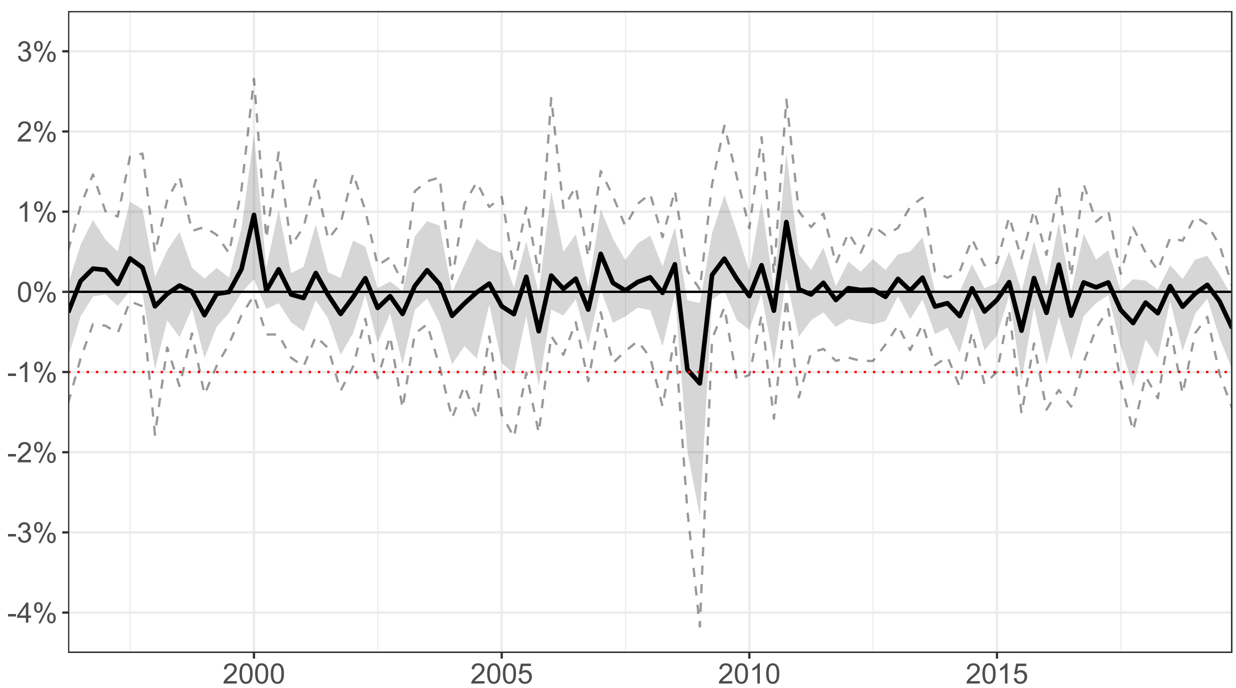
Notes: Solid line represents the median from 10000 draws of the model posterior. Shaded area is the 68% and the area between dashed lines the 95% credible set.

Figure A23: Contributions of Demand 2 shocks to the stochastic component of *gdp* in the sample, Finland.

(a) Baseline identification



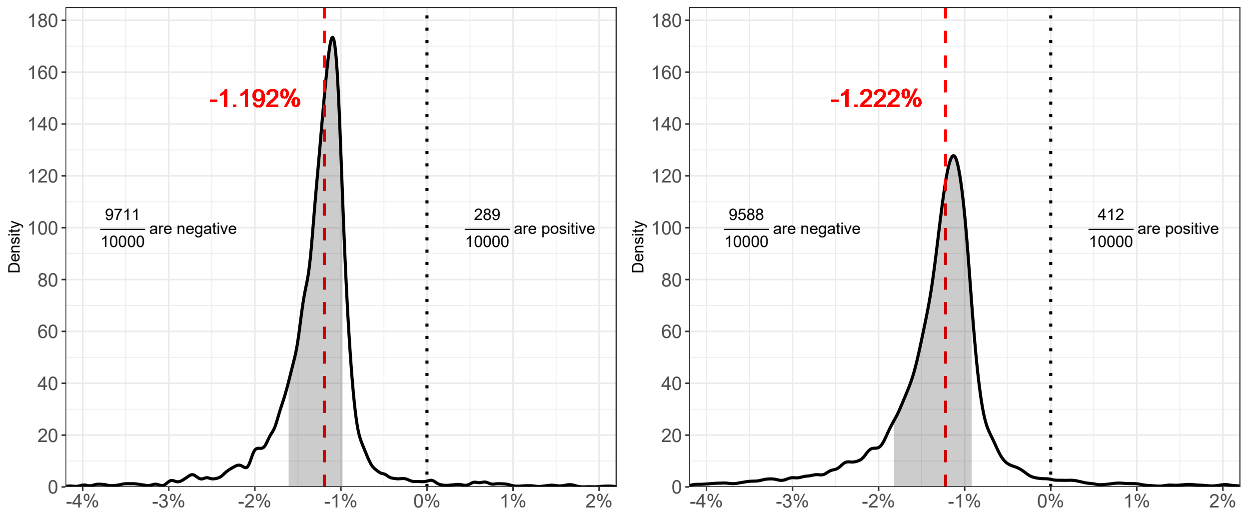
(b) Alternative identification



Notes: Solid line represents the median from 10000 draws of the model posterior. Shaded area is the 68% and the area between dashed lines the 95% credible set.

Figure A24: Posterior distributions of the long-run $(t + \infty)$ response of output to a Supply 2 shock at time t that moves US *gdp* at $t + 4$ by -1%.

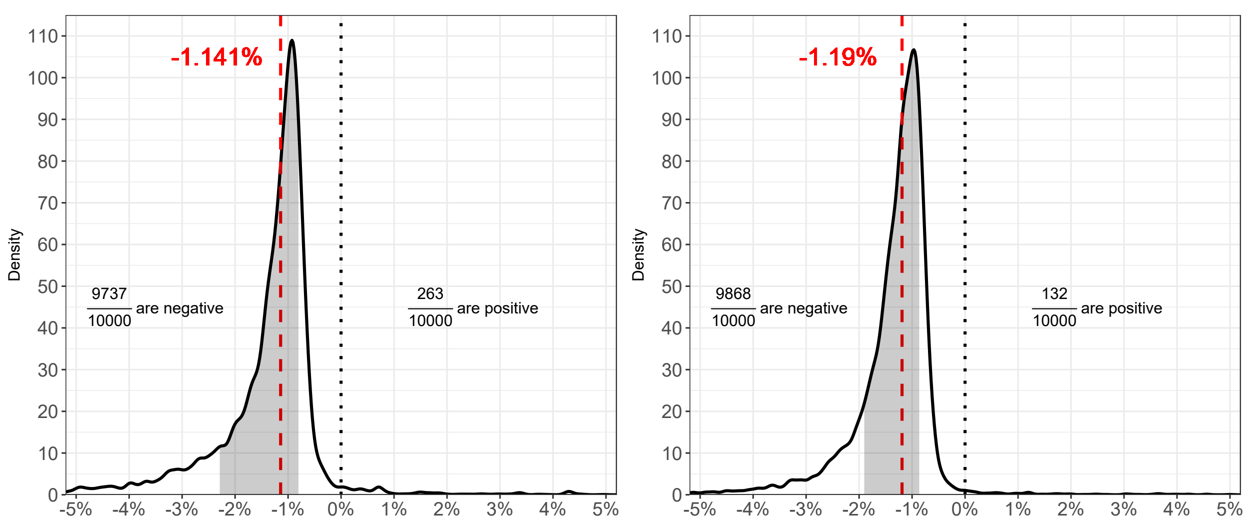
(a) Baseline identification **(b)** Alternative identification



Notes: This figure plots kernel density estimates on the distribution of the permanent effects of Supply 2 shocks on output that is implied by a sample of 10000 draws from the model posterior. Median draw is highlighted with a red dashed line. Shaded area represents 68% credible set.

Figure A25: Posterior distributions of the long-run $(t + \infty)$ response of output to a Supply 2 shock at time t that moves Finnish *gdp* at $t + 4$ by -1%.

(a) Baseline identification **(b)** Alternative identification



Notes: This figure plots kernel density estimates on the distribution of the permanent effects of Supply 2 shocks on output that is implied by a sample of 10000 draws from the model posterior. Median draw is highlighted with a red dashed line. Shaded area represents 68% credible set.