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How Oil Supply Shocks Affect the Global Economy: Evidence from Local Projections



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Abstract

We provide empirical evidence on the impact of oil supply shocks on global aggregates. To do this, we first extract structural oil supply shocks from a standard oil-price determination model found in the literature. Impulse response functions are then estimated using local projections. This technique has recently been used to estimate the effect of monetary policy and government spending shocks. To our knowledge, however, this is the first time it is used to analyze the effect of oil supply shocks on global aggregates. While there is a high level of uncertainty around our estimates, results can be summarized with three main takeaways. Following a supply-driven decline in oil prices: (1) US business investment usually decreases, highlighting the importance of the shale oil industry, while the reaction of US gross domestic product (GDP) is often not statistically significant; (2) domestic demand in the euro area usually increases strongly; and (3) GDP among commodity exporters declines in the short term, reflecting the importance of the terms-of-trade channel, but increases in the longer term, reflecting the aggregate benefits of increased oil production.

Bank topics: Business fluctuations and cycles; International topics

JEL codes: C, C2, C22, C5, E, E3, E37, Q, Q4, Q43

Résumé

Nous fournissons des résultats empiriques sur l'incidence de chocs d'offre de pétrole sur les agrégats macroéconomiques mondiaux. Pour ce faire, nous employons un modèle structurel standard de détermination des prix du pétrole provenant de la littérature, et nous en isolons les chocs d'offre de pétrole. Les fonctions de réponse sont alors estimées au moyen de projections locales. Cette technique a récemment été utilisée pour estimer les effets des chocs de politique monétaire et de dépenses publiques. À notre connaissance, cependant, il s'agit de la première fois où elle sert à analyser les effets des chocs d'offre de pétrole sur les agrégats macroéconomiques mondiaux. Bien qu'une grande incertitude entoure nos estimations, nos résultats nous permettent de tirer trois grandes conclusions. Après une baisse des prix du pétrole attribuable à des facteurs d'offre : 1) les investissements des entreprises aux États-Unis diminuent habituellement – ce qui montre l'importance de l'industrie du pétrole de schiste –, alors que la variation du produit intérieur brut (PIB) du pays n'est souvent pas statistiquement significative; 2) la demande intérieure dans la zone euro a tendance à augmenter fortement; 3) le PIB des pays exportateurs de produits de base recule à court terme, ce qui reflète l'importance du canal des termes de l'échange, mais augmente à long terme, ce qui témoigne des avantages globaux de la production pétrolière accrue.

Sujets : Cycles et fluctuations économiques; Questions internationales

Codes JEL : C, C2, C22, C5, E, E3, E37, Q, Q4, Q43

Section 1 | Introduction

In global macroeconomic models, economists often calibrate the response of aggregate variables to oil supply shocks because it is difficult to estimate these relationships empirically in a semi-structural setting. This paper provides an empirical assessment of the link between oil supply shocks and global macroeconomic aggregates using local projections. The results from this analysis were particularly useful in informing the calibration of the dynamic properties of IMPACT, the Bank of Canada's new global macroeconomic model, with respect to an oil supply shock.¹

The key results are as follows. After a supply-driven decline in oil prices:

- US business investment usually decreases, highlighting the importance of the shale oil industry, while the reaction of US gross domestic product (GDP) is often not statistically significant.
- Domestic demand in the euro area usually increases.
- GDP among commodity exporters usually declines in the short term, reflecting the importance of the terms-of-trade channel, but increases in the longer term, reflecting the aggregate benefits of increased oil production.

The remainder of the paper is structured as follows. Section 2 presents the oil price decomposition model and the local projection setting used in the empirical exercise. Section 3 discusses the main results by region. Section 4 concludes. The appendix shows alternative impulse response functions.

Section 2 | Empirical methodology

To estimate the impact of oil supply shocks on the global economy, a two-step empirical approach is used, in the spirit of Cloyne and Hürtgen (2016):

Step 1: Estimate structural oil supply shocks. We use a structural model of the oil market proposed in the literature and extract estimates of oil supply shocks.

Step 2: Estimate impulse response functions. Armed with the estimated structural oil supply shocks obtained from step 1, we estimate the marginal impact over time of an oil supply shock on a given variable. We obtain the impulse response functions using the method of local projections from Jordà (2005) and then check the results for robustness using a vector autoregression (VAR) analysis.

¹ See Blagrove et al. (2019)

Local projections have recently been used in the literature to estimate the impact of monetary policy shocks (Cloyne and Hürtgen 2016; Champagne and Sekkel 2017) and the impact of fiscal spending shocks (Owyand, Ramey and Zubairy 2013). While there is extensive literature on the impact of oil supply shocks on specific economies, we believe this is the first time that this technique is used to evaluate the relationship between oil supply shocks and global economic aggregates.

Step 1: Estimating structural oil supply shocks

To identify oil supply shocks, we use the estimates of the structural VAR proposed by Kilian and Murphy (2014).² To structurally identify their model, these authors apply restrictions on the sign and magnitude on the oil demand/supply price elasticities at impact. The VAR is composed of four variables:

- the Baltic dry index that captures movements in real global economic activity,
- global oil production,
- the real price of oil as defined by the acquisition costs of US refiners, and
- total US crude oil inventories.³

As such, the model decomposes movements in oil prices into four structural shocks:

1. an oil demand shock associated with unexpected movements in the global business cycle;
2. an oil supply shock capturing supply disruptions;
3. an oil-specific demand shock that captures shifts in the demand for oil inventories coming from forward-looking behaviour—this type of shock can originate from either speculative demand or expected disruption shocks; and
4. a residual shock that captures idiosyncratic oil demand shocks not otherwise accounted for (such as weather shocks).

In this paper, our preferred measure of structural oil supply shocks is the sum of Kilian and Murphy's (2014) oil supply shock (2) and oil-specific demand shock (3). We use the oil-specific demand shock in our measure because it would have similar impact on the macroeconomy as a pure supply shock, and it can capture expected supply disruptions. To validate the findings, we

² The oil model used in this paper does not identify the regional origin of the supply innovation, as done in Mohaddes and Pesaran (2016). A shock, as defined here, can very well be an unexpected production cut by the Organization of Petroleum Exporting Countries (OPEC) that pushes oil prices up or a technological change in the United States that leads to lower oil prices.

³ The VAR is estimated at monthly frequency, but we convert the structural shocks to quarterly frequency to be consistent with national accounts data.

also consider Kilian and Murphy's oil supply shock on its own as well as the supply-induced shock in the model of oil price determination elaborated by Perez-Segura and Vigfusson (2016).⁴

Step 2: Estimating impulse response functions using local projections

We use local projections to estimate the impact of the structural oil supply shocks on various global macroeconomic variables.⁵ Local projections are a useful method for estimating the impulse response function of a variable to an exogenous shock that is identified by a third-party model (see Jordà 2005). This approach has three advantages:

- it is flexible enough to estimate the response of macroeconomic variables for several regions,
- it allows for several robustness checks using different definitions of oil shocks, and
- it does not impose a rigid theoretical structure on the data.

Specifically, the change in a variable of interest (x) between time t and time $t + h$ is regressed on the estimated structural oil supply shocks ($OilShk$) along with a series of control variables (equation 1). The coefficient associated with the shock (β_h) then represents the impulse response at horizon $t + h$:

$$x_{t+h} - x_t = c + \beta_h OilShk_t + \Omega(L)Controls_{t-1} + \varepsilon_t \quad (1)$$

The variables of interest for the United States are real gross domestic product (GDP), consumption and business investment. We are interested in the response of GDP and total domestic demand for five other regions: the euro area, Japan, China, commodity-importing emerging-market economies (EMEs), and commodity-exporting rest of the world.⁶ The real effective exchange rate and the nominal interest rate of each respective region are added as

⁴ Perez-Segura and Vigfusson (2016) distinguish between shocks induced by supply and demand. A supply-induced shock is identified if a movement in oil prices is matched by an opposite movement in metal and equity prices. This assumes that lower oil prices, coming from higher supply, should increase the economic prospects and therefore raise metal and equity prices contemporaneously. A demand-induced shock is identified when oil, equity and metal prices all move in the same direction. For instance, worsening economic prospects for global demand should cause all three prices to decline.

⁵ Note that the structural shocks and impulse response functions can also be used to calculate a structural historical decomposition of the macroeconomic variables. See, for instance, Ellwanger, Sawatzky and Zmitrowicz (2017).

⁶ As in the Bank of Canada's IMPACT and its *Monetary Policy Report*, the EME grouping excludes China. It is composed of large emerging markets from Asia, Latin America, the Middle East and Africa (such as India, Brazil and South Africa), emerging and developing Europe and newly industrialized economies (such as South Korea). "Rest of the world" is a grouping of all other economies not included in the first five regions. It is composed of oil-exporting emerging markets (such as Russia, Nigeria and Saudi Arabia) and other advanced economies (such as Canada, the United Kingdom and Australia).

control variables.⁷ Of note, the sample is limited for China, EMEs and the rest of the world grouping, so the results for these regions should be taken with caution.⁸

To ensure the robustness of the results, we also perform a VAR analysis. This is a particularly useful check in this context given that VARs can take into account the dynamic interactions between macroeconomic variables.⁹ For the purpose of this paper, the VAR is composed of the estimated structural oil supply shock, the region's output gap, its exchange rate and its policy rate.

Section 3 | Empirical results

In this section, we analyze impulse response functions to a positive oil supply shock that lowers oil prices by 15 percent. We focus on impulse response functions derived from local projections of our main oil supply shock stemming from the model of Kilian and Murphy (2014).¹⁰ Results are shown in **Figure 1**. Results derived from the two alternative oil supply shocks and the VAR analysis (for GDP only) are similar and presented in the appendix.

United States

Most impulse response functions show a small positive reaction of US GDP to the decline in oil prices, but with considerable uncertainty around the point estimates (results are not statistically significant at 95 percent).

There is evidence in favour of a strong and statistically significant decline of business investment (-1 percent) following a 15 percent supply-driven decline in oil prices.¹¹ This result is corroborated by alternative impulse response functions, as shown in the appendix. This result may be counterintuitive given that a decline in oil prices lowers input costs for most businesses and should therefore push up investment. In reality, this result reflects the growing importance of

⁷ Control variables also include lags of the oil supply shocks and the target variable. Note that removing the exchange rates and interest rates as control variables does not alter the main results.

⁸ The estimation sample begins in 1981, 1983 and 1986 for the United States, the euro area and Japan, respectively. However, we are constrained to begin in 1992, 1995 and 1994 for China, EMEs and the rest of the world grouping, respectively. The sample stops in the fourth quarter of 2016 for all regions.

⁹ For instance, US monetary policy may become more accommodative following a rise in oil prices, which should partially offset the positive impact of higher oil prices.

¹⁰ The confidence intervals are calculated using the standard deviations of the beta parameters and do not account for the uncertainty around the oil shocks series because they are generated regressors.

¹¹ This result is mostly driven by the statistically significant negative reaction of investment in structures. In contrast, the reaction of investment in machinery and equipment is not statistically significant.

the shale oil industry in the United States.¹² When estimating the local projections until 2008 (before the shale boom), we find that the response of US business investment is positive following a decline in oil prices.

For consumption, the overall impact of lower oil prices appears small and insignificant. This contrasts with recent research showing that the response of US consumers to lower oil prices in 2014–15 was positive and significant (Alexander and Poirier 2018).¹³

Euro area and Japan

In most specifications, GDP in the euro area displays a large positive reaction to a decrease in oil prices, driven by domestic demand. This is in line with the net oil-importing nature of the euro area. While the reaction of domestic demand is statistically significant, the response of GDP is not. This finding is consistent across alternative specifications.

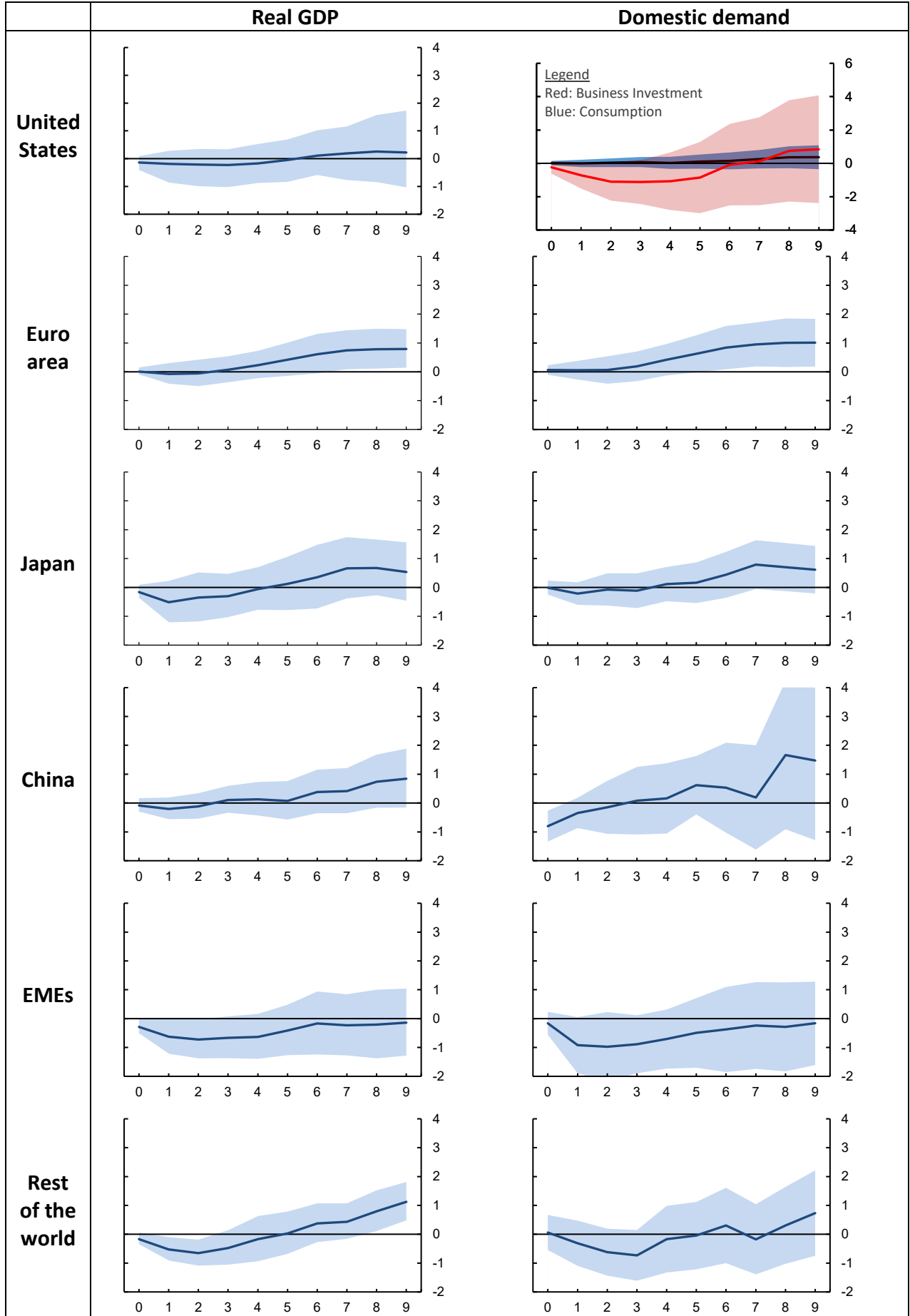
Similar to the euro area, the point estimates for Japan's GDP and domestic demand suggest a small positive reaction following a decline in oil prices, although not statistically significant.

¹² The stark response of business investment in the US oil sector following the large decline in global oil prices in 2014–15 is one key reason why the benefits to the US economy from lower oil prices were not apparent at the outset of the price decline. See Fay, Gu enette and Morel (2016).

¹³ The difference in the results may be because Alexander and Poirier (2018) look at the specific episode of 2014–15, while in this paper we assess the average response of consumption. Also, the decline in oil prices in 2014–15 was not entirely due to a supply shock.

Figure 1: Impact of a supply-driven 15 percent decline in oil prices

Shaded areas are 95% confidence intervals, quarterly data, Kilian-Murphy (shocks 2 + 3) and local projections



China and emerging-market economies

For China, GDP reacts positively following the oil supply shock. While this is consistent with our prior findings that a net oil importer should benefit from lower prices, the uncertainty around the point estimates is large and cannot provide statistically significant results.

For EMEs, a decline in oil prices leads to lower GDP. This may be surprising given that the block is a net oil importer. In fact, a more granular analysis of this block suggests that these results are likely driven by the commodity producers in this EME block. The economic drag faced by these countries would more than offset the support to oil-importing EMEs. Nevertheless, the results should be treated with caution given the very short sample period for this block.

Rest of the world

Initially, lower oil prices lead to a decline in GDP for the rest of the world grouping. This decline is statistically significant for the first three quarters after the shock. These results highlight the importance of the terms-of-trade channel for net oil exporters in the short run.

In the longer run, however, the effect of lower oil prices turns positive and statistically significant. This is in line with the idea that an increase in oil production should ultimately benefit oil producers (Mohaddes and Pesaran 2016). For instance, if Saudi Arabia were to increase its oil production substantially, it would require additional labour and capital and, despite lower oil prices, would lead to higher revenues. Here again, caution should be taken when interpreting these results because the sample period for this block is also short.

Section 4 | Conclusion

In this paper we provide estimates of the impact of structural oil supply shocks on global macroeconomic aggregates. Using oil supply shocks from structural models of the oil market along with local projections, we reach three main conclusions: a decline in oil prices leads to (1) lower US business investment, (2) stronger domestic demand in the euro area, and (3) lower GDP in the rest of the world in the short run, but higher in the longer run. However, the shocks specified here can be considered global by definition because their regional origin is not specified. In future work, it would be interesting to assess the impact of oil supply shocks from specific countries, such as shocks to the US shale oil industry, and assess how they propagate globally.

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Appendix | Alternative impulse response functions

Figure A1: Local projections: Impact of a supply-driven 15 percent decline in oil prices

Shaded areas are 95% confidence intervals, quarterly data, alternative shock 1 (Kilian and Murphy shock 2 only)

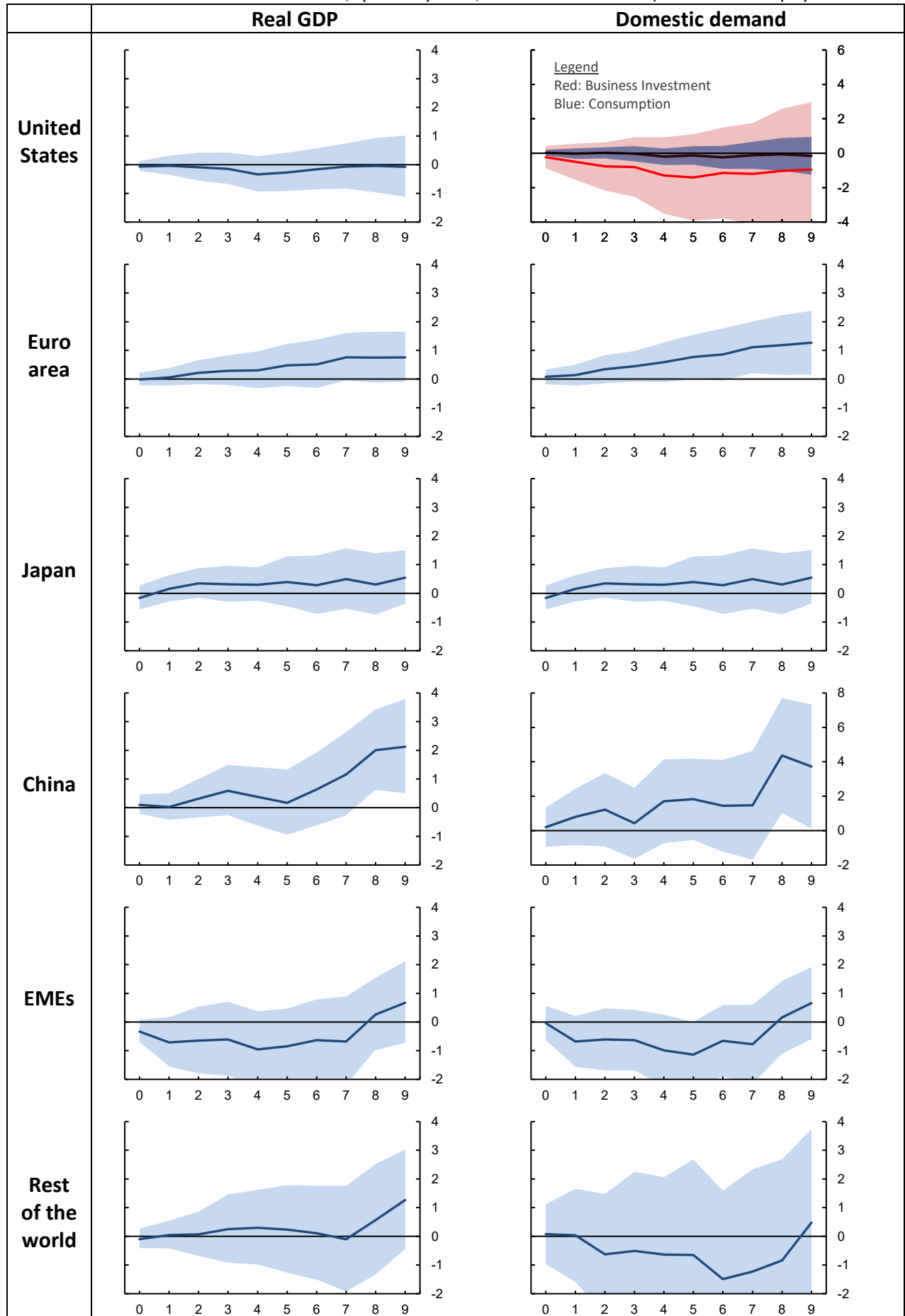


Figure A2: Local projections: Impact of a supply-driven 15 percent decline in oil prices

Shaded areas are 95% confidence intervals, quarterly data, alternative shock 2 (Perez-Segura and Vigfusson)

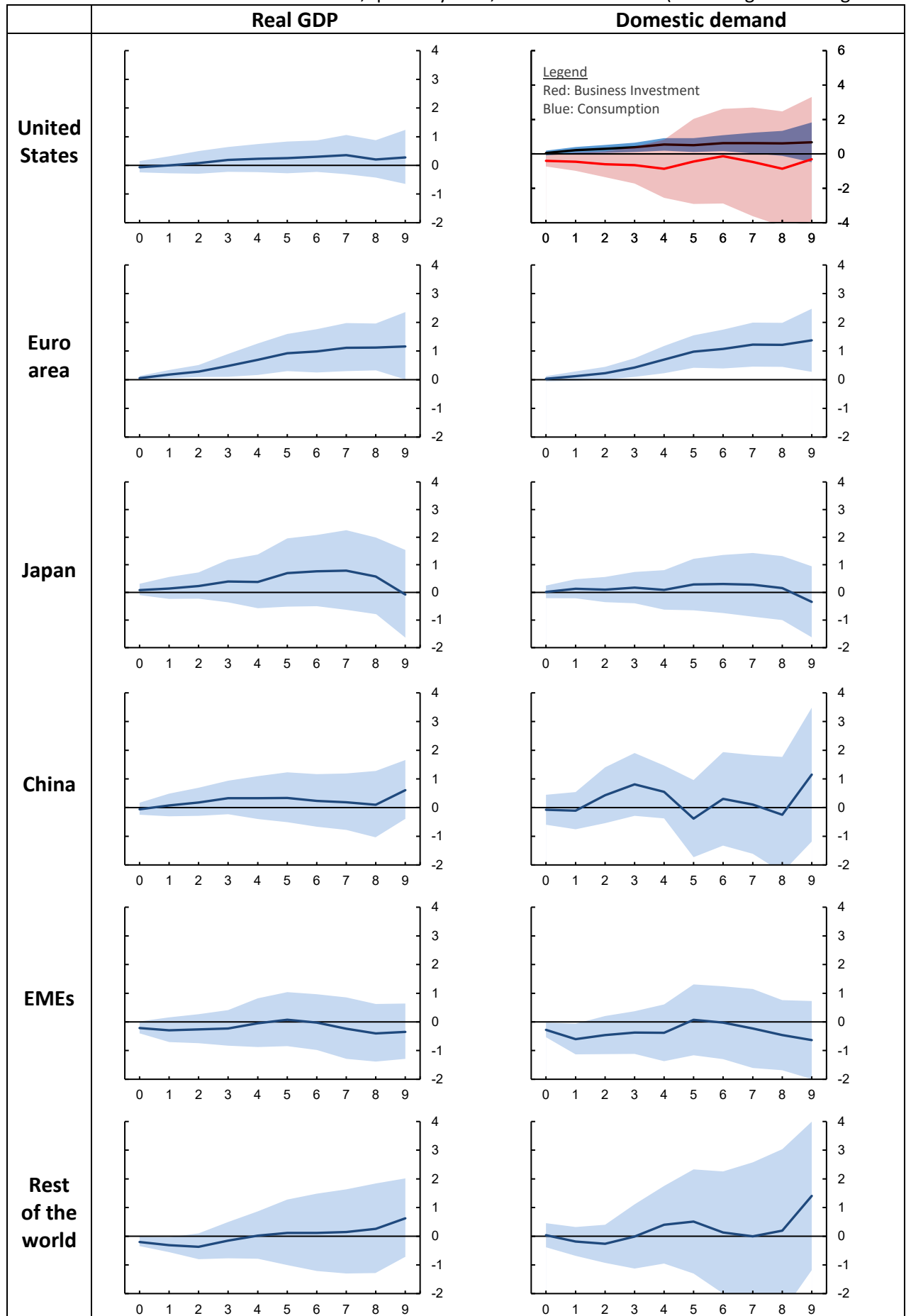


Figure A3: VAR: Impact of a supply-driven 15 percent decline in oil prices on real GDP

Shaded areas are 95% confidence intervals, quarterly data

