Government Spending and International Transmission: Fiscal Rules in Imperfect Financial Markets*

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Abstract

I provide a unified explanation to two prominent puzzles in international economics: the responses of the real exchange rate (RER) and net trade flows to government spending shocks, and the RER disconnect. I develop a theory where agents face costs to re-balance their portfolios between domestic and foreign assets. When the supply of government bonds rises, the RER depreciates so that the return on this bond increases to offset portfolio re-balancing costs. This triggers an expenditure switching effect that raises net trade. This mechanism is crucial to capture the responses of the RER and net trade to government spending shocks and contributes considerably to account for the RER disconnect, demonstrating that fiscal policy is a key driver of international business cycles.

JEL Classifications: E62, F44 , E30, E44

Keywords: International Business Cycles, Fiscal Policy, Exchange Rates, Trade Balance

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1 Introduction

Explaining the cross-country differences in business cycles is fundamental to macroeconomics and international economics from both a positive and normative perspective. In this context, two variables stand out as crucial for the international transmission; the real exchange rate (RER), which reflects the prices that clear the international goods and asset markets, and the net trade flows, the quantities traded in those markets. Although these are key variables for the international transmission, and a source of considerable interest by politicians and other economic agents, their joint dynamics over the business cycle are hard to account for in standard international macro models.

One of the main puzzles in international macro is the RER disconnect, which is summarized by two sets of observations: (*i*) macro fundamentals are weakly correlated with the RER, and (*ii*) the unconditional dynamics of the RER are hard to account for in international macro models.[1] While there have been recent advances toward developing general equilibrium models that account for the unconditional dynamics RER, the theories rely on shocks to residuals in equations for which we have limited direct empirical evidence.[2] On the other hand, existing models have failed to account for the RER and net trade dynamics in response to well identified shocks. In advanced economies, positive government spending shocks lead to a depreciation of the RER and, in some cases, increases in net trade, contrary to the predictions of existing models.[3]

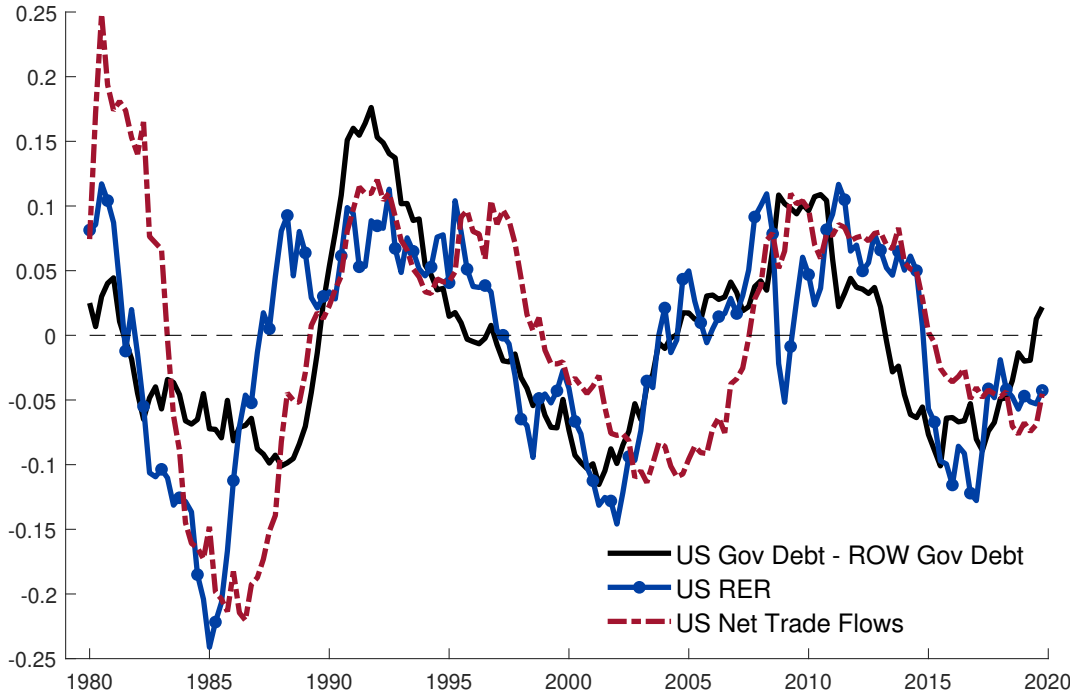
I document new empirical evidence demonstrating that there is a strong relation between fiscal policy, the RER and net trade flows in the US. Figure 1 presents the cyclical component of the US RER (blue line with *o*), US net trade flows (red dotted line), and government debt in the US relative to the rest of the world (solid black line), filtered to capture cyclicality between two

[1] These moments are: (*i*) exchange rates are an order of magnitude more volatile than macro fundamentals and follows an almost unit root process (Meese and Rogoff, 1983), there is low relative consumption in periods of low relative prices (or a depreciated RER) (Backus and Smith, 1993; Kollmann, 1995), (*iii*) the UIP condition is violated (Fama, 1984).

[2] See Itskhoki and Mukhin (2021b); Alessandria and Choi (2021); Mac Mullen and Woo (2024); Kekre and Lenel (2024a); Bodestein, Cuba-Borda, Gornemann and Presno (2024). These include financial shocks, trade shocks, and demand shocks. These shocks are usually residuals of the uncovered interest parity condition, the export-import demand ratio, or the Euler equation.

[3] See Kim and Roubini (2008); Monacelli and Perotti (2010a); Ravn, Schmitt-Grohé and Uribe (2012); Corsetti, Meier and Müller (2012); Kim (2015); Forni and Gambetti (2016); Miyamoto, Nguyen and Sheremirov (2019).

Figure 1: Government Debt in US relative to ROW, the US RER, and US Net Trade Flows



Notes: The time series are obtained after de-trending the data using the Christiano and Fitzgerald (2003) filter capturing cyclicality between two quarters and twenty years (see Appendix A for details). An increase in the US RER means a depreciation of the dollar. Net trade flows are measured as the log of the real export to import ratio. ROW stands for Rest of the World.

quarters and twenty years, the frequency where most of the variance of the RER arises (Rabanal and Rubio-Ramirez, 2015; Gornemann, Guerrón-Quintana and Saffie, 2020; Mac Mullen and Woo, 2024).[4] The relationship between these variables is very strong. The correlation of relative government debt with the RER is 0.63, and with net trade is 0.57. When government debt in the US is high relative to the rest of the world (ROW), the US RER is depreciated relative to its long-run level, and net trade flows are high. The strong connection of fiscal policy with the RER and net trade flows suggests that developing a theory that explains these dynamics is important for understanding the drivers of the RER and net trade over the business cycle.

In this paper, I provide a unified explanation for the two key puzzles mentioned above: the responses of the RER and net trade flows to government spending shocks, and the RER disconnect. The theory relies on a fiscal rule that emphasizes debt financing, and the presence of portfolio

[4] I measure government debt in the rest of the world as a PPP-trade weighted average of real government debt. The results are robust to computing the government debt in nominal terms or in real terms deflated by the CPI or by the price of the government bonds. See Figure A2 for a comparison.

re-balancing costs between domestic and foreign assets.[5] Given the fiscal rule, the supply of government bonds increases in response to a positive government spending shock. To offset portfolio re-balancing costs, the RER depreciates on impact, raising the return on US government bonds relative to foreign bonds. The depreciation of the RER induces an expenditure switching effect that increases net trade flows, allowing the model to capture the dynamics of these variables in response to government spending shocks. I embed this mechanism in a model that features additional shocks and find that the model captures the joint dynamics of relative government debt, the RER and net trade shown in Figure 1. Government spending shocks contribute considerably to this outcome and to account for the RER disconnect.

For the empirical analysis, I focus mostly on the relationship between government spending and debt, since I find a strong (positive) correlation among these variables and I take advantage of existing identification strategies that isolate the causal effect of government spending shocks, which is useful to identify the international transmission channels of US fiscal policy.[6] I show that when US government spending is high, the RER is depreciated relative to its long-run level.[7] While the correlation is small contemporaneously (0.37), it becomes stronger with leads of the RER, with values up to 0.80. I also find similar patters for the comovement between government spending and net trade. Hence, US government spending leads the movement of government debt, the RER and net trade.[8]

To isolate the effect of US government spending shocks, I estimate a Structural VAR (SVAR) model. Following Ramey (2011, 2016a), I identify these shocks by instrumenting realized government spending with forecasts, thereby controlling for anticipation effects.[9] I find that a positive shock to US government spending triggers a RER depreciation and an increase in net trade. Moreover, this shock induces dynamics to these variables that align with their unconditional comovement, suggesting that government spending shocks are a significant driver of these variables.

[5] By fiscal rule I mean the systematic response of government debt and taxes to changes in government spending.

[6] In Appendix C I show that similar results are obtained focusing on tax shocks.

[7] The dynamics of US government spending at cyclicality up to twenty years are mainly driven by military build-ups, a shown by Ramey (2011).

[8] While it is an established fact that the RER leads the cycle in net trade in the US, the so called J-curve (Baldwin and Krugman, 1989; Rose and Yellen, 1989; Backus, Kehoe and Kydland, 1994; Fitzgerald, Yedid-Levi and Haller, 2019; Alessandria and Choi, 2021), I show that US government spending leads the cycle of both of them.

[9] The SVAR results are robust to several controls and alternative identification strategies, such as, external instruments or proxy SVARs (Mertens and Ravn, 2013; Ferrara, Metelli, Natoli and Siena, 2021).

Indeed, I find that this shock explains around 30% of the unconditional variance of the US RER and net trade. This highlights the importance of rationalizing the international transmission of government spending shocks to explain a substantial portion of the unconditional dynamics of the RER and net trade.

I use the SVAR to provide evidence that the interaction between government debt and frictions in international financial markets is an important feature of the international transmission of government spending shocks. I find that the increase in US government spending is financed mostly with government debt that, in the medium run, pays expected excess returns relative to the government bonds in the ROW. In other words, the shock triggers deviations from the uncovered interest parity (UIP). Moreover, I find that while US agents save more in US government bonds they also increase their holdings of foreign assets in response to the shock. These results suggest the presence of financial market imperfections, consistent with a broad set of findings in the literature.[10,11] While the response of the UIP deviations and the US gross foreign assets contradict the prediction of frictionless models, they are particularly informative about the transmission mechanism. I show in the quantitative model that portfolio re-balancing costs are crucial to capture the responses of UIP deviations and the gross foreign assets to government spending shocks, and that this leads the model to account for the RER and net trade flows responses.

To rationalize the relationship between the dynamics of government spending and debt, the RER, and net trade flows, I develop a theoretical framework based on the two-country general equilibrium model in Backus et al. (1994) and Heathcote and Perri (2014). I incorporate two key elements; a fiscal rule and portfolio re-balancing costs. The fiscal rule, governing the response of government debt to changes in government spending, is a simplified version of that in Leeper, Plante and Traum (2010). The portfolio friction is modeled as a cost to deviate from the long-run portfolio share of foreign assets, similar to that in Guo, Ottonello and Perez (2023), and Fukui, Nakamura and Steinsson (2023). The model also includes productivity, trade, and financial shocks.

I estimate the model via Simulated Method of Moments, targeting a combination of empirical

[10] Engel and West (2005); Gabaix and Maggiori (2015); Bacchetta, Davenport and van Wincoop (2022)

[11] Imperfections in financial markets result in the failure of Ricardian Equivalence (Barro, 1974). See Barro (1989) for a discussion of the implications of Ricardian Equivalence for the joint dynamics of fiscal and trade deficits.

impulse response functions from the SVAR, and a set of unconditional moments. Importantly, the fiscal rule and the portfolio re-balancing cost are separately identified. The portfolio re-balancing cost is disciplined externally to match the partial equilibrium aggregate demand elasticity estimated by Koijen and Yogo (2024) in the cross-section of global investors, while the fiscal rule is pinned down by targeting the response of government debt to the government spending shock. The model successfully captures both the responses of key variables to the government spending shocks and a broad set of unconditional moments.

The fiscal rule plays a central role in the international transmission due to its interaction with portfolio frictions.[12] In the model, the domestic household can save in both domestic government bonds and foreign bonds issued in foreign currency.[13] Positive government spending shocks financed with debt directly decrease the share of the domestic household's financial savings held in foreign bonds. In a frictionless model, the RER would appreciate so that there is an expected depreciation of the RER that equates the expected returns of domestic and foreign bonds. The presence of portfolio re-balancing costs, which induce deviations from UIP, tend to depreciate the RER so that the expected depreciation is smaller, or even generate an expected appreciation. This rises the expected returns of US government bonds relative to foreign bonds, offsetting portfolio re-balancing costs. Furthermore, the gross foreign assets increase to smooth out the cost of deviating from the long-run portfolio of foreign assets. The depreciation of the RER triggers an expenditure switching effect that increases net trade. This mechanism allows the model to capture the responses of the RER and net trade, as well as UIP deviations and gross foreign assets, to US government spending shocks.

Finally, the model successfully captures the unconditional comovement between government spending and debt, the RER and net trade. Furthermore, government spending shocks contribute considerably to this outcome, as well as to account for the RER disconnect. Consequently, the theory, which relates shocks to demand for goods, the government spending shock, with

[12] In Appendix C, I use the measure of unanticipated tax shocks in the US from Mertens and Ravn (2012), and find results in line with those triggered by US government spending shocks, providing an external validation of my mechanism relating the use of government debt with the adjustment in the RER and net trade.

[13] To simplify the model and the intuition of the mechanism I do not allow for cross-country trade in government bonds. However, allowing for this does not change the results, which is shown in the sensitivity analysis of the model in Section 7.

changes in asset's demand in the context of imperfect financial markets, endogenizes some of the channels treated as exogenous in the literature on exchange rate and net trade dynamics. In particular, shocks to the demand for goods (Kekre and Lenel, 2024a) and the UIP condition (Itskhoki and Mukhin, 2021b).

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 presents the stylized facts. In Section 4, I present the SVAR analysis, the identification of shocks to US government spending, the impulse response functions and evidence on transmission mechanisms. Section 5 presents the quantitative model, and its estimation. Section 6 presents the main results of the model. Section 7 discusses the sensitivity of the model and present further evidence in favor of the theory using cross-country panel data. Finally, Section 8 presents the concluding remarks and discusses further avenues of research.

2 Literature Review

First, I contribute to the literature studying the international transmission of fiscal shocks. The literature has documented puzzling behavior of the responses of the RER and net trade to government spending shocks, and lacks a theory rationalizing the evidence (Corsetti and Müller, 2006; Kim and Roubini, 2008; Monacelli and Perotti, 2010a; Ravn et al., 2012; Corsetti et al., 2012; Kim, 2015; Auerbach and Gorodnichenko, 2016; Forni and Gambetti, 2016; Miyamoto et al., 2019; Boehm, 2020; Ferrara et al., 2021).[14] I find that positive US government spending shocks depreciate the RER and increase net trade.[15] However, my main contribution is to propose a mechanism that rationalizes the quantitative responses of the RER and net trade to this shock.[16] Key for

[14] See Appendix F.1 for a detailed description of the empirical results in the literature. The literature has also documented significant heterogeneity in the response of the RER and net trade to government spending shocks across countries. In appendix REF, I show that I also contribute to understanding these cross-country differences, by linking the differential responses of these variables to heterogeneity in the fiscal rules across countries.

[15] While Ferrara et al. (2021) argues that the opposite happens in the US data when applying external instruments or Proxy SVARs (Mertens and Ravn, 2013), using Ramey (2016b) military news as external instrument, I show that this is driven by the absence of trends in the SVAR. In other words, if one focuses on identifying transitory shocks and include a trend in the SVAR, as it is the standard practice, then the RER depreciates and net trade increases in the US using Proxy SVARs.

[16] While Corsetti et al. (2012) model generates a depreciation of the RER and improvement in net trade, arising from government spending reversals, the responses of these variables are various orders of magnitude smaller than in the data. For example, the size of the IRF of the RER appear to be only 2 percent of that in the data, and the net

identifying the mechanism is the evidence I provide on the interaction between government debt and frictions in international financial markets for the international propagation. In particular, the puzzling response of the deviations of UIP and the US gross foreign assets to government spending shocks.[17]

I also contribute to the literature on international business cycles and exchange rate dynamics (Meese and Rogoff, 1983; Backus et al., 1994; Obstfeld and Rogoff, 2000; Devereux and Engel, 2002; Heathcote and Perri, 2002, 2014; Engel and West, 2005; Alessandria and Choi, 2007, 2021; Corsetti, Dedola and Leduc, 2008; Rabanal and Rubio-Ramirez, 2015; Gabaix and Maggiori, 2015; Farhi and Gabaix, 2016; Valchev, 2020; Gornemann et al., 2020; Itskhoki and Mukhin, 2021a,b; Jiang, Krishnamurthy and Lustig, 2021; Akinci, Kalemli-Ozcan and Queralto, 2023; Mac Mullen and Woo, 2024; Chahrour, Cormun, De Leo, Guerrón Quintana, and Valchev, 2024; Bodestein et al., 2024). I show that US government spending shocks explain around 30 percent of the unconditional variance of the RER and net trade, which contrasts the view that exchange rates are disconnected from fundamentals. I contribute by developing a theory that endogenizes some of the transmission channels treated as exogenous in the literature, such as UIP and demand shocks (Itskhoki and Mukhin, 2021b; Kekre and Lenel, 2024a), which arise in response to a government shock, that is a well-identified shock. Furthermore, the model generates a positive comovement between gross foreign assets and liabilities, which is hard to generate in existing models (Broner, Didier, Erce and Schmukler, 2013; Davis and van Wincoop, 2024; Oskolkov, 2024). Finally, the theory has policy implications, since it generates an endogenous international risk-sharing inefficiency, introducing a new trade-off between distortionary taxes and debt.

3 Stylized Facts

I start by documenting some stylized facts on the unconditional comovement between US government spending, government debt, the RER, and net trade flows. I find that there is a strong correlation among these variables, which has been overlooked by the literature. First, I describe

trade flows only 0.002 percent.

[17]Another difference with the literature is that I include ROW variables in my SVAR, having the advantage to account for the state of the ROW economy, and provide a closer mapping to two-country general equilibrium models.

the data and its sources, the filtering technique, and finally present the stylized facts.

3.1 Data

The details on the data sources and construction of variables are in Appendix A. I focus on the period of flexible exchange rate regime after the fall of the Bretton Woods system and before the Covid pandemic. My baseline specification is between 1980Q1 and 2019Q4, but the results are robust to starting in 1973Q1. I use data on per-capita gross domestic product, consumption, investment, government spending, federal and defense spending in the US, exports, imports, interest rates and the RER.[18] The main data sources are NIPA, OECD, IMF, and Bank of International Settlements. The ROW is constructed as a trade weighted average of eighteen countries.[19,20] Finally, I focus on federal spending in the US, and refer to it either as federal spending or government spending.

I focus on business cycles that take up to twenty years since the cyclical component of US government spending is mainly driven by military build-ups, which last for more than a decade (Ramey, 2011), and because the bulk of the variance of net trade and the RER arises at cycles that last up to twenty years (Rabanal and Rubio-Ramirez, 2015; Gornemann et al., 2020; Mac Mullen and Woo, 2024). I use the filter proposed by Christiano and Fitzgerald (2003) (henceforth CF), since it outperforms other filters at lower frequencies, such as the Hodrick and Prescott (1997). Since most of the variation in the RER and net trade flows arises from cycles up to twenty years, I apply the CF filter to capture cyclicality between two quarters and twenty years.[21] I focus on the cyclical component of US federal spending, but the results are robust to using the cyclical component of general government spending, or the raw data on federal spending or defense spending which do not present trends.[22] Furthermore, similar results are obtained using the

[18] I measure net trade flows by the log of the export-import ratio because it is stationary and controls for trade integration. See Alessandria and Choi (2021) for more details.

[19] The ROW countries are Australia, Austria, Belgium, Canada, Denmark, Finland, Germany, Ireland, Italy, Japan, South Korea, Netherlands, Norway, Portugal, Spain, Sweden, Great Britain and Mexico.

[20] In Figure A1, I show that the results are very similar using GDP weights.

[21] I start at two quarters cyclicality since in the estimation of the model I combine unconditional moments with empirical IRFs, and the latter includes effects at short horizons. However, the results are robust to capturing cyclicality between two and twenty years. The results are also robust to using linear, quadratic or cubic detrend, or the band-pass filter.

[22] This is explained by the fact that the cyclical component of general government spending and federal spending

cyclical component of business cycles up to twelve or sixteen years.[23]

3.2 US Government Spending, Government Debt, the RER and Net Trade

Figure 2 Panel (a) presents the time series of the cyclical component of US government spending (solid black). There are two big cycles. The first one started in the early 1980's with the Reagan-Bush military build-up and lasted until the late 1990's, and a latter cycle triggered by the Iraq war between the early 2000's and 2015. Moreover, Panel (a) also presents the time series of the US trade-weighted RER (blue line with *o*), where an increase means a depreciation of the US RER. It can be observed that there is a strong comovement between these two variables, particularly at lower frequencies. It is clear from the figure that periods where US government spending is high, correlate with a depreciated RER. Furthermore, a similar pattern is observed for the comovement between US government spending and net trade flows (red dotted line).

The time series of these variables also show that US government spending leads the cycle of the RER and net trade, since the big swings in the former preceded those of the latter variables. This can be seen more clearly in Panel (b), which presents the dynamic correlation between the contemporaneous component of US government spending with lags and leads of the RER (blue line with *o*) and net trade flows (red dotted line). The strongest correlation with the RER is found with the two years lead RER, which has a value of around 0.80. This result contrasts with the standard view in the literature that RERs are disconnected from macro aggregates (Obstfeld and Rogoff, 2000; Itskhoki and Mukhin, 2021a). Finally, the strongest comovement with net trade is found at further leads of the latter, which is not surprising since it is a well-known fact that the RER leads the cycle of net trade flows in the US.[24,25]

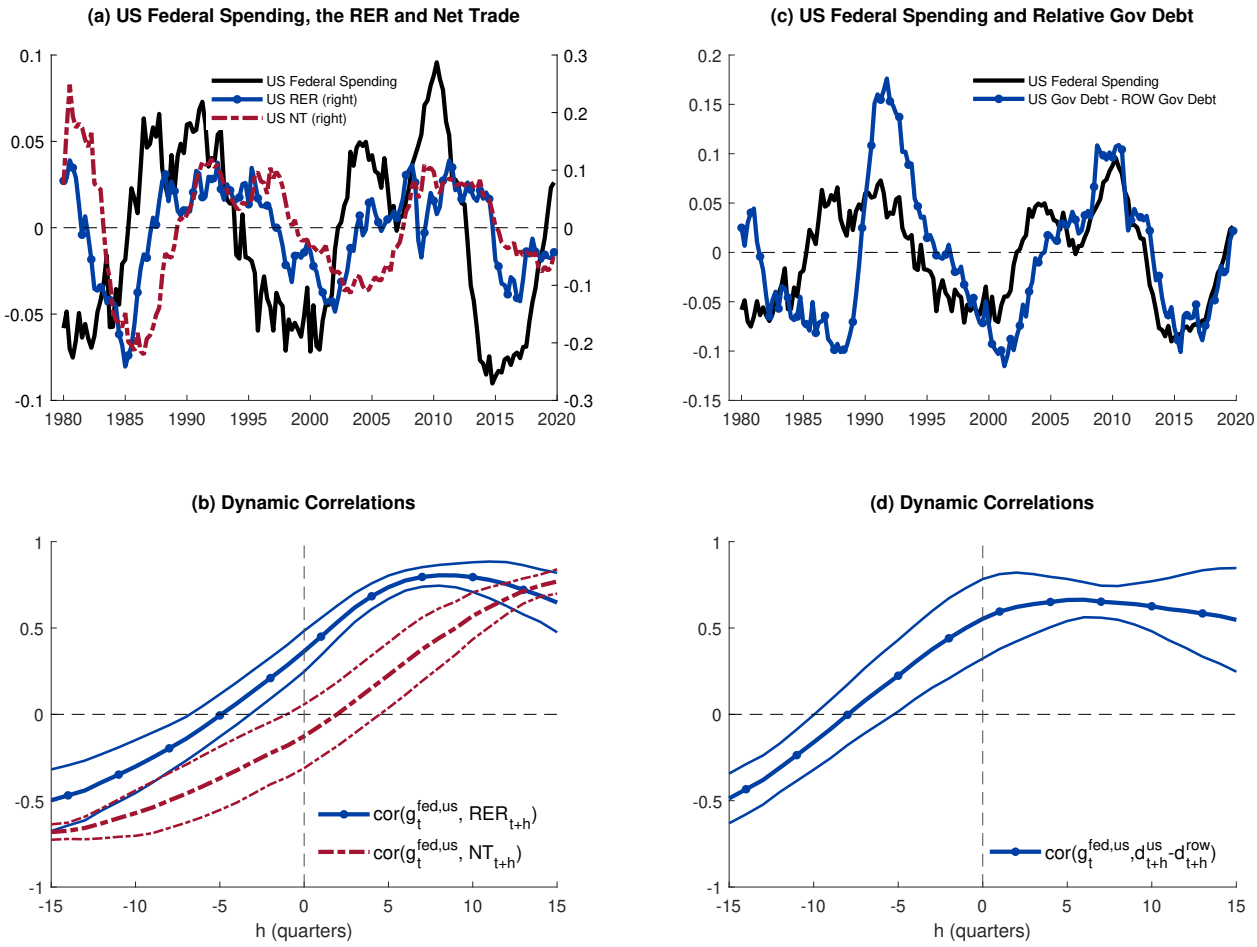
in the US are driven by defense spending, as shown by Ramey (2011).

[23] See Appendix A for the robustness to these alternative measures.

[24] See the J-curve literature (Baldwin and Krugman, 1989; Rose and Yellen, 1989; Backus et al., 1994; Fitzgerald et al., 2019; Alessandria and Choi, 2021).

[25] I show in the Appendix A, that the results are robust to using general government spending, or the raw data of US federal and defense (Figures A4 and A5), or when focusing on cycles up to sixteen or twelve years (Figures A6 and A7). This arises from the fact that most of the cyclicality in general government spending is driven by defense spending, consistent with the findings in Ramey (2011). I show this in Figure A8 Panel (a) where it is clear that the raw data on US federal spending is highly correlated with that of defense spending, while Panel (b) shows that the cyclical component of US general, federal and defense spending are highly correlated (under the CF filter). Furthermore, when comparing with the ROW cyclical component of government spending, it can be seen from Figure A10 that the US cyclical component is significantly more volatile than the ROW counterpart, which also arises from the strong

Figure 2: US Government Spending, Relative Government Debt, the RER and Net Trade Flows



Notes: Standard error bands are 68% confidence intervals in Panels (b) and (d). They are calculated using 80 quarters rolling windows, where the data is de-trended in each sub-sample using the CF filter.

An even stronger relationship with the RER is found when focusing on government debt, as shown in the introduction in Figure 1. Furthermore, Figure 2 Panel (c) presents the time series of the cyclical component of US federal spending (black solid line), and government debt in the US relative to the ROW (blue line with *o*). The Figure shows that US government spending leads the variation in relative government debt and that they are highly correlated as shown in Panel (d). This is consistent with government debt in the US being the primary instrument used to finance spending, with its stock evolving slowly over time in response to changes in spending.[26]

To summarize, US government spending is highly correlated with relative government debt, the RER and net trade flows, and it leads the variation among these variables. But, what explains the comovement among these variables? In order to provide an answer one needs to take a stand in establishing a causal relation. In the next section, I estimate a SVAR to isolate the effects of US government spending shocks. I show that this shock triggers conditional dynamics in line with the dynamic correlations documented in this Section, and that it drives a significant share of the variance of the RER and net trade flows.

4 The Effects of Government Spending Shocks

In this section, I present the empirical strategy to identify the effect of US government spending shocks, and the main empirical results, including the impulse responses and forecast error variance decomposition of this shock. Furthermore, I present evidence that imperfections in international financial markets are important for understanding the international propagation of this shock. Finally, I show that the results are robust to a variety of controls and alternative identification strategies.

military build-ups experienced by the US. The excess volatility of the US government spending component relative to the ROW, vanishes when focusing on the standard business cycle frequencies (Figure A11), i.e. cycles up to eight years, since shorter cyclicality misses the persistence of the US military build-ups.

[26] See Figure A9 for the path of US government debt.

4.1 Identification of Government Spending Shocks

To identify innovations to US government spending I follow the strategy in Ramey (2011, 2016a). The identification is based on Blanchard and Perotti (2002), which argues that, due to institutional features, the endogenous component of government spending takes at least one quarter to react to the state of the economy.[27] Under this assumption, ordering government spending first in the VAR and applying a Cholesky decomposition would identify the exogenous variation in government spending. However, Ramey (2011, 2016a) argues that the private sector might react in anticipation to the change in the exogenous component of government spending, for which it is necessary to control for the anticipation effects. To do so, I follow Ramey (2011, 2016a) and construct one-quarter ahead forecast errors of federal spending in the US, using data from the survey of professional forecasters available from the Federal Reserve Bank of Philadelphia.[28] Hence, applying the Cholesky decomposition to a VAR where the forecast error on federal spending is ordered first and the realized spending second, would identify the exogenous component of government spending while controlling for anticipation effects of the private sector. I estimate the following VAR model of the data,

$$Y_t = \Phi(L_h)Y_{t-1} + B\varepsilon_t$$

where the vector Y_t contains data on the US and the ROW aggregate and L_h is the lag operator. Specifically, the vector Y_t contains

$$Y_t' \equiv \left[FEG_t^{fed,us},\ g_t^{fed,us},\ g_t^{row},\ y_t - y_t^{row},\ inv_t - inv_t^{row},\ r_t - r_t^{row},\ NT_t,\ RER_t\right] \tag{1}$$

where $FEG_t^{fed,us}$ are the one quarter-ahead error forecast on US real federal spending, $g_t^{fed,usa}$ is US real federal government spending, g_t^{row} is real general government spending in the ROW, $y_t - y_t^{row}$ is relative real GDP between the US and ROW, $inv_t - inv_t^{row}$ is relative real investment between the US and ROW, $r_t - r_t^{row}$ the (long) real interest rate differential, NT_t is the US real export-import ratio, and RER_t the US trade-weighted real exchange rate. Alternatively, I replace

[27] For this reason it is preferred to focus on federal spending rather than state and local spending, since the latter is more discretionary, and to exclude transfers.

[28] I use the same measure as Ramey (2011), who shows that the professional forecasts Granger-cause the standard VAR shocks and are powerful instruments for federal spending for the period after 1970.

relative real investment by relative real consumption, $c_t - c_t^{row}$. Contrary to the standard practice in the literature, I include the ROW variables in my SVAR because it accounts for the state of the economy in the ROW and provides a better mapping with two-country general equilibrium models. Finally, following the literature the VAR is in log-levels.

To identify the unanticipated component of the innovations to US federal spending, I follow Ramey (2011, 2016a) and apply a Cholesky decomposition as explained before. Finally, I include a linear and quadratic trend, as it is standard in the literature, and control for four lags in the SVAR to deal with omitted variables (Galí, López-Salido and Vallés, 2007; Blanchard and Perotti, 2002; Ramey, 2011, 2016a; Forni and Gambetti, 2016). It is worth mentioning that the main results are robust to bulk of alternative controls and different identification strategies, including Blanchard and Perotti (2002) identification, and external instruments or Proxy SVARs (Mertens and Ravn, 2013; Ferrara et al., 2021), which I discuss in detail in Section 4.5.

4.2 Impulse Response Functions to Government Spending Shocks

Figure 3 presents the main impulse response functions to a positive shock to the one quarter-ahead forecast error on US federal spending.[29] First, the US government spending shock has only modest effects on its ROW counterpart. Secondly, the shock increases relative GDP on impact, but the effect is not persistent. Relative consumption slightly increases on impact, although it is not statistically significant, and later on presents a small fall below trend. The biggest effect is on relative investment, which shows that there is a strong crowding-out of US investment relative to the ROW. In Figure G.1, I present the IRFs of macro aggregates in dollars, where it can be observed that an impact effect of one dollar increase in US government spending, triggers a crowding-out of relative investment or around 1.5 dollars for approximately twenty quarters.

The strong fall in investment triggers a cycle of positive net trade flows. Furthermore, the RER experiences a depreciation cycle following a positive shock to US government spending. The real (long) interest rate differential increases on impact, consistent with the fact that the increase in spending is financed with government debt as will be shown later in this Section. After some

[29] The impulse responses are normalized so that the impact effect on US federal spending equals one percent.

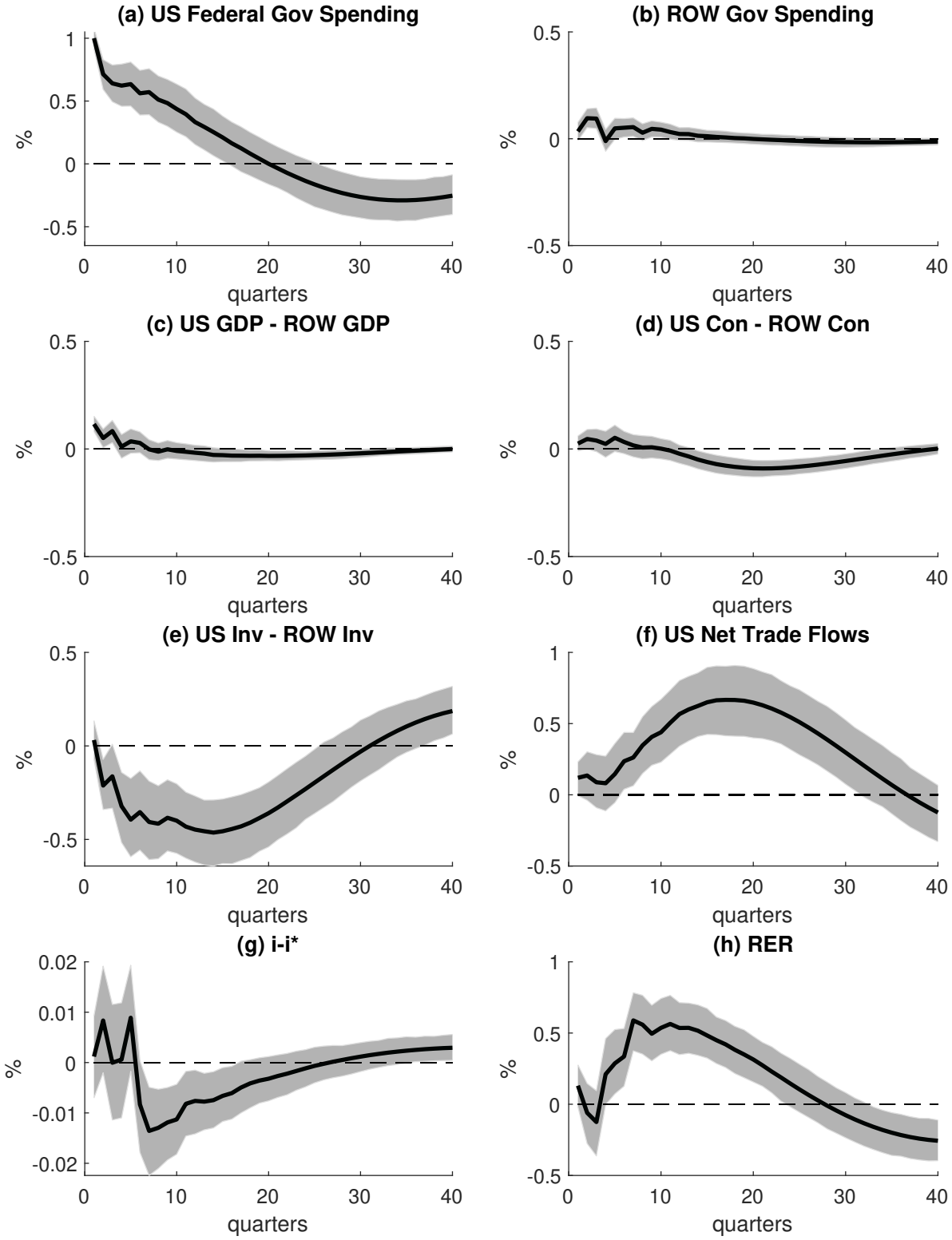


Figure 3: Impulse Response Functions to a Positive US Government Spending Shock

Notes: Standard error bands are 68% confidence intervals.

quarters, the interest rate differential falls below trend.

Overall, the results from the SVAR show that a positive innovation to US government spending triggers a strong crowding-out of relative investment, a cycle of positive net trade flows and a depreciation of the RER.

4.3 Quantifying the Importance of Shocks to Government Spending

The comovement between US government spending, net trade and the RER triggered by the government spending shock is consistent with the unconditional comovement among these variables documented in Section 3. This raises the question: to what extent the unconditional dynamics are driven by this shock? To provide an answer, I compute the contribution of the US government spending shocks to the forecast error variance of these variables, presented in Table 1. The first column presents the variables of interest. The second one, the contribution of the identified unanticipated shock to US government spending, while the third column shows the contribution of anticipated shocks to government spending. The sum of the contribution of the unanticipated and anticipated shock to US government spending is displayed in column 4. Finally, column 5 presents the contribution of the remaining (reduced form) innovations in the SVAR.

	Forecast Error US Gov	Anticipated US Gov	Total US Gov	Other Shocks
Interest Rate Differential	5	6	11	89
Relative GDP	7	4	11	89
Relative Consumption	13	8	21	79
Relative Investment	19	12	31	69
Net Trade	24	10	34	66
RER	24	9	33	67

Table 1: SVAR Error Forecast Variance Decomposition

The sum of the contribution of unanticipated and anticipated shocks to US government

spending accounts for 31% of the variance of relative investment, 34% of the variance of net trade, and 33% of the variance of the RER. Between 60% and 75% of the contribution of US government spending shocks is driven by the unanticipated component. Hence, shocks to US government spending are important drivers of net trade flows and the RER, consistent with the documented stylized facts in Section 3. This has not been pointed out in the literature and constitutes one of the contributions of this paper. In Section 4.5, I show that these results are robust to a variety of controls and specifications.

4.4 Evidence on Propagation Mechanisms

Having established that a positive shock to US government spending leads to a RER depreciation and increase in net trade, I focus on documenting empirical evidence on the transmission mechanisms. To do this, I extend the SVAR analysis to a broader set of variables. I present evidence suggesting that the interaction of government debt and frictions in international financial markets is relevant for the international transmission of government spending shocks.

Panel (a) in Figure 4, shows the response of the US federal government debt held by US agents (excluding government institutions), which increases significantly. Indeed, it is through increases in government debt that the US fiscal authority finances the increase in spending.[30] Panel (c) in Figure 4, shows the response of the UIP deviations, or excess return of US government bonds relative to ROW government bonds, while Panel (d) presents the one year cumulative UIP deviations.[31] In the short run there are negative UIP deviations, although the results are noisy due to the behavior of the UIP components in the initial periods (Figure 3). However, in the medium run there are positive UIP deviations, or expected excess returns on US government bonds relative to ROW government bonds. The existence of UIP deviations suggests the presence of imperfections in international financial markets, consistent with previous findings in the literature (Engel and West, 2005; Gabaix and Maggiori, 2015; Bacchetta et al., 2022). Moreover, Panel (b) shows that US agents increase their savings in foreign assets. This is opposite to what a frictionless

[30] Appendix B presents the response of other fiscal instruments. I find that marginal tax rates in general fall in response to this shock.

[31] The deviations from UIP are defined as, $UIP_t \equiv r_t^{us} - r_t^{row} - \mathbb{E}_t\left[\Delta e_{t+1}\right]$.

model would predict, hence being further evidence of financial market imperfections.[32]

In Appendix B, I also investigate the response of a broader set of variables. I show that the strongest adjustment in the international goods markets is in capital goods, shown in figure B.2. I find that there is a stronger crowding-out of net trade and deterioration of the terms of trade of capital goods than for the average of the goods. This is consistent with the increase in net trade flows arising from the sizable crowding-out of investment. Furthermore, I find that tax rates either do not change or they fall.[33] I also find that US Banks significantly increase their holdings of treasuries, and that they reduce loans to the private sector. Consequently, total credit to the private sector as a share of GDP falls. The nominal interest rate on corporate bonds rises and so does the bond premium (i.e. corporate bond yields relative to treasury yields).[34] Finally, I observe that the US price-dividend ratio falls and that there is an increase in the volatility of the financial sector, as measured by the VXO index.[35] These results suggests that risk in the US increases after the shock.

To summarize, I document that the increase in federal spending in the US has been financed mostly with debt. Furthermore, the UIP deviations and the increase in US gross foreign assets triggered by this shock suggest the presence of financial market imperfections. These results motivates the inclusion of a fiscal rule determining the response of government debt to increases in spending, and portfolio frictions in the quantitative model in Section 5. These are the two key features that allows the model to generate a depreciation of the RER and increase in net trade following a positive government spending shock.

[32] In frictionless models, increases in the supply of government bonds rises the interest rate so that agents are willing to hold these bonds. Consequently, the agents would decrease the holdings of other assets, such as foreign assets, until the returns across all assets are equalized. Hence, the frictionless model predicts a fall in gross foreign assets in response to an increase in the supply of government bonds. This is true under a first order log-linearized model, or certainty equivalent model. Under higher order approximations, changes in risk might generate an incentive to increase the foreign assets in response to the increase in the supply of home government bonds. However, the previous effect would still be present and most likely dominate due to its first order effects.

[33] While I do observe a weak increase in corporate taxes, other taxes actually fall.

[34] This is consistent with the findings in Krishnamurthy and Vissing-Jorgensen (2015).

[35] The VXO index measures the volatility in the financial market. It is highly correlated with the VIX, but available from 1986Q1, whereas the VIX data starts in 1990.

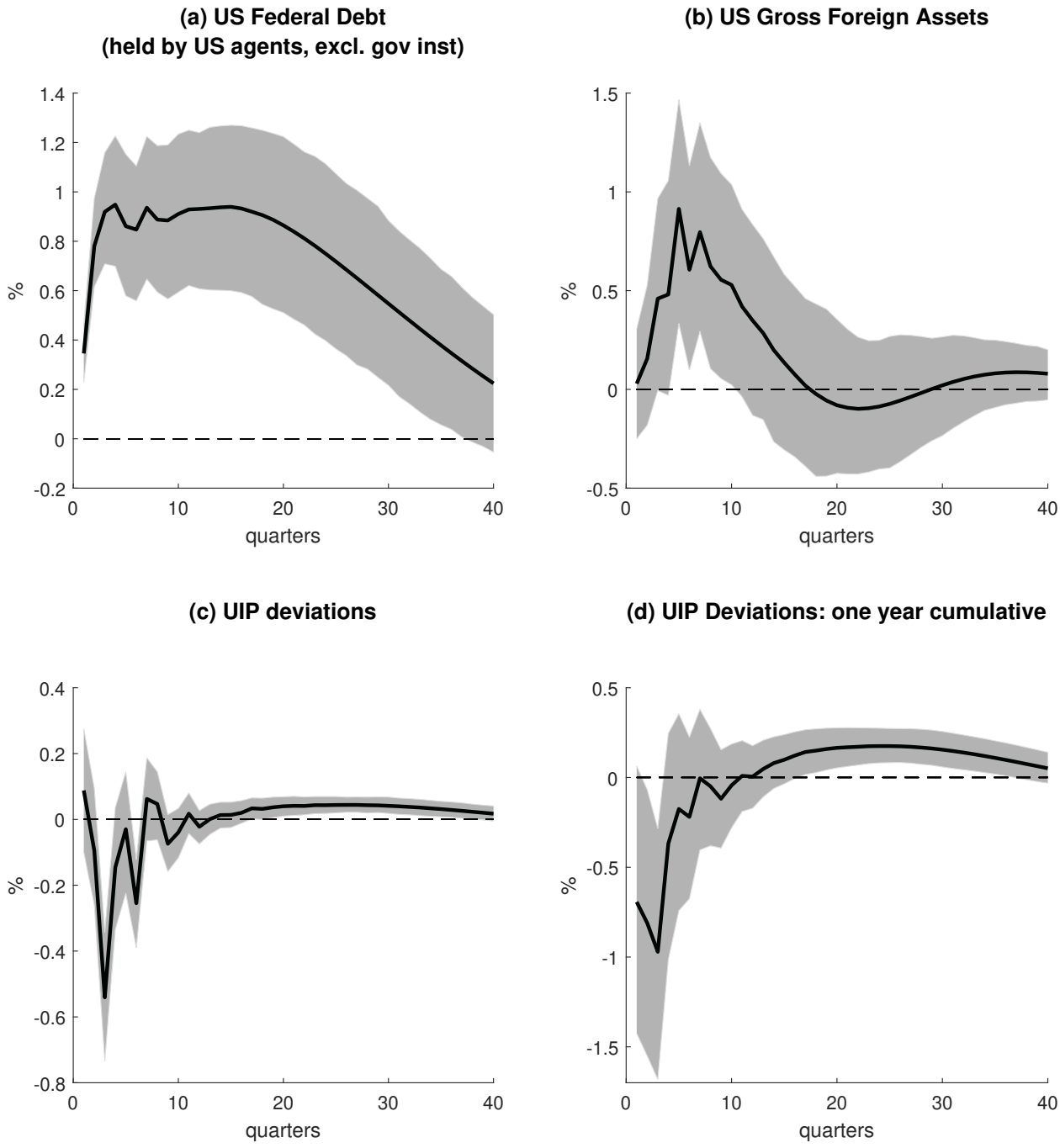


Figure 4: Impulse Response Functions to a Positive US Government Spending Shock: International Financial Markets

Notes: Standard error bands are 68% confidence intervals. The one-year cumulative UIP deviation in (d) is defined as $UIP_{t,t+4} \equiv \sum_{h=0}^{4} r_{t+h}^{us} - r_{t+h}^{row} - \mathrm{E}_t\left[\Delta e_{t+1+h}\right]$.

4.5 Robustness

I perform robustness analysis to a battery of controls, identification strategies, and also study the effect of tax shocks. All the details are presented in Appendix C. Overall, the main results are robust to these alternative specifications: in response to a positive US government spending shock the RER depreciates, the net trade flows increase and there is a strong crowding-out of relative investment. The contribution of this shock to the error forecasts variance of variables of interest is also similar across specifications. Finally, tax cuts in the US trigger increases in debt together with a depreciation of the RER and increase in net trade, similar to the dynamics triggered by government spending shocks.

The results are robust to including the following controls: (*i*) using the Price-Dividend ratio in the US to control for the possibility of US government spending reacting endogenously to expected changes in the economy, (*ii*) the inclusion of forecast errors of other macro aggregates to control for the potential correlation with forecasts of government spending, (*iii*) using the sample up to the great recession (1980Q1 to 2007Q4), (*iv*) long nominal interest rates, (*v*) short nominal interest rates, (*vi*) short real interest rates, (*vii*) using US general government spending from OECD, (*viii*) using US defense spending from NIPA, (*ix*) controlling for the US fiscal balance, (*x*) ordering ROW government spending first and US forecast error and government spending last to control for the possibility that innovations in the ROW drive the dynamics of government spending in the US, (*xi*) using only linear de-trend, and (*xii*) controlling for the possibility of anticipation effects of wars using the geopolitical risk index in Caldara and Iacoviello (2022).

Furthermore, the results are robust to the following alternative identification strategies: (*i*) Blanchard and Perotti (2002) and (*ii*) Ferrara et al. (2021) narrative SVAR identification.[36] This is important because it means that the results are robust to the main identification strategies developed in the literature. Lastly, I find similar results using tax shocks. Figures C.16 and C.17, show the responses to unanticipated tax cuts using the measure from Mertens and Ravn (2012) and to VAR shocks to federal tax rates, respectively.[37] In all these cases, tax cuts lead to increases

[36]Figure C.2 shows that the results obtained in the Proxy SVAR, which includes trends as it is the standard practice in the literature, are very similar to the Baseline specification. Figure C.3 shows that the results differ when one estimates the Proxy SVAR with no trends in the VAR.

[37]The VAR shocks to federal tax are from a VAR under Cholesky decomposition where the federal tax rate is

in government debt, depreciation of the RER and increase in net trade, consistent with the results obtained using government spending shocks.

5 Quantitative Model

In this section I present the quantitative model developed to rationalize the empirical evidence. The model is based on Backus et al. (1994) and Heathcote and Perri (2014), but departs in several dimensions. I also present the estimation of the model.

5.1 Two-Country Model: Fiscal Rules and Portfolio Frictions

I depart from the standard two-country international business cycle model in various aspects. First, I incorporate a fiscal rule that allows government spending, lump-sum taxes and government debt to respond endogenously to the state of the economy, together with shocks to government spending, similar to Leeper et al. (2010).[38] Second, the household can save in two assets, a home government bond and a foreign bond issued by the foreign household in foreign currency.[39] I assume that the household needs to pay a cost of deviating from the long-run portfolio share of foreign assets, similar to Guo et al. (2023) and Fukui et al. (2023), which generates endogenous deviations from UIP.

Following Boileau (1999) and Engel and Wang (2011), I model aggregate capital as a composite of domestic and imported capital, giving rise to trade in capital goods, and include trade frictions through adjustment costs in the use of imported to domestic inputs following Erceg, Guerrieri and Gust (2006). In each country there are three different retailers, for materials, consumption and investment goods, aggregating bundles of domestic and imported intermediate goods using a CES technology. The aggregators are heterogeneous in their home bias, to capture the average trade structure of the US economy. Finally, the model includes shocks to aggregate

ordered after the forecast error on federal spending, although results are almost unchanged if the federal tax rate is ordered first.

[38] To be precise, these are shocks to purchases of goods by the government, in line with the identified shocks in Section 4.

[39] The home household can borrow from the foreign household by issuing a bond in home currency.

TFP, the marginal cost of exporting (or iceberg trade cost shocks) as in Alessandria and Choi (2021) and Mac Mullen and Woo (2024), and to the long-run portfolio shares of foreign assets capturing differences in financial liberalization that give rise to exogenous deviations from UIP as in Itskhoki and Mukhin (2021a). The two countries are symmetric reflecting the US and the ROW economies. I present the model from the point of view of US agents.

5.1.1 Households

The representative household has balanced growth preferences and habits in consumption. She maximizes the discounted expected utility over consumption, C_t and labor, L_t,

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[\left(C_t - \phi C_{t-1} \right)^{\eta} \left(1 - L_t \right)^{1-\eta} \right]^{1-\sigma} - 1}{1-\sigma}$$

where $\phi \in [0, 1)$ determines the degree of habits in consumption, $\eta > 0$ and σ governs the risk-aversion. The flow budget constraint is given by

$$\begin{aligned} & P_t^c C_t + P_t^I I_{us,us,t} + \mathcal{E}_t P_t^{I^*} I_{row,us,t} + B_{t+1}^{g,us} P_t^{g,us} + \mathcal{E}_t B_{t+1}^{row,us} P_t^{row,us} + \mathcal{F}\left(B_{t+1}^{row,us}, \bar{S}_{t+1}^{us}; \psi_t^{us} \right) \\ & \leq W_t L_t + R_t^k K_t + \Pi_t^{us} - T_t^{us} + B_t^{g,us} + \mathcal{E}_t B_t^{row,us} + B_{t+1}^{us,row} P_t^{us,row} - B_t^{us,row} \end{aligned}$$

where P_t^c is the price index of the final consumption good in the US, P_t^I is the price index of the final investment good in the US, $I_{us,us,t}$ are the purchases of US investment goods, $P_t^{I^*}$ is the price index of the final investment good in the ROW denominated in ROW currency, $\mathcal{E}_t$ is the nominal exchange rate (NER) in terms of final consumption goods, where an increase in $\mathcal{E}_t$ is a depreciation of the US currency, $I_{row,us,t}$ are the purchases of ROW investment goods, K_t is aggregate capital in the US, $B_{t+1}^{g,us}$ are the holdings of US government bonds, P_t^g the price of this bonds, Π_t^{us} the aggregate profits of intermediate firms, and T_t are lump-sum taxes from the government.

The international asset block is given by two gross bonds. $B_{t+1}^{row,us}$ are the quantity of bonds purchased by the US household issued by the ROW household in ROW currency at period t and $P_t^{row,us}$ its price (i.e. $B_{t+1}^{row,us} > 0$ are the savings of US household in ROW bonds, or the US gross foreign assets). $B_{t+1}^{us,row}$ are the quantity of bonds purchased by the ROW household issued by

the US household in US currency at period t and $P_t^{us,row}$ its price (i.e. $B_{t+1}^{us,row} > 0$ is the amount borrowed by the US household from the ROW household, or the US gross foreign liabilities).

The function $\mathcal{F}\left(B_{t+1}^{row,us}, \bar{S}_{t+1}^{us}; \psi_t^{us}\right)$ captures frictions in international financial markets. In particular, it takes the following form,

$$\mathcal{F}\left(B_{t+1}^{row,us}, \bar{S}_{t+1}^{us}; \psi_t^{us}\right) = \frac{\Gamma}{2}\left(\frac{\mathcal{E}_t B_{t+1}^{row,us} P_t^{row,us}}{\bar{S}_{t+1}^{us}} - \frac{\mathcal{E}_{ss} B_{ss}^{row,us} P_{ss}^{row,us}}{\bar{S}_{ss}^{us}} \times e^{\psi_t^{us}}\right)^2 \times \bar{S}_{t+1}^{us} \tag{2}$$

where $\Gamma \geq 0$ governs the cost of adjusting the portfolio of gross foreign assets, $\bar{S}_{t+1}^{us} = \bar{B}_{t+1}^{g,us} P_t^{g,us} + \mathcal{E}_t \bar{B}_{t+1}^{row,us} P_t^{row,us}$ are the aggregate financial savings of the US household, and ψ_t^{us} are shocks to the long-run portfolio of foreign assets capturing changes in financial liberalization. In equilibrium, the cost depends on the portfolio share of foreign assets, $\frac{\Gamma}{2}\left(s_{t+1}^{row,us} - s_{ss}^{row,us} \times e^{\psi_t^{us}}\right)^2$, where $s_{t+1}^{row,us} \equiv \frac{\mathcal{E}_t B_{t+1}^{row,us} P_t^{row,us}}{S_{t+1}}$ and $s_{ss}^{row,us} \equiv \frac{\mathcal{E}_{ss} B_{ss}^{row,us} P_{ss}^{row,us}}{S_{ss}}$. The adjustment cost in equation 2 follows the specification in Guo et al. (2023) and Fukui et al. (2023). The main difference with Guo et al. (2023) and Fukui et al. (2023), is that the household does not internalize the effect on the aggregate financial savings, $\bar{S}_{t+1}^{us}$, in a similar fashion as Kekre and Lenel (2024b) treat aggregate holdings of assets in the preferences for assets in their model, to avoid mechanical changes in the stochastic discount factor. The main implication of this adjustment cost is that it reduces the elasticity of demand for foreign assets.[40] This friction also generates similar results as in the specification followed by Bacchetta et al. (2022) where in the cost is paid relative to the previous period portfolio share rather than the long-run share.[41] In sum, this portfolio re-balancing friction makes agents reluctant to deviate from their long-run portfolio share of foreign assets, relative to the frictionless case.

There are several reasons why agents face portfolio re-balancing costs. First, there is a growing literature on institutional investors that finds that investors face strict mandates in the allocation of wealth across different assets (Basak and Pavlova, 2013; Greenwood, Hanson and

[40] As will be shown later, assuming that the household does not internalize the effect on aggregate savings allows the model to generate a perfectly elastic demand for US government bonds and an inelastic demand for foreign assets, consistent with empirical findings in the literature.

[41] Another difference is that Bacchetta et al. (2022) solve for the optimal portfolio, which requires second and third order approximations, where in my case long-run portfolios are pinned down by the presence of $s_{ss}^{row,us}$ in $\mathcal{F}\left(s_{t+1}^{row,us}, s_{ss}^{row,us}\right)$ and by the the fiscal rule described later. This allows the model to capture the same average holdings of US government debt (held by US agents, excluding government institutions) and foreign assets as in the data.

Liao, 2018; Gabaix and Koijen, 2021; Bacchetta et al., 2022; Pavlova and Sikorskaya, 2022; Koijen and Yogo, 2024; Moretti, Pandolfi, Schmukler, Bauer and Williams, 2024). This type of frictions reduces the re-allocation of assets, and result in more inelastic demands. Second, increasing the holdings of domestic government bonds raises the exposure to domestic risk. It has been shown that inflation risk matters for the pricing of assets (Moerman and van Dijk, 2010). Moreover, in Appendix B I document that risk in the US increases after a positive government spending shock, since the VXO increases and the Price-Dividend ratio in the US falls. Higher risk in the US can tilt portfolios towards foreign assets to diversify the risk, making portfolio shares less volatile. Finally, the literature on household portfolios has documented the presence of sticky portfolios and behavioral biases, which generate hump-shape dynamics and reduce the elasticity of demand for assets (Brunnermeier and Nagel, 2008; Calvet, Campbell and Sodini, 2009; Alvarez, Guiso and Lippi, 2012; Chien, Cole and Lustig, 2012). To summarize, different microfoundations can generate portfolio dynamics similar to those induces by the portfolio friction in equation 2.

The presence of the portfolio friction affects the demand for foreign assets. To see this consider the FOCs of the US household for US government bonds and foreign assets,

$$1 = \beta \mathbb{E}_t \left[\Omega_{t+1} (1 + r_t^{g,us}) \right], \tag{3}$$

and

$$1 + \Gamma \left(s_{t+1}^{row,us} - s_{ss}^{row,us} \times e^{\psi_t^{us}} \right) = \beta \mathbb{E}_t \left[\Omega_{t+1} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} (1 + r_t^{row,us}) \right], \tag{4}$$

where equation 3 is the demand for US government bonds, and equation 4 is the demand for foreign assets, Ω_{t+1} is the stochastic discount factor, and $(1 + r_t^{g,us}) \equiv 1/P_t^{g,us}$ and $(1 + r_t^{row,us}) \equiv 1/P_t^{row,us}$. The portfolio friction induces an inelastic demand for foreign bonds, through the presence of the second term on the left hand side of the equation, while keeping a perfectly elastic demand for US government bonds. This is consistent with empirical findings showing that the demand for US government bonds is more elastic than for other classes of assets, and close to perfectly elastic.[42]

[42] If alternatively the household internalizes the effect on aggregate savings, S_{t+1}, then the demand for government bonds would also have an extra term making this demand more inelastic. The results of the quantitative model are almost the same in this case, except for counterfactual dynamics interest rate on government bonds. Since the

Using the demand for foreign assets it is useful to derive the partial equilibrium aggregate demand elasticity of internationally traded bonds, since this elasticity would be informative to identify the size of the adjustment cost Γ. The following Proposition shows this result.

Proposition 1 (Identification of Γ)**.** *The partial equilibrium aggregate demand elasticity for the ROW bond ($\epsilon^d_{b^{row,us}}$) is given by,*

$$\frac{\partial(\beta \hat{B}^{row,us}_{t+1})}{\partial \hat{R}^{row,us}} = \frac{\beta(1+\Gamma \bar{s}^{row,us})}{\Gamma \bar{s}^{row,us}} = \epsilon^d_{b^{row,us}}$$

where $\bar{s}^{row,us}$ is the steady state share of savings in ROW bonds.

Hence, the value of Γ *consistent with micro estimates of $\epsilon^d_{b^{row,us}}$ is,*

$$\Gamma = \frac{\beta}{\bar{s}^{row,us}(\epsilon^d_{b^{row,us}} - \beta)}$$

The formal proof is in Appendix D. This result shows a clear mapping between the portfolio adjustment cost Γ, the discount factor (β), the steady state share of savings in ROW bonds ($\bar{s}^{row,us}$), and the partial equilibrium aggregate demand elasticity of internationally traded bonds ($\epsilon^d_{b^{row,us}}$). Hence, the portfolio adjustment cost can be externally disciplined by using empirical estimates of the partial equilibrium aggregate demand elasticity of internationally traded bonds. Koijen and Yogo (2024) estimate this elasticity by exploiting the cross-section of global investors. They find a value of the partial equilibrium aggregate demand elasticity of 2.1.[43]. This together with a discount factor of 0.99, and an average share of savings in ROW bonds of 0.61 in the US, gives a value of the portfolio adjustment cost, Γ, of 1.462. This is the value used in the Benchmark model, where the estimation of the full model is discussed in Section 5.2.

The presence of this friction affects the propagation of fiscal shocks by breaking Ricardian equivalence (Barro, 1974).[44] Suppose that the US government changes the composition of financ-

demand for government bonds would be too inelastic, the interest rate would be too sensitive to changes in the economy, resulting in counterfactual IRFs of interest rates, which is shown in Section 7.

[43]This value corresponds to the long-term debt, which I map to the model since most of the increase in US government debt has been long-term.

[44]To clarify, the model features another source of deviation from Ricardian equivalence arising from the endogenous response of government expenditure to changes in deviations from the steady state level of debt as shown later. Assume for now that this other source of deviation from Ricardian equivalence is shut down.

ing its expenditure by reducing the lump-sum taxes and increasing the supply of government bonds, for a given path of government expenditure. If Γ is zero, Ricardian equivalence holds, and there is no effect in the aggregate of the US economy, so net trade flows and the RER are unaffected. Consider now the case of $\Gamma > 0$. If there is an increase in the supply of government bonds, a value of $\Gamma > 0$ generates an incentive for the US household to also increase their savings in foreign (gross) assets, to smooth the cost of deviating from the long-run portfolio, since the change in the supply of government bonds affects the portfolio cost through changes in $\bar{S}^{us}_{t+1}$. The response of US gross foreign assets is increasing in the value of Γ, and for a sufficiently high cost the US will save against the ROW, in which case the net trade flows will increase. Furthermore, the presence of $\Gamma > 0$ affects the equilibrium response of the RER through UIP deviations.

To see the role of Γ, consider the first order log-linearized UIP condition,

$$r^{g,us}_t - r^{g,row}_t - \mathbb{E}_t\left[\Delta e_{t+1}\right] = \Gamma \bar{s}^{g,us}\left(s^{g,us}_{t+1} - \bar{s}^{g,us}\right) + \Gamma(1-\bar{s}^{g,us})\psi^{us}_t \tag{5}$$

where $\bar{S}^{us}$ is the value of total financial savings in the US in steady state, s^{g}_{t+1} the portfolio share of US government bonds between t and $t+1$, and $\bar{s}^{g,us}$ the steady state portfolio share of US government bonds.[45] There are two sources of UIP deviations. The first term in the right hand side captures the endogenous deviations of UIP arising from the portfolio frictions, and the second term the exogenous deviations arising from shocks to long-run portfolios, capturing the UIP shock in Itskhoki and Mukhin (2021a).

By rolling forward equation 5, I can derive an expression for the transitory component of the exchange rate, given by

$$e_t = -\mathbb{E}_t \sum_{j=0}^{\infty}\left(r^{g,us}_{t+j} - r^{g,row}_{t+j}\right) + \Gamma \bar{s}^{g,us}\mathbb{E}_t \sum_{j=0}^{\infty}\left(s^{g}_{t+1+j} - \bar{s}^{g}\right) + \Gamma(1-\bar{s}^{g,us})\mathbb{E}_t \sum_{j=0}^{\infty}\psi^{us}_{t+j} \tag{6}$$

so that the exchange rate depreciates in response to: (*i*) a fall in the sum of expected future (transitory) interest rate differentials, (*ii*) an increase in the sum of expected future (transitory) portfolio share differentials of government bonds, (*iii*) an increase in the sum of the exogenous UIP wedge. The second term on the right hand side explicitly indicates how the presence of port-

[45] The portfolio share of government bonds is defined as $s^{g,us}_{t+1} \equiv \frac{B^{g,us}_{t+1} P^{g,us}_t}{S_{t+1}}$, or $s^{g,us}_{t+1} = 1 - s^{row,us}_{t+1}$.

folio adjustment costs affect the propagation of shocks in the economy by linking the response of the portfolio shares to the exchange rate determination. This equation shows that the exchange rate would depreciate in response to a government spending shock through the portfolio channel if the share of savings in US government bonds increases sufficiently. This implies that the fiscal rule, determining the response of government debt, has implications for the exchange rate determination by inducing deviations of UIP when $\Gamma > 0$. Indeed, I argue that the fiscal rule is a key feature needed to capture the empirical IRF of the RER to the US government spending shock. In Section 6, I show quantitatively how the fiscal rule and the portfolio frictions shape the international adjustment to a government spending shock.

Next, the US household purchases capital goods from US retailers, $I_{us,us,t}$, and from foreign retailers, $I_{row,us,t}$. Capital accumulation is country specific as in Boileau (1999) and Engel and Wang (2011), and follows the law of motion,

$$K_{us,us,t+1} = (1-\delta)K_{us,us,t} + I_{us,us,t} \times \left[1 - \frac{\kappa}{2}\left(\frac{I_{us,us,t}}{I_{us,us,t-1}} - 1\right)^2\right],$$

and

$$K_{row,us,t+1} = (1-\delta)K_{row,us,t} + I_{row,us,t} \times \left[1 - \frac{\kappa}{2}\left(\frac{I_{row,us,t}}{I_{row,us,t-1}} - 1\right)^2\right],$$

where the parameter κ governs the adjustment cost of investment following Christiano, Eichenbaum and Evans (2005). $K_{us,us,t+1}$ is the stock of US capital good accumulated by the US household, and $K_{row,us,t+1}$ the stock of ROW capital good accumulated by the US household. Aggregate capital in the US (used for production of intermediate goods) is a CES composite of domestic and imported stock of capital,

$$K_t = \left[(1-\gamma_k)^{\frac{1}{\rho_k}} K_{us,us,t}^{\frac{\rho_k-1}{\rho_k}} + \gamma_k^{\frac{1}{\rho_k}} \left(\varphi_t^k K_{row,us,t}\right)^{\frac{\rho_k-1}{\rho_k}}\right]^{\frac{\rho_k}{\rho_k-1}}$$

where $(1-\gamma_k)$ is the home bias in capital goods, ρ^k the long-run Armington elasticity, and φ_{t+1}^k is an adjustment cost as in Erceg et al. (2006) given by

$$\varphi_{t+1}^k = \left[1 - \frac{\iota^k}{2}\left(\frac{K_{row,us,t+1}/K_{us,us,t+1}}{K_{row,us,t}/K_{us,us,t}} - 1\right)^2\right]$$

where $\iota^k \geq 0$ measures the adjustment cost. A higher adjustment cost (ι^k) makes domestic and foreign capital more complementary in the short run, triggering a differential short and long run elasticity of trade in capital goods.

The problem of the US Household is to maximize the expected life-time utility subject to the budget constraint, the capital accumulation equations, the CES aggregator of capital and the adjustment cost in the CES. The Real Exchange Rate is defined in units of the final consumption good,

$$\mathcal{Q}_t = \mathcal{E}_t \frac{P_t^{c^*}}{P_t^c}$$

5.1.2 Retailers

In each country there are three representative retailers, one for consumption goods, one for investment goods and one for materials. Denote the retailer by $X \in \{C, I, M\}$. These retailers aggregate bundles of domestic and imported varieties from,

$$Y^x_{us,us,t} = \left(\int_0^1 y^x_{us,us,t}(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} \qquad Y^x_{row,us,t} = \left(\int_0^1 y^x_{row,us,t}(j)^{\frac{\hat{\theta}_t-1}{\hat{\theta}_t}} dj \right)^{\frac{\hat{\theta}_t}{\hat{\theta}_t-1}}$$

where $\hat{\theta}_t = \theta \mathcal{Q}_t^{\zeta}$ is a reduced form pricing-to-market friction as in Alessandria and Choi (2021), Mac Mullen and Woo (2024) and Kekre and Lenel (2024a). The CES aggregators of retailers are given by

$$Y^x_t = \left[(1-\gamma^x)^{\frac{1}{\rho^x}} \left(Y^x_{us,us,t} \right)^{\frac{\rho^x-1}{\rho^x}} + \gamma^{x\,\frac{1}{\rho^x}} \left(\varphi^x_t Y^x_{row,us,t} \right)^{\frac{\rho^x-1}{\rho^x}} \right]^{\frac{\rho^x}{\rho^x-1}}$$

and

$$\varphi^x_t = 1 - \frac{\iota^x}{2} \left(\frac{Y^x_{row,us,t}/Y^x_{us,us,t}}{Y^x_{row,us,t-1}/Y^x_{us,us,t-1}} - 1 \right)^2$$

where $(1-\gamma^x)$ is the home bias of good X, ρ^x is the long-run Armington elasticity and φ^x is an adjustment cost in the use of imported to domestic intermediates. The problem of the retailer X is given by

$$\max_{\{Y^x_{t+k}, Y^x_{us,us,t+k}, Y^x_{row,ust+k}\}} E_t \sum_{k=0}^{\infty} \beta^k \Omega_{t+k} \left(P^x_{t+k} Y^x_{t+k} - P^x_{us,us,t+k} Y^x_{us,us,t+k} - P^x_{row,us,t+k} Y^x_{row,us,t+k} \right)$$

subject to the CES aggregator and adjustment cost φ^x, where Ω_{t+k} is the US Household stochastic discount factor and $P^x_{us,us,t}$ and $P^x_{row,us,t}$ are ideal price indexes of bundles of varieties. The FOCs yield the demand functions

$$P^x_t \frac{\partial Y^x_t}{\partial Y^x_{us,us,t}} + \beta E_t \left(\Omega_{t+1} P^x_{t+1} \frac{\partial Y^x_{t+1}}{\partial Y^x_{us,us,t}} \right) = P^x_{us,us,t} \quad \text{and} \quad P^x_t \frac{\partial Y^x_t}{\partial Y^x_{row,us,t}} + \beta E_t \left(\Omega_{t+1} P^x_{t+1} \frac{\partial Y^x_{t+1}}{\partial Y^x_{row,us,t}} \right) = P^x_{row,us,t}$$

The ideal price index of final good X in the US is $P^x_t = \left[(1-\gamma^x) \left(P^x_{us,us,t} \right)^{1-\rho^x} + \gamma^x \left(P^x_{row,us,t} \right)^{1-\rho^x} \right]^{\frac{1}{(1-\rho^x)}}$.

The consumption good retailer sells to the US household and the US government, so that its revenue is given by $P^c_t \left(C_t + G^c_t \right)$, were C_t is the US household purchases of US consumption goods and G^c_t the US government purchases of the US consumption good. The investment good retailer sells to the US household, the ROW household and the US government, so that its revenue is given by $P^I_t \left(I_{us,us,t} + I_{us,row,t} + G^I_t \right)$. Here $I_{us,us,t}$ are the US household purchases of US investment goods, $I_{us,row,t}$ the ROW household purchases of US investment goods, and G^I_t the US government purchases of US final investment good. Finally, the materials retailer only sells domestically, so that its revenue is given by $P^M_t (M_t)$, where M_t are the purchases of materials.

5.1.3 Intermediate Firms

Home output is produced under monopolistic competition. Since in equilibrium all varieties are the same I omit the subscript j indexing each firm and present the problem for a single firm. The intermediate firm faces a Cobb-Douglas production function,

$$Y^{us}_t = e^{z^{us}_t} \left(K^{\alpha}_t L^{1-\alpha}_t \right)^{\eta} M^{1-\eta}_t$$

where α is the capital share of income, η the share of materials in total expenditure and z^{us}_t is the aggregate productivity in the US.

The firm maximizes profits in the US and ROW markets by setting $P^x_{us,us,t}$ and $P^x_{us,row,t}$ subject to demands and resource constraint $Y^{us}_t = \sum_{x \in \{C,I,M\}} \left(Y^x_{us,us,t} + Y^x_{us,row,t} e^{\xi^{us}_t} \right)$, where ξ^{us}_t is an stochastic

iceberg trade cost.[46] Profits are given by

$$\Pi_t^{us} = \sum_{x\in\{C,I,M\}} \left(P^x_{us,us,t} - MC_t\right) Y^x_{us,us,t} + \sum_{x\in\{C,I,M\}} \left(P^x_{us,row,t} - MC_t\right) Y^x_{us,row,t}$$

The solution to this problem is characterized by the optimal price setting, which is a markup over the marginal cost,

$$P^x_{us,us,t} = \frac{\theta}{\theta-1} MC_t \quad \text{and} \quad \mathcal{E}_t P^x_{us,rowt} = e^{\xi^{us}_t} \frac{\hat{\theta}}{\hat{\theta}-1} MC_t$$

where $\mathcal{E}_t$ is the NER, and by demands for factors of production,

$$W_t L_t = (1-\eta)(1-\alpha) MC_t Y_t^{us}; \quad R_t^k K_t = (1-\eta)\alpha MC_t Y_t^{us}; \quad P_t^M M_t = \eta MC_t Y_t^{us}$$

where MC_t is the marginal cost of production, given by

$$MC_t = \frac{\left[e^{-z_t^{us}} \left(R_t^k\right)^{\alpha} (W_t)^{1-\alpha})^{(1-\eta)}\right] \left(P_t^M\right)^{\eta}}{\eta^{\eta}\left[(1-\eta)\alpha^{\alpha}(1-\alpha)^{1-\alpha}\right]^{1-\eta}}$$

5.1.4 Fiscal Rule

I focus on the federal government in the US to be consistent with the empirical evidence documented in Sections 3 and 4. The US government purchases consumption and investment goods from local retailers, G_t^c and G_t^I respectively. To finance its expenditures, the US fiscal authority uses a combination of lump-sum taxes, T_t, and debt, $\hat{B}^{g,us}_{t+1}$. The budget constraint of the US government is given by,

$$T_t + P_t^{g,us} \hat{B}^{g,us}_{t+1} = P_t^c G_t^c + P_t^I G_t^I + \hat{B}^{g,us}_t$$

Lump-sum taxes and government spending follows a rule similar to the one adopted by Leeper et al. (2010).[47] Lump-sum taxes are used in the steady state to finance government purchases of con-

[46] The iceberg trade cost is not good specific. Trade in capital goods is also subject to the same iceberg trade cost. This induces a wedge in the law of one price of the investment goods, i.e. $P_t^I = (1/\mathcal{E}_t)\hat{P}_t^I \xi_t^{us}$.

[47] In my case I do not considering distortionary taxation, since I do not observe an increase in taxes in response to a US government spending shock in the SVAR analysis. Moreover, since the presence of distortionary taxation would not affect UIP deviations directly, its effect on the international adjustment to shocks to government spending

sumption and investment goods, denoted by μ_{ss}^{g}, and the interest payments on debt, denoted by μ_{ss}^{b}. Outside the steady state, lump-sum taxes are allowed to respond endogenously to deviations in interest payments on debt according to the rule,

$$T_t = \mu_{ss}^{g} + \mu_{ss}^{b} + \varphi^{T,b}\left(P_t^{g,us}\hat{B}_{t+1}^{g,us} - \mu_{ss}^{b}\right)$$

where $\varphi^{T,b}$ governs the response of lump-sum taxes to deviations in interest payments of debt from the steady state. Finally, the evolution of US government spending has a stochastic and an endogenous component,

$$\hat{g}_t^{us} = \varphi^{G,b}\left(P_{t-1}^{g,us}\hat{B}_t^{g,us} - \mu_{ss}^{b}\right) + \rho_g^{us}\hat{g}_{t-1}^{us} + \sigma_g^{us}\varepsilon_{g,t}^{us} \quad \text{with} \quad \varepsilon_{g,t}^{us} \sim N(0,1)$$

where $\varphi^{G,b}$ is the endogenous response of government spending to deviations from steady state debt payments, ρ_g^{us} governs the persistence of the process, σ_g^{us} the size of the shock, and $\varepsilon_{g,t}^{us}$ is *iid* across time.

Government spending in consumption and investment goods, evolve according to

$$G_t^c = \mu_{ss}^{G_c} \times e^{\hat{g}_t^{us}} \quad \text{and} \quad G_t^I = \mu_{ss}^{G_I} \times e^{\hat{g}_t^{us}}$$

where $\mu_{ss}^{G_c}$ and $\mu_{ss}^{G_I}$ capture the average share of government spending in consumption and investment goods, respectively. The log of real federal government spending is defined as,

$$g_t^{fed,us} \equiv \ln\left(G_t^c + G_t^I\right)$$

5.1.5 Other Shock Processes

The other stochastic processes for $i \in \{US, ROW\}$ are given by $\Phi \in \{z, \psi, \xi\}$: total factor productivity (z_t^i), the long-run portfolio shock (ψ_t^i), and the trade cost (ξ_t^i). I assume that the stochastic process have a common and a differential component following Alessandria and Choi (2021). That

in the model would be negligible.

is

$$\begin{bmatrix} \Phi_t^{us} \\ \Phi_t^{row} \end{bmatrix} = \begin{bmatrix} \Phi_t^c + \Phi_t^d/2 \\ \Phi_t^c - \Phi_t^d/2 \end{bmatrix}$$

where

$$\begin{aligned} \Phi_t^c &= \mu_\Phi^c \times (1-\rho_\Phi^c) + \rho_\Phi^c \times \Phi_{t-1}^c + \varepsilon_{\Phi t}^c & \varepsilon_{\Phi t}^c &\sim N(0,\sigma_\Phi^c) \\ \Phi_t^d &= \rho_\Phi^d \times \Phi_{t-1}^d + \varepsilon_{\Phi t}^d & \varepsilon_{\Phi t}^d &\sim N(0,\sigma_\Phi^d) \end{aligned}$$

where Φ_t^c and Φ_t^d are the common and differential components. I assume that $\mu_\Phi^c = 0$ for all processes, except TFP (where I choose the mean of the process to normalize steady state GDP to 1). Finally, trade costs have only a differential component, i.e. $\xi_t^c = 0 \forall t$, following Mac Mullen and Woo (2024). Finally, all innovations are assumed to be uncorrelated with each other.

5.1.6 Market Clearing and Country Budget Constraint

The US consolidated budget constraint is obtained by combining the US Household budget constraint with the US government budget constraint and the profits of US intermediate firms. The consolidated US budget constraint is given by,

$$\mathcal{E}_t \left(\frac{B_{t+1}^{row,us}}{R_t^{row,us}} - B_t^{row,us} \right) - \left(\frac{B_{t+1}^{us,row}}{R_t^{row,us}} - B_t^{us,row} \right) = NX_t - \frac{\Gamma}{2} \left(s_{t+1}^g - s_{ss}^g \times e^{\psi_t^{us}} \right)^2$$

where NX_t are net exports and given by

$$NX_t \equiv \sum_{x \in \{C,I,M\}} \left(\mathcal{E}_t P_{us,us,t}^x Y_{us,us,t}^x - P_{row,us,t}^x Y_{row,us,t}^x \right) + \left(P_t^I I_{us,row,t} - \mathcal{E}_t P_t^{I^*} I_{row,us,t} \right)$$

The summation term captures the trade balance in intermediate goods, and the second term the net trade in capital goods.

Market clearing in bonds markets requires that at all t,

$$\hat{B}^{g,us}_{t+1} = B^{g,us}_{t+1} \quad ; \quad \hat{B}^{g,row}_{t+1} = B^{g,row}_{t+1} \quad ; \quad B^{us,row}_{t+1} = \hat{B}^{us,row}_{t+1} \quad ; \quad B^{row,us}_{t+1} = \hat{B}^{row,us}_{t+1}$$

where $\hat{B}^{g,row}_{t+1}$ and $B^{g,row}_{t+1}$ are the supply and demand of ROW government bonds by the ROW government and ROW household respectively, $\hat{B}^{us,row}_{t+1}$ the demand of US assets from ROW household, and $\hat{B}^{row,us}_{t+1}$ the supply of ROW assets from ROW households.

Finally, the foreign country budget constraint is satisfied by Walras Law.

5.2 Estimation

In this section, I describe the estimation procedure and discuss the identification strategy. I define two sets of parameters. I set the parameters in the first set externally, and estimate those in the second set using Simulated Method of Moments (SMM). Table 2 presents the parameters of the first group, and Tables 3 and 4 the moments and parameters estimated in the SMM procedure.

The first group includes parameters that are quite standard and others that deserve more discussion. In particular, I choose the home bias in the four CES aggregators to match the average structure of trade in the US between 1980 and 2019. That is, a trade-to-GDP ratio of 21%, a share of material goods in trade of 29%, a share of consumption goods in trade of 39%, and a share of capital goods in trade of 32%.[48,49] Furthermore, I target a steady value of US gross foreign assets to GDP of 0.79 and a portfolio share of US government bonds of 0.39, to be consistent with the average values in the US between 1980 and 2019.[50]

[48] I use the classification in NIPA to define trade in capital goods. I use the category 'Capital goods, except automotive', and split the category 'Automotive vehicles, engines, and parts' into capital goods and consumption goods. Since I do not observe directly within the last category how much is trade in capital goods, I estimate it using the shares from Erceg, Guerrieri and Gust (2008), who has data on this decomposition for the year 2004. Their average share of capital goods trade within this category is 0.135. This gives a share of trade in capital goods in my data of 32%, close to the value in Erceg et al. (2008) data of 36%, and 46% in Engel and Wang (2011) who only focuses on durable goods.

[49] In the model imports of capital goods are composed by the bundles of imported goods in the capital and investment aggregators. Since I do not have data to distinguish the shares accounted for by the two aggregators I split them in half.

[50] I map the holdings of US government bonds by US households in the model to the holdings of US government bonds by US agents net of the holdings of US government institutions in the data. I use the gross foreign assets in the data as my measure in the model. The results are similar if I consider the US gross foreign assets net of the claims

I target a steady state ratio of US federal government spending to GDP of 0.085, the avergae in the sample period, and a share of government spending in consumption goods to government spending of 75%. I set the volatility of the US government spending shock to match the impact effect of the US government spending impulse response from the SVAR. I use a value for habits in consumption of 0.80 from Devereux, Engel and Wu (2023). I set the adjustment cost of investment to 10.31, the value estimated in Bodenstein, Cuba-Borda, Gornemann, Presno, Prestipino, Queralto, and Raffo (2023). Finally, the portfolio adjustment cost is set to match the partial equilibrium aggregate demand elasticity for internationally traded bonds, as shown in Proposition 1, which gives a value of 1.462.

Parameter		Value	Target Moment
Mean common TFP	μ_z^c	3.5	Normalize GDP to 1
Discount factor	β	0.99	Annual interest rate of 4%
Risk aversion	σ	2	Intertemporal elasticity of substitution of .5
Weight on labor	ϱ	0.29	Hours worked of 1/3
Materials Share	η	0.50	Intermediate input share of 0.5 of expenditure
Capital share	α	0.36	Capital share in value added
Depreciation rate of capital	δ	0.025	standard
Elasticity of substitution across varieties	θ	4	Producer markup of 33%
Steady State Portfolio Gov Bonds	s_{ss}^g	0.39	Portfolio share of US gov bonds to foreign assets of 0.39
Steady State Gross Financial Flows	B^{ss}	0.798	Ratio of (value of) US foreign assets to GDP of 0.79
Portfolio adjustment cost	Γ	1.462	PE aggregate asset demand elasticity of 2.1 (Koijen and Yogo, 2024)
Consumption habits	ϕ	0.80	Devereux et al. (2023)
Investment adjustment cost	κ	10.31	Bodenstein et al. (2023)
Armington elasticity intermediate goods	$\rho^c = \rho^I = \rho^m$	1.5	standard
Armington elasticity final K goods	ρ^k	9.1	Engel and Wang (2011)
Home bias in aggregators	γ^I	0.056	i. Trade-to-GDP ratio of 21%
	γ^m	0.030	ii. Share of Materials in US Trade 29%
	γ^c	0.058	iii. Share of Consumption in US Trade 39%
	γ^k	0.065	iv. Share of Capital in US Trade 32%
Steady State gov expenditure	$\mu_{ss}^{G_k}$	0.0212	i. Share of US federal government spending over GDP of 0.085%
	$\mu_{ss}^{G_c}$	0.0638	ii. Share of US government consumption goods of 75%
Std US gov spending shock	σ_g^{us}	0.011	impact effect US gov spending IRF

Table 2: Externally Calibrated Parameters

The moments used in the SMM estimation are displayed in Table 3, and the estimated pa-

on foreign government bonds for the period for which I have quarterly data on the components of US gross foreign assets (1980Q1-2004Q4) (Gourinchas and Rey, 2007).

rameters with their standard errors in Table 4. The parameters include those related to shock processes, adjustment costs, the endogenous response of the fiscal rule to the state of the economy, and the pricing-to-market friction. To simplify the estimation, I assume that the adjustment costs in the CES aggregators are all the same ($\iota = \iota^c = \iota^I = \iota^m = \iota^k$). The moments include a subset of the empirical IRFs estimated in Section 4, and unconditional moments chosen to capture a broad set of international business cycle moments, including those of the net trade and the RER. Hence, my identification strategy targets a combination of conditional and unconditional moments.[51] To estimate the unconditional moments, I filter the data using the Christiano and Fitzgerald (2003) filter (henceforth CF filter), to capture cyclicality up to twenty years.[52,53] This allows to capture the unconditional variation of the US government spending, net trade and RER documented in Section 3.1.

In total there are 15 parameters and 122 moments (Table 4 displays the parameters, and Table 3 the target moments).[54] Out of 122 moments, 98 correspond to IRF moments, and the remaining 24 are unconditional moments. Since I have more moments than parameters, I weight the moments according to the inverse of their variance. Similar to Christiano et al. (2005), let τ denote the vector of parameters, $\mathbf{\Psi}(\tau)$ the mapping from τ to model moments, and $\hat{\mathbf{\Psi}}$ the corresponding empirical estimates. Then the estimator τ is the solution to

$$J = \min_{\tau} [\hat{\mathbf{\Psi}} - \mathbf{\Psi}(\tau)]' \mathbf{V}^{-1} [\hat{\mathbf{\Psi}} - \mathbf{\Psi}(\tau)]$$

where $\mathbf{V}$ is diagonal matrix with sample variances of $\hat{\mathbf{\Psi}}$'s along the diagonal.[55]

[51] Targeting a combination of conditional and unconditional moments is a strategy also followed by Winberry (2021) and Fukui et al. (2023).

[52] There are three moments that I estimate without the CF filter. These are the short and long-run trade elasticity to prices from an error correction model, and the coefficient on the interest rate differential in the Fama (1984) regression.

[53] The results are robust to using linear, quadratic or cubic de-trend, or the band-pass filter. For more details on the filtering see Appendix A.1

[54] I set the volatility and persistence of the differential TFP process to zero, since the estimation pushed towards a very limited effect of this process. This is driven by the high comovement between GDP in the US and ROW at this frequency, as shown in Figure A10 Panel (a).

[55] The variances of the IRF moments are the confidence intervals at each horizon following Christiano et al. (2005), and for the unconditional moments these are the variances across rolling window estimations.

I. SVAR IRFs	$\{g_h^{us},\ P_h^{g,us}\ B_h^{g,us}\}$, for $h = 1, ..., 40$
	$\{rer_h,\ nt_h\}$, for $h = 1, 4, 8, 12, 16, 20, 24, 28, 32$
II. Standard business cycle moments	$\sigma(gdp^{us})$; $\rho(gdp^{us}, gdp^{row})$; $\frac{\sigma(g^{us})}{\sigma(gdp^{us})}$;
	$\frac{\sigma(g^{row})}{\sigma(gdp^{us})}$; $\rho(g^{row})$
III. International quantities and prices	$\frac{\sigma(rer)}{\sigma(gdp^{us})}$; $\frac{\sigma(nt)}{\sigma(gdp^{us})}$; $\frac{\sigma(tot)}{\sigma(gdp^{us})}$;
	$\rho(rer)$; $\rho(nt)$
	Short-Run Trade Elasticity (ECM);
	Long-Run Trade Elasticity (ECM)
IV. Financial variables	$\frac{\sigma(gfa^{us})}{\sigma(gdp^{us})}$; $\frac{\sigma(B^{g,us})}{\sigma(gdp^{us})}$; $\frac{\sigma(s^{g,us})}{\sigma(gdp^{us})}$; $\frac{\sigma(i^{us}-i^{row})}{\sigma(gdp^{us})}$
	$\rho(s^{g,us})$; $\rho(i^{us} - i^{row})$; β^{Fama}
	$\rho(B^{g,us} - B^{g,row}, rer)$
V. US gov spending and macro variables	$\rho(g_t^{us}, rer_{t-5})$; $\rho(g_t^{us}, rer_{t+5})$
	$\rho(g_t^{us}, nt_{t-5})$;$\rho(g_t^{us}, nt_{t+5})$

Table 3: SMM Target Moments

5.2.1 Discussion of Identification

The goal of the estimation is to capture the conditional and unconditional dynamics of US government spending, net trade flows and the RER, while being consistent with a broad set of moments related to international financial and real variables. The moments and estimated parameters are displayed in Tables 3 and 4. For the conditional moments, displayed in Panel I of Table 3, I target horizons one to forty of the IRFs of US government spending and debt to identify the fiscal rule. I also target the IRFs of the RER and net trade, but I target one period per year to reduce the weight on these IRFs. Hence, the model is estimated to capture the main aggregate facts triggered by the US government spending shock, that is the increase in net trade and depreciation of the RER, conditional on matching the response of the US government spending and debt.

The unconditional moments are displayed in Panel II to V in Table 3. Panel II includes some standard international business cycle moments related to GDP and government spending in the US and ROW. These moments are informative about the TFP processes, as well as the fiscal rule. Panel III, includes a broad set of international quantities and prices. In particular it includes information about the variances, correlations and autocorrelations of net trade, the terms of trade, and the RER. These moments have proven to be hard to account for in the literature. The Benchmark model successfully captures these moments. They are informative about the financial and trade shock processes, the pricing-to-market friction, and the trade adjustment costs in the CES aggregators.

Panel IV, shows the financial variables. It includes the variance of the US gross foreign assets, the US government debt, the interest rate differential and the portfolio share of US government bonds of US agents. I also includes the autocorrelation of the interest rate differential and the portfolio share of US government bonds of US agents, and the coefficient on interest rates from the Fama (1984) regression. Furthermore, it includes the correlation between the relative government debt and the RER, which was discussed in Section 3. These moments are informative about the financial shock processes, and the fiscal rule.

Finally, Panel V include moments related to the comovement of US government spending with macro variables. In particular, it includes the correlation with five periods lags and leads of the RER and net trade, capturing the dynamic comovement documented in Section 3. These moments are informative about the trade adjustment costs in the CES aggregators.

The estimation identifies a lower volatility and persistence of ROW government spending shocks than in the US, consistent with the unconditional dynamics of these variables. The endogenous response of government spending to changes in government debt ($\varphi^{G,b}$) is negative, consistent with the findings in Corsetti et al. (2012). The volatility of the differential financial shock is higher than the common one, although the persistence is significantly lower. This implies that differential financial shock, affect more the high frequency than the lower frequency dynamics, consistent with the findings in Mac Mullen and Woo (2024).

The adjustment cost in the CES aggregators is lower than the estimated one in Rabanal

Parameter		Value	se	Parameter		Value	se
1. Std common prod shock	σ_z^c	0.054	(0.001)	9. Pers differential financial shock	ρ_ψ^d	0.75	(0.222)
2. Pers common prod shock	ρ_z^c	0.99	(0.165)	10. Std common portfolio shock	σ_ψ^c	0.006	(0.002)
3. Pers US gov shock	ρ_g^{us}	0.92	(0.032)	11. Pers common financial shock	ρ_ψ^c	0.97	(0.453)
4. Std ROW gov shock	σ_g^{row}	0.004	(0.002)	12. Pricing-to-Market friction	ζ	1.22	(0.237)
5. Pers ROW gov shock	ρ_g^{row}	0.84	(0.176)	13. Adj cost CES	ι	191.5	(3.888)
6. Std differential trade shock	σ_ξ^d	0.016	(0.005)	14. Response gov spending to debt	$\varphi^{g,b}$	-0.03	(0.010)
7. Pers of differential trade shock	ρ_ξ^d	0.95	(0.045)	15. Response taxes to debt	$\varphi^{T,b}$	0.04	(0.020)
8. Std differential financial shock	σ_ψ^d	0.016	(0.005)				

Notes: standard errors (se) are calculated using the asymptotic Delta function method as in Christiano et al. (2005).

Table 4: SMM Estimated Parameters

and Rubio-Ramirez (2015), although they do not consider trade in capital goods.[56] The pricing to market friction is estimated so that the exchange rate pass-through is 59% in the short-run, in line with the estimated values in the literature (Gopinath and Itskhoki, 2010).

6 Quantitative Results

I now turn to the main results of the quantitative model. First, I show that the benchmark model successfully captures the target and untargeted moments. Second, I explore the role of the fiscal rule and portfolio frictions in the international transmission of government spending shocks, and finally the implications for unconditional moments.

[56] Rabanal and Rubio-Ramirez (2015) preferred calibration has a value of adjustment cost of 325.

6.1 The Benchmark Model

Panels (a) to (d) in Figure 5 present the targeted IRFs to US government spending shocks, with the empirical IRFs displayed in solid black and the benchmark model IRFs in blue (with *o*). The benchmark model successfully captures the responses of the RER and net trade, conditional on matching the responses of US government spending and government debt. It is worth mentioning that matching the quantitative response of the RER is not an easy task, as it is well known that international business cycle models in general perform extremely bad in terms of RER dynamics.

The benchmark model not only captures the size and persistence of the RER and net trade responses, but also their hump-shaped dynamics. The reason why the RER present a hump-shape dynamic can be seen clearly from Equation 6, which relates the RER with the sum of the expected future portfolio share of government bonds. Because the response of the US government debt is hump-shaped, so is the portfolio share of these bonds, and through Equation 6 so is the RER. This mechanism operates through deviations of the UIP condition, as shown by Equation 5. The model captures the UIP deviations, as shown in Panel (e) of Figure 5. Furthermore, the demand for foreign bonds increases, captured by the response of the gross foreign assets in Panel (f), in order to smooth out the cost of deviating from the long-run portfolio share of government bonds. The depreciation of the RER triggers an expenditure switching effect that rises net trade flows. The response of the net trade flows is also hump-shaped, although it peaks at a further horizon than the RER, due to the presence of adjustment costs in trade that give rise to a dynamic trade elasticity that is smaller in the short than in the long run. Finally, Figure D.1 shows that the model generate the net trade flows dynamics through a strong crowding-out of investment, while being consistent with the responses of relative GDP, consumption and interest rates.

In terms of the unconditional moments, the model also performs very well. Table 5 Panel A, displays the target unconditional moments. The model captures standard international business cycle moments, the dynamics of international quantities, prices, and financial variables, and the comovement of US government spending with macro variables. Moreover, Table 5 Panel B, present the untarget unconditional moments. These include some of the RER disconnect moments, such as the Backus-Smith-Kollmann condition and the R^2 of the Fama regression. The

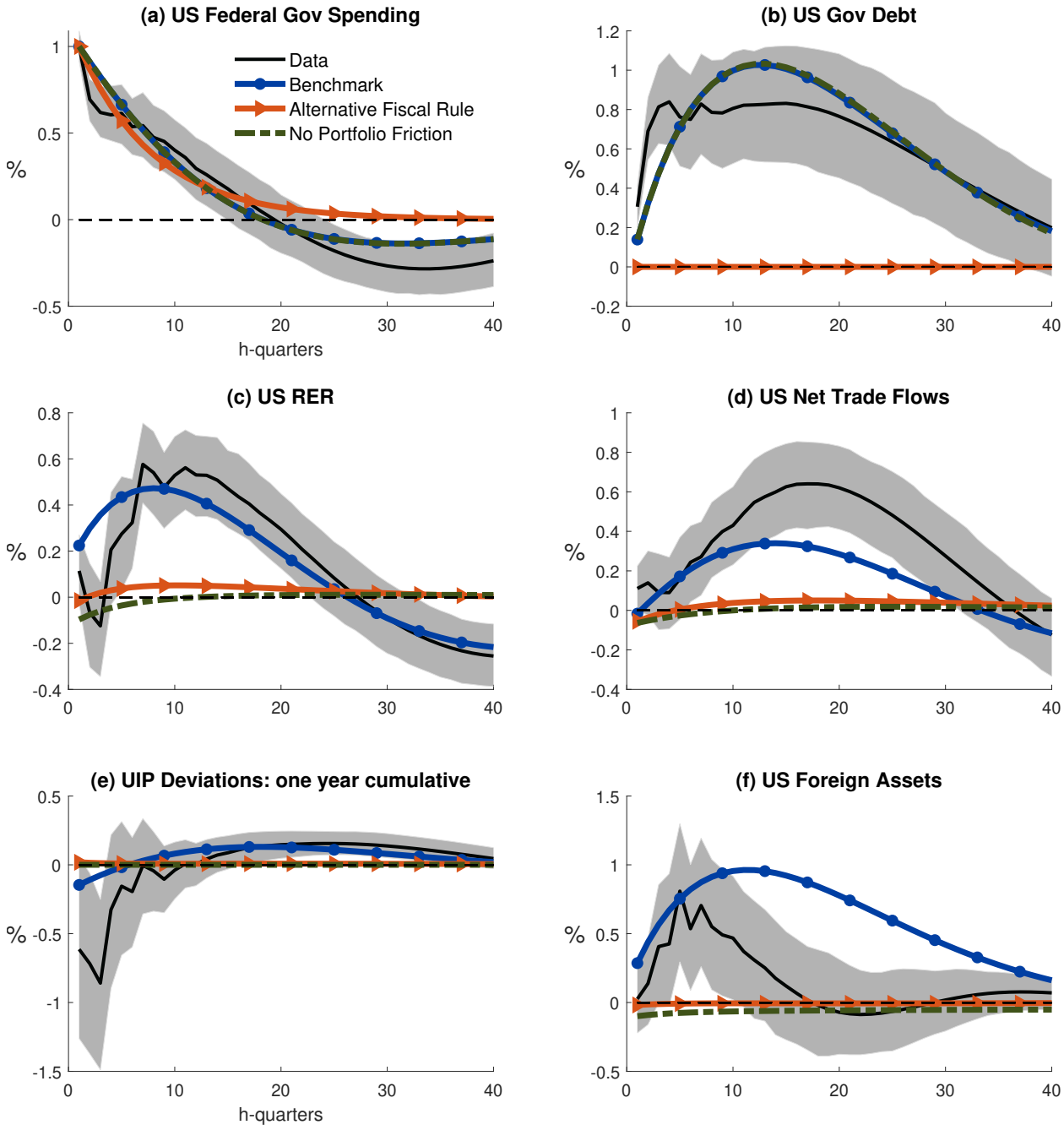


Figure 5: Impulse Response Functions: SVAR and Models

Notes: Standard error bands are 68% confidence intervals.

model captures these moments, together with other important RER moments, for example the spectrum decomposition of the RER and the correlation between the RER and the terms of trade. It also captures the correlation between the gross foreign assets and the gross foreign liabilities, which is hard to account for in existing models (Broner et al., 2013; Davis and van Wincoop, 2024;

Oskolkov, 2024).

Overall, the benchmark model captures the IRFs to government spending shocks without compromising the ability of the model to account for a broad set of unconditional international business cycle moments, including those of the exchange rate disconnect. Now I turn to study the importance of the fiscal rule and portfolio frictions for the success of the benchmark model in explaining the data. First, I focus on the implication of these features for the international transmission of government spending shocks, and later on their implications for unconditional moments.

6.2 The Role of the Fiscal Rule and Portfolio Frictions for the International Transmission of Government Spending Shocks

To understand the role of the fiscal rule, consider an alternative case where the government stabilizes the value of its debt.[57] The responses to US government spending shocks of this case are displayed in Figure 5 under the label 'Alternative Fiscal Rule' (orange line with >).[58] Panel (b), shows the response of the value of government debt stays constant. The effect on the portfolio share is muted in this case, which can be seen from Panel (e). Consequently, on impact the RER appreciates, as shown in Panel (c), and the net trade flows fall due to expenditure switching substituting away from US goods, as shown in Panel (d). This exercise shows the crucial role that the fiscal rule plays in shaping the international transmission of government spending shocks.

To see how it is the interaction of the fiscal rule with the presence of portfolio frictions what is crucial for the model, consider now the same fiscal rule as in the benchmark model but no portfolio frictions.[59] The responses to US government spending shocks of this case are displayed in Figure 5 under the label 'No Portfolio Friction' (green dash-dotted line). Even though the response of the US government debt is virtually the same as in the benchmark model (Panel b), in the case without portfolio frictions there are (almost) no deviations from UIP, as shown in

[57] This equilibrium is achieved by replacing the lump-sum tax rule equation for an equation for the time t value of government bonds equal to its steady state value.

[58] The response of government spending is different in this case, but re-calibrating to match it does not make a difference in the remaining results.

[59] In this case I set $\Gamma = 0$, and I add a small adjustment cost (0.001) on the level of the foreign assets in the US and the ROW with the only purpose of closing the model, following Schmitt-Grohé and Uribe (2003).

Moment	Data	Benchmark	No differential trade & financial shocks	Moment	Data	Benchmark	No differential trade & financial shocks
Panel A: Target Moments							
1. $\sigma(gdp^{us})$	0.02	0.01	0.01	13. $\sigma(gfa^{us})/\sigma(gdp^{us})$	4.07	4.50	4.49
2. $\rho(gdp^{us}, gdp^{row})$	0.84	0.98	0.99	14. $\sigma(B^{g,us})/\sigma(gdp^{us})$	2.10	3.43	3.45
3. $\sigma(gov^{us})/\sigma(gdp^{us})$	2.03	2.19	2.20	15. $\sigma(s^{g,us})/\sigma(gdp^{us})$	1.01	0.82	0.81
4. $\sigma(gov^{row})/\sigma(gdp^{row})$	0.63	0.61	0.61	16. $\sigma(r^{us} - r^{row})/\sigma(gdp^{us})$	0.06	0.07	0.04
5. $\rho(gov^{row})$	0.78	0.78	0.78	17. $\rho(s^{g,us})$	0.91	0.86	0.89
6. $\sigma(rer)/\sigma(gdp^{us})$	3.32	2.02	1.66	18. $\rho(r^{us} - r^{row})$	0.87	0.74	0.69
7. $\sigma(nt)/\sigma(rer)$	1.19	0.99	0.73	19. β_{Fama}	-1.38	-1.26	2.24
8. $\sigma(tot)/\sigma(rer)$	0.34	0.42	0.38	20. $\rho(B^{g,us} - B^{g,row}, rer)$	0.63	0.45	0.87
9. $\rho(rer)$	0.94	0.89	0.98	21. $\rho(gov^{us} - gov^{row}, rer_{-5})$	0.00	0.05	0.08
10. $\rho(nt)$	0.97	0.99	0.99	22. $\rho(gov^{us} - gov^{row}, rer_{+5})$	0.73	0.50	0.74
11. SR trade elast.	0.17	0.13	0.16	23. $\rho(gov^{us} - gov^{row}, nt_{-5})$	-0.35	-0.03	-0.27
12. LR trade elast.	1.30	1.40	0.56	24. $\rho(gov^{us} - gov^{row}, nt_{+5})$	0.23	0.26	0.55
Panel B: Untarget Moments							
1. BSK: $\rho(\Delta rer, \Delta(c^{us} - c^{row}))$	-0.17	-0.47	-0.79	8. $\rho(inv^{us})$	0.96	0.98	0.98
2. R^2_{Fama}	0.01	0.01	0.09	9. $\rho(con^{us})$	0.96	0.97	0.97
3. $\rho(tot, rer)$	0.86	0.98	1.00	10. $\rho(inv^{us} - inv^{row}, rer)$	-0.62	-0.71	-0.91
4. $\rho(r^{us} - r^{row}, rer)$	-0.43	0.16	0.13	11. $\rho(B^{g,us})$	0.95	0.98	0.98
5. Low freq RER spectrum	0.62	0.64	0.69	12. $\rho(B^{g,us}, g^{us})$	0.60	0.22	0.22
6. BC freq RER spectrum	0.31	0.28	0.25	13. $\rho(B^{g,us}, gfa^{us})$	0.23	0.65	0.66
7. $\sigma(inv^{us})/\sigma(gdp^{us})$	2.87	2.25	2.26	14.$\rho(gfa^{us}, gfl^{us})$	0.87	0.75	0.66

Notes: gfa and gfl stand for gross foreign assets and liabilities. BC stands for 'Business Cycle'. The moments reported in the columns under 'No differential trade & financial shocks' correspond to those obtained from simulating the model shutting down the differential trade and differential financial shock, i.e. $\sigma^d_\xi = \sigma^d_\psi = 0$.

Table 5: Unconditional Moments

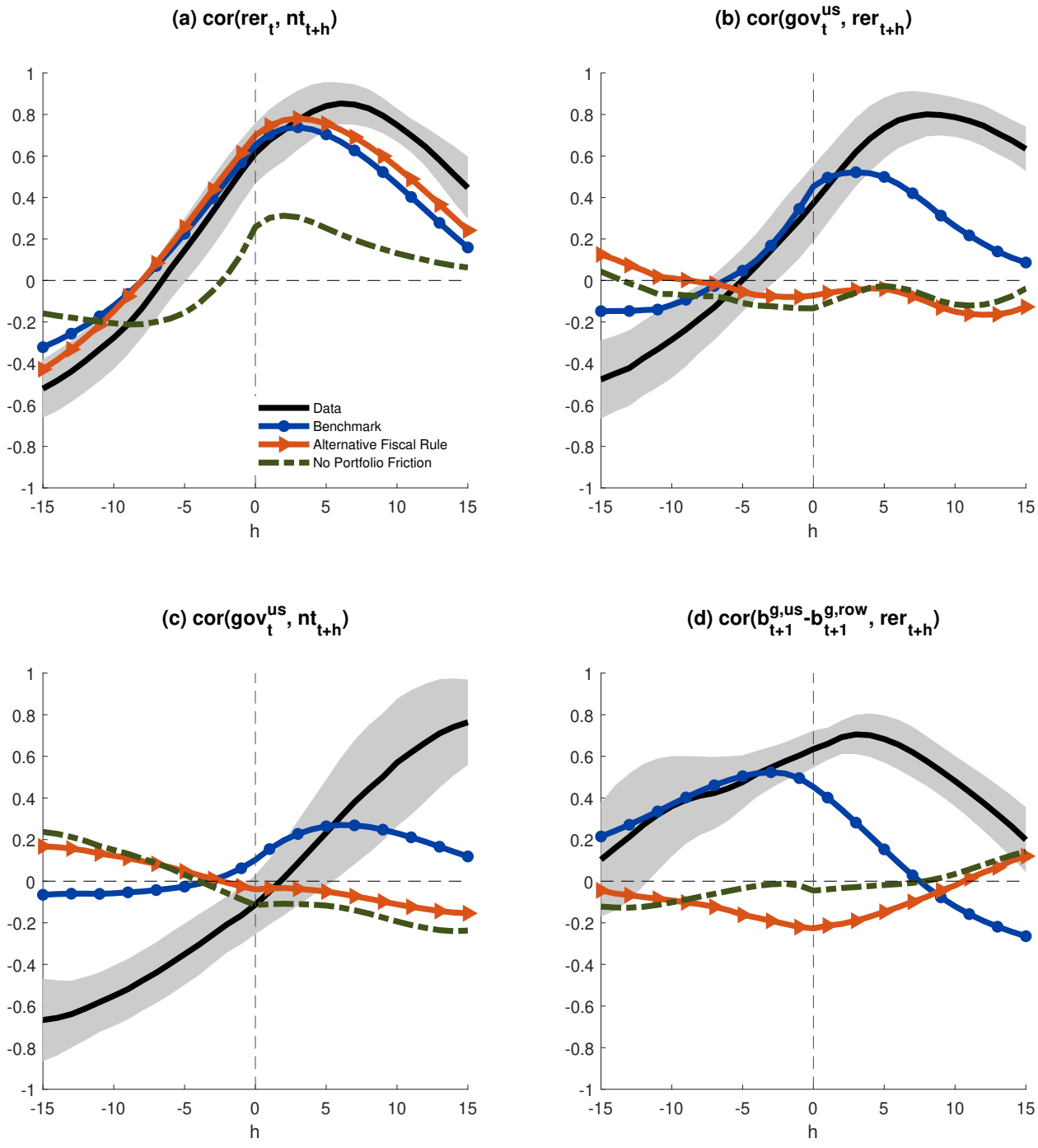


Figure 6: Unconditional Dynamic Correlations in Data and Models

Notes: Standard error bands are 68% confidence intervals.

Panel (e).[60] Consequently, the dynamics of the RER and net trade are driven by the traditional mechanism triggered by a positive government spending shock. That is, the RER appreciates due

[60] Due to the adjustment cost on the level of foreign assets introduced to close the model there are small deviations from UIP, but they are quantitatively insignificant due to the small adjustment cost.

to home bias in expenditure, which triggers a fall in net trade flows due to expenditure switching.

Having shown the crucial role played by the fiscal rule and portfolio frictions in the international transmission of US government spending shocks, I turn to study the implications for international business cycles. That is, I focus on unconditional moments.

6.3 Implications for International Business Cycles

First, I show the importance of the mechanism for capturing the joint comovement between government spending, government debt, the RER and net trade flows, emphasized in Section 3. Secondly, I show that the mechanism greatly contributes to the ability of the model to capture some of the unconditional moments of net trade and the RER, including the disconnect.

Figure 6 show the dynamic correlations among variables of interest. First of all, the benchmark model captures the comovement between the RER and net trade, as shown in Panel (a). Moreover, the benchmark model successfully captures the comovement between the US government spending and the RER, as shown in Panel (b). However, under the alternative fiscal rule or no portfolio frictions the model fails to replicate this comovement, where the correlations tend to be negative across the whole lead-lag structure.[61] Panel (c) shows the dynamic correlation between US government spending and net trade. The model captures the fact that the correlation is negative for lags and positive for leads of net trade, although the size is missed. Nevertheless, under the alternative fiscal rule or no portfolio frictions the model generate the opposite signs for the dynamic correlation, hence the benchmark model improves over these results. Finally, Panel (d) shows the dynamic correlation between relative government debt and the RER. The benchmark model is able to generate the shape of this correlation, specially with lags of the RER, and it improves notably relative to the alternative cases. These results show that the government spending mechanism is crucial to capture the unconditional comovement between government spending, government debt, the RER and net trade flows.

Finally, Table 5 shows the unconditional moments obtained from simulating the model with-

[61] I also calculated the dynamic correlation under the benchmark calibration but with no realization of US government spending shocks, and the results are similar although the correlation with leads of the RER become slightly weaker.

out the differential trade and financial shocks under the columns 'No differential trade & financial shocks'. This version of the model tracks very closely most of the moments. In particular, it generates a RER that is more volatile than GDP and highly persistent, even more than in the benchmark model. Furthermore, Panel (b) shows that this version generates an even more negative Backus-Smith-Kollmann condition. The comovement of relative government spending with the RER and net trade is improved in this case, and so is the correlation between relative government debt and the RER. The main downside of this version is the implications for the Fama regression, since past interest rates predict depreciation and they explain a higher portion of the variance of the changes in the RER.

Overall, the government spending mechanism is key to account for the unconditional dynamic correlations between US government spending, government debt, the RER and net trade. Furthermore, it contributes considerably to matching other RER moments, specially the real disconnect. Finally, the importance of US government spending shocks can further be seen from the variance decomposition in Table G.2, that shows that these shocks explain 39% of the unconditional variance of the RER in the model, close to the 33% from the SVAR in Section 4.

7 Sensitivity Analysis

In this section, I perform sensitivity analysis in the model to four alternative cases, and explore the implications of the theory for the fiscal rule using cross-country panel data. The details are in Appendix E.1 and E.2. First, I show the results for a version of the model where I only focus on conditional moments, that is I only target the empirical IRFs to US government spending shocks, since this practice is common in the literature. Second, I consider a case where I shut down trade frictions, by setting the adjustment costs in the CES aggregators to zero, that is a case with no dynamic trade. Third, a version where agents internalize the effect on aggregate financial savings in the portfolio adjustment cost in equation 2. Fourth, a version of the model where the ROW household can save in US government bonds. Finally, I also show that the predictions of the model on the role of the fiscal rule in the international transmission of government spending shocks is further supported by cross-country panel evidence.

Focusing only on conditional moments trigger similar results in terms of the identified parameters related to the US government spending process and fiscal rule, as shown in Table F.1, and the moments matching of the IRFs in Figure F.1 (under the label 'Only G^{us} Shocks'). Overall, this strategy gives similar results than in the Benchmark model.

The version of the model that shuts down trade frictions generates some of the same key qualitative results than the Benchmark model, e.g. the RER depreciates and net trade increase in response to US government spending shocks, but performs much poorly quantitatively. The results are presented in Tales F.1, F.2, and F.3, the IRFs in Figure F.1 and dynamic correlations in Figure F.4 (under the label 'No Dynamic Trade'). Hence, trade frictions are important for the ability of the Benchmark model to capture the conditional and unconditional moments. The IRF of the RER and net trade are much less persistent and the size is smaller. Furthermore, the net trade flows are significantly more volatile and the short and long run trade elasticity is worsen as well. To summarize, while trade frictions are not necessary to generate some of the key the qualitative results they are important for the quantitative success of the model.

The model where agents internalize the effect on aggregate financial savings in the portfolio adjustment cost generates similar results for the IRFs than in the Benchmark model, but performs significantly worse in terms of unconditional moments. The results are presented in Tales F.1, F.2, and F.3, the IRFs in Figure F.2, and dynamic correlations in Figure F.4 (under the label 'Internalize Agg Fin Savings'). Furthermore, the standard errors of the estimated parameters are significantly larger than in the benchmark model. Overall, the results strongly favor the Benchmark model over this alternative case.

The version of the model where ROW households can save in US government bonds generate similar results than the Benchmark model. This arises from the fact that the mechanism is unchanged since the same UIP condition in equation 5 is derived in this version of the model. The results are presented in Tales F.1, F.2, and F.3, the IRFs in Figure F.1, and dynamic correlations in Figure F.4 (under the label 'ROW saves in US gov debt'). Furthermore, Figure F.3 shows that the model captures the response of US government debt held by foreigners to US government spending shocks.

Finally, the role of the fiscal rule in shaping the international transmission of government spending shocks can be further tested empirically. The model predicts that the more a country relies on debt financing in response to a positive government spending shock, the stronger the depreciation of the RER and the increase in net trade. Using the panel data on military spending shocks from Miyamoto et al. (2019), I show that these predictions are supported by cross-country panel data. In particular, I estimate country-by-country responses of government debt, the RER and the current account, to military spending shocks and find results consistent with the implications of my theory. Hence, the theory also contributes to rationalize some of the cross-country heterogeneity in the response of the RER and net trade to government spending shocks.

8 Concluding Remarks

This paper provides a comprehensive analysis of the joint dynamics of government spending, government debt, the RER, and net trade flows. I propose a theory that rationalizes the puzzling dynamics of the RER and net trade in response to government spending shocks. The mechanism is based on the fiscal rule that relies heavily on government debt to finance spending, and portfolio re-balancing costs. I embed the mechanism in a model that features additional shocks and show that it is crucial to capture the joint unconditional dynamics of government spending, government debt, the RER and net trade. Furthermore, it also contributes considerably to account for the RER disconnect. Hence, the theory endogenizes some of the the channels recently treated as exogenous in the literature, in particular shocks to the UIP condition (Itskhoki and Mukhin, 2021a) and demand shocks (Kekre and Lenel, 2024a).

Finally, the framework is well suited to study other important topics. In particular, it has implications for optimal taxation. In models where Ricardian equivalence hold (Barro, 1974), financing transitory spending with government debt is always desired over distortionary taxes. However, the presence of portfolio frictions induces an endogenous international risk-sharing inefficient of debt financed spending, inducing a trade-off between debt and distortionary taxes. This is particularly important in present times given the sizable increase in government spending and debt after the COVID Pandemic which is also expected to increase in the future. Additionally,

the framework also has implications for the government spending multipliers, the interaction of fiscal and monetary policy in the open economy, and the dynamics of gross financial flows.

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Appendix

A Data Description

The data description, sources and variable codes are listed below:

- Rest of the world (ROW) countries: Australia, Austria, Belgium, Canada, Denmark, Germany, Finland, France, Ireland, Italy, Japan, Mexico, Netherlands, Norway, South Korea, Portugal, Spain, Sweden, United Kingdom
- Trade weights are calculated using bilateral trade data between the US and the ROW countries for the period 1991-2019. I use the average value of the period.
- Population (PWT10, annual), and US population from FRED (B230RC0Q173SBEA, quarterly)
- GDP expenditure approach (B1_GE, OECD quarterly)
- Consumption: Private final consumption expenditure (P31S14_S15, OECD quarterly)
- Investment: Gross fixed capital formation (P51, OECD quarterly)
- Government spending in the US: I use federal spending from NIPA, following Ramey (2011).
- Government spending in the ROW: General government final consumption expenditure (P3S13, OECD quarterly)
- Exports: Exports of goods and services (P6, OECD quarterly)
- Imports: Imports of goods and services (P7, OECD quarterly)
- Narrow Trade Weighted Real Exchange Rate (RER) (BIS quarterly)
- Interest rates: 10 year government bonds in US and ROW countries (IMF, FRED), and short rates are Effective federal funds rate (IMF) fo the US and money market rates IMF) for the ROW. Real interest rates are calculated using inflation forectas from OECD, whenever available, otherwise using realized inflation.

- NIPA variables for US:
  - US Macro aggregates ("Table 1.1.5. Gross Domestic Product")
  - Price indexes to transform to real ("Table 1.1.4. Price Indexes for Gross Domestic Product")
- US government debt:
  - i US Market Value of Marketable Treasury Debt (MVMTD027MNFRBDAL)
  - ii US total public debt held by foreigners (FRED, FDHBFIN)
  - iii US total public debt held by Federal Reserve System (FRED, FDHBFRBN)
  - US gov debt in hands of US agents (excluding US gov institutions) $= i - ii - iii$
  - In real terms: deflated by US CPI
- Tax rates:
  - total federal and corporate (TaxFoundation and Splinter (2020))
  - labor and capital income (US vs ROW) (globaltaxation.world)
- US net and gross financial flows (Rey and Gourinchas 07 + NIPA)
- Composition of international trade quantities and prices (NIPA)
- US Baking and financial markets data for Figure B.4 (FRED)

Macro aggregates are in log per-capita, expressed in US dollars, volume estimates, fixed PPPs.

A.1 Filtering

To capture cyclicality of variables of interest, I use the filter proposed by Christiano and Fitzgerald (2003) (henceforth CF), since it outperforms other filters at lower frequencies, such as the Hodrick and Prescott (1997) (henceforth HP). I focus on business cycles that take up to twenty years for the

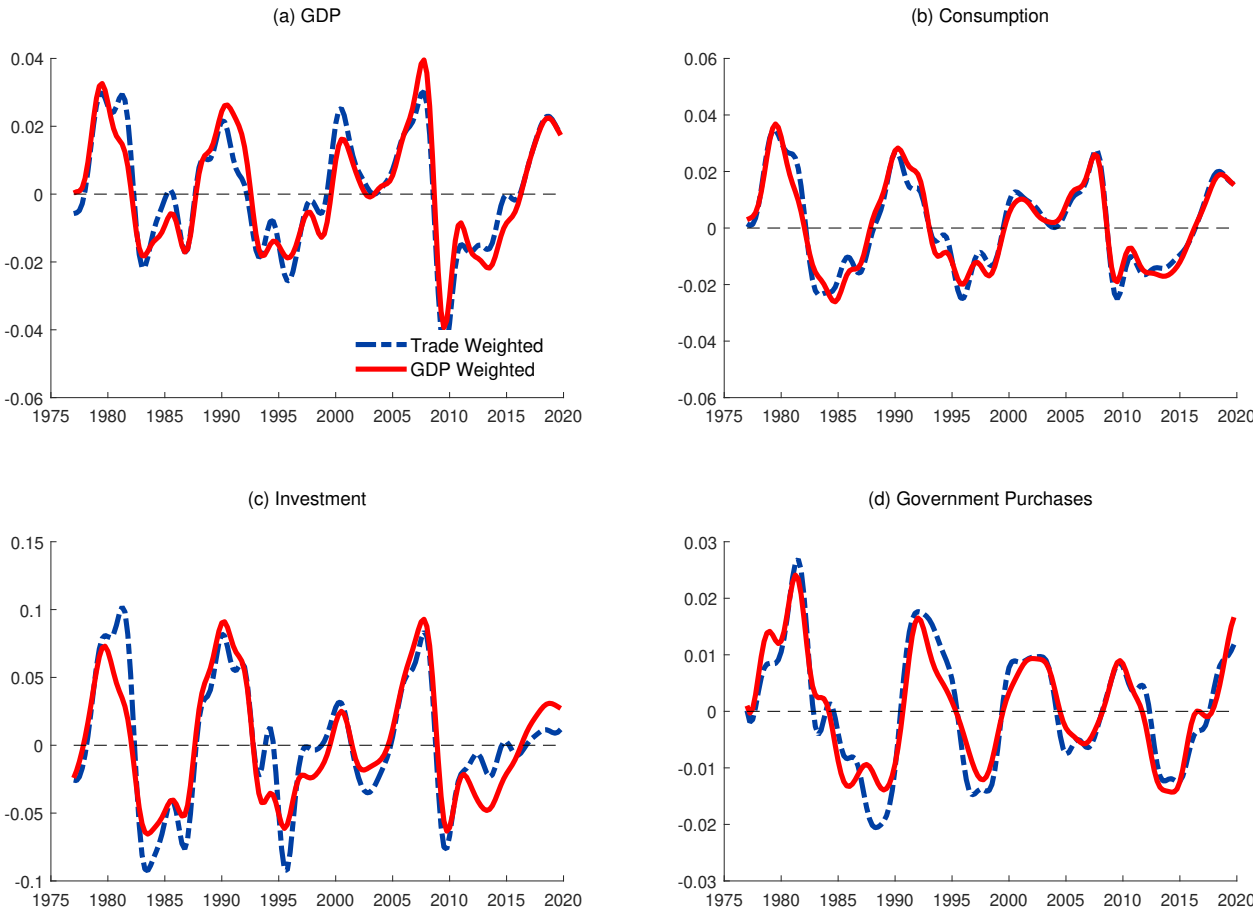


Figure A1: ROW - Trade Weights vs GDP Weights

reasons mentioned in Section 3.1. I apply the CF filter to all macro aggregates to capture cyclicality between two quarters and twenty years.[62] The results are robust to using linear, quadratic or cubic de-trend, or the band-pass filter.

Figure A1 show the time series of the cyclical component of GDP, consumption, investment and government spending in the ROW using trade weights and GDP weights. The aggregate time series are very similar under both ways of weighting the data.

The unconditional moments calculated for the estimation of the quantitative model in Section 5.2 are obtained using the cyclical component after applying the CF filter as explained above.

[62] I start at two quarters cyclicality since in the estimation of the model I combine unconditional moments with empirical IRFs, and the latter includes effects at short horizons. However, the results are robust to capturing cyclicality between two and twenty years.

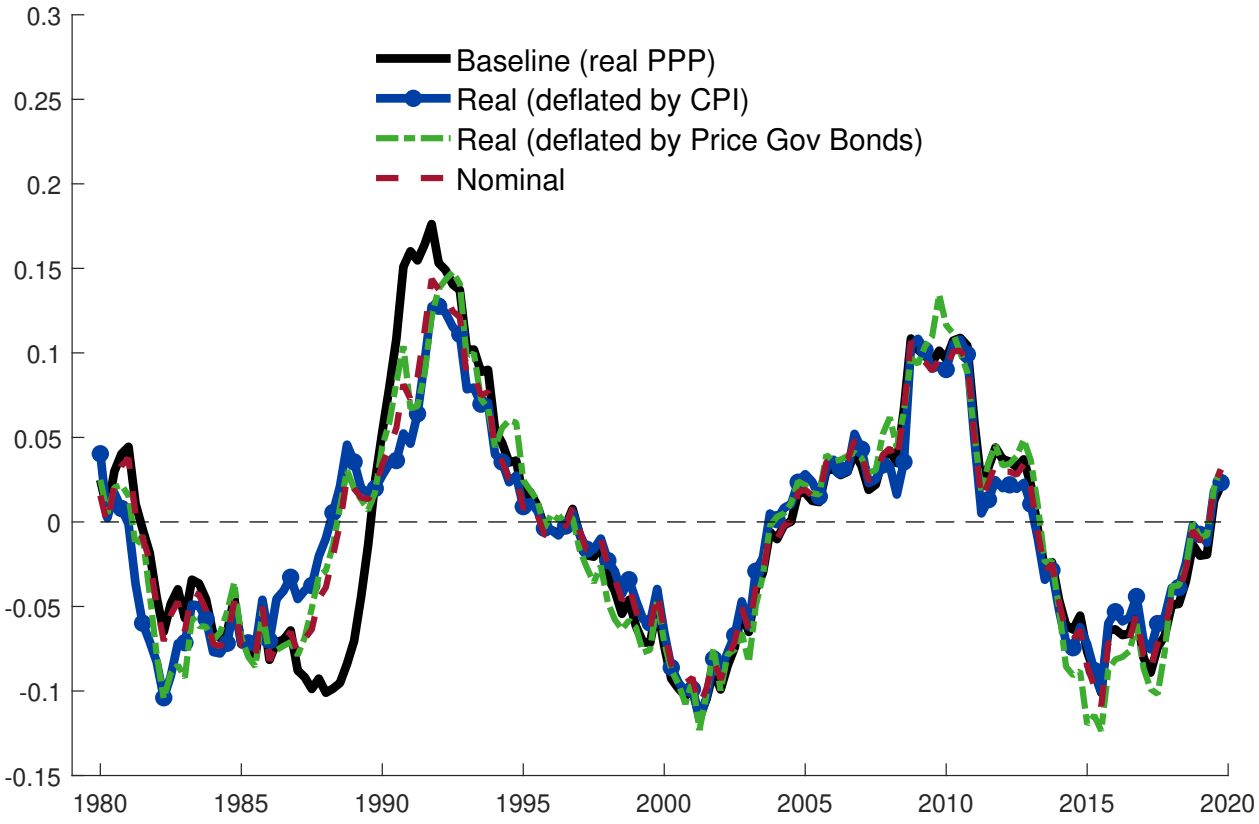


Figure A2: Relative Government Debt: Robustness Alternative Measures

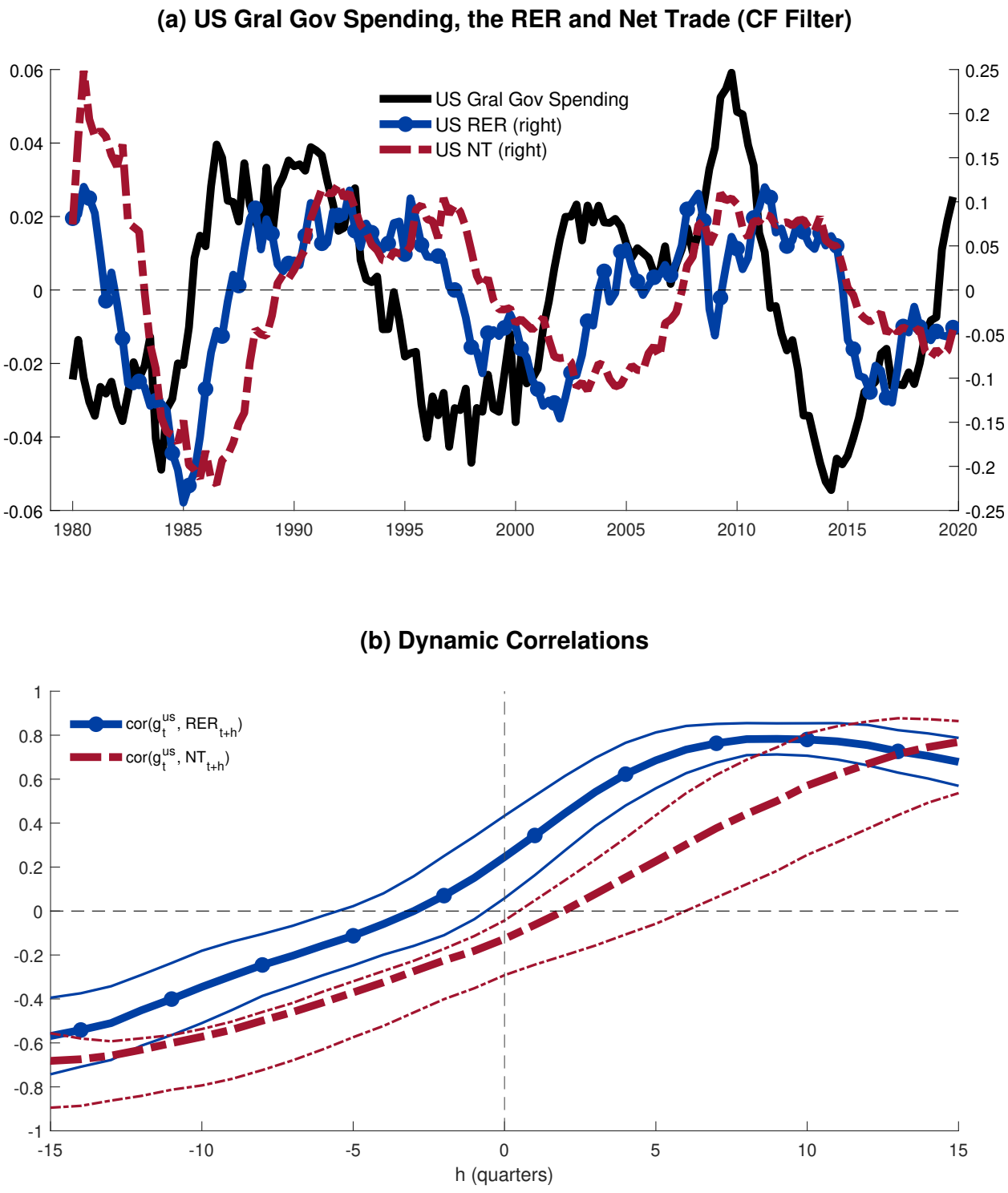


Figure A3: US General Spending, the RER and Net Trade Flows

Notes: Standard error bands are 68% confidence intervals in Panel (b). They are calculated using 80 quarters rolling windows.

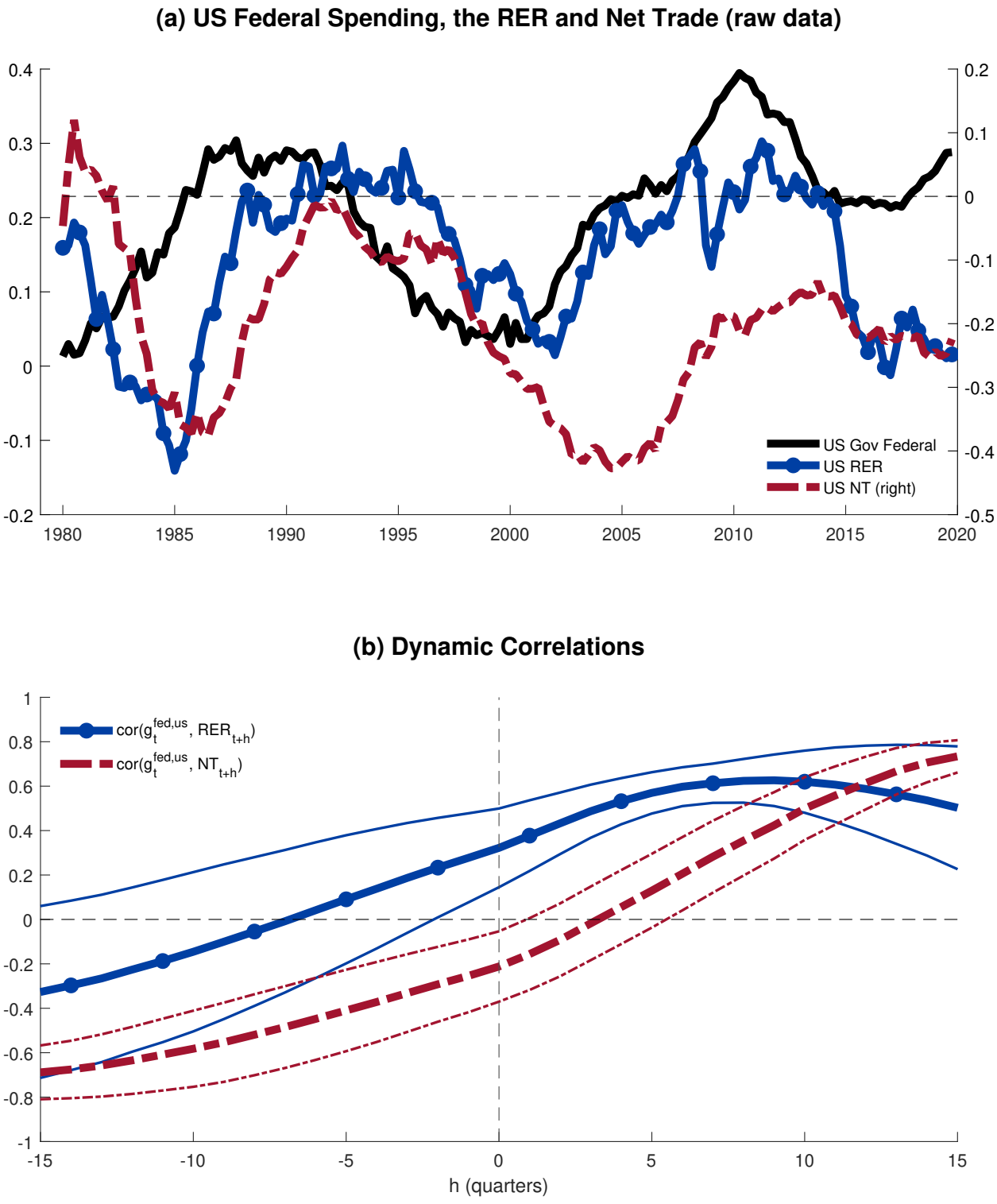


Figure A4: US Federal Spending, the RER and Net Trade Flows (raw data)

Notes: Standard error bands are 68% confidence intervals in Panel (b). They are calculated using 80 quarters rolling windows.

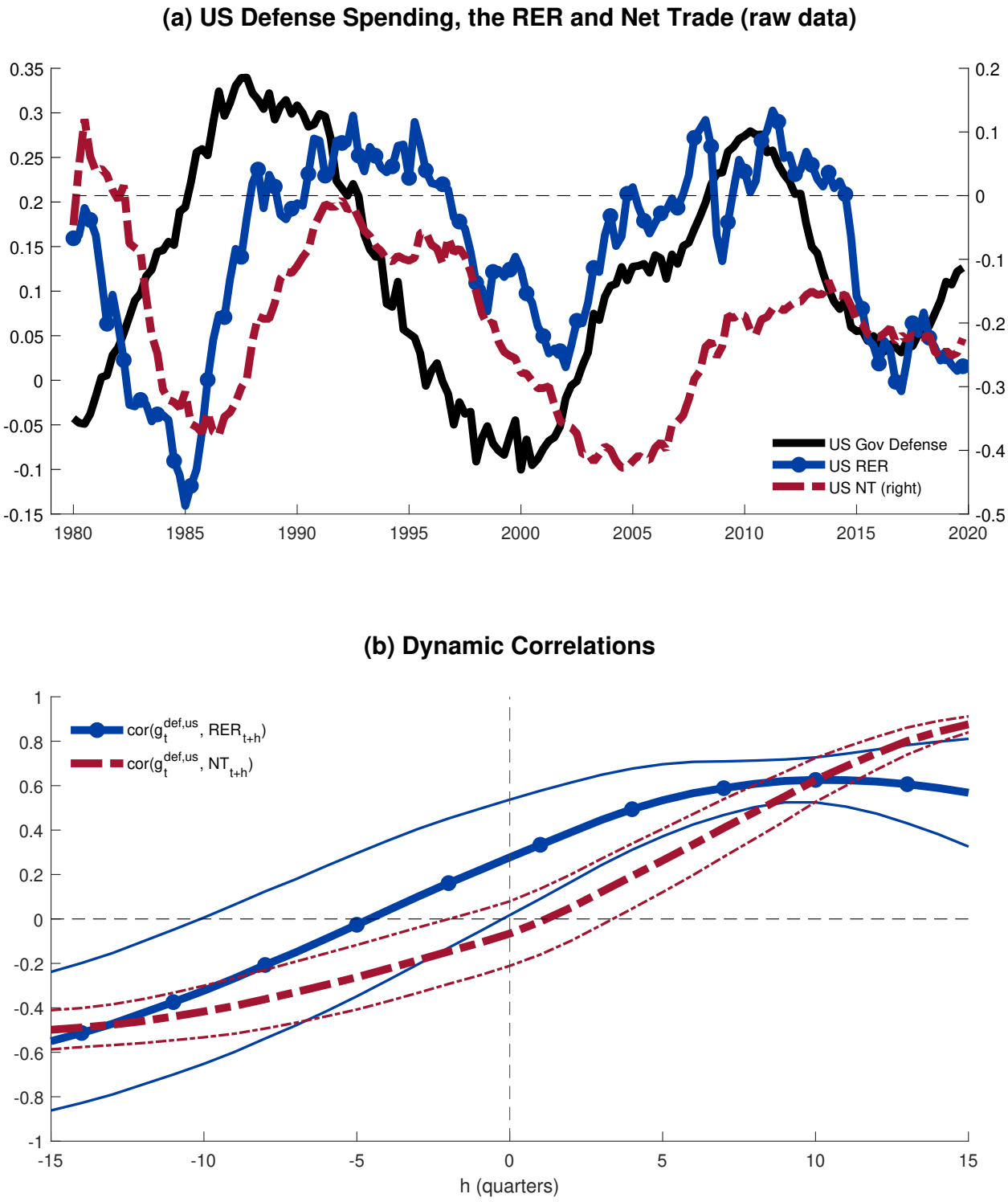


Figure A5: US Defense Spending, the RER and Net Trade Flows (raw data)

Notes: Standard error bands are 68% confidence intervals in Panel (b). They are calculated using 80 quarters rolling windows.

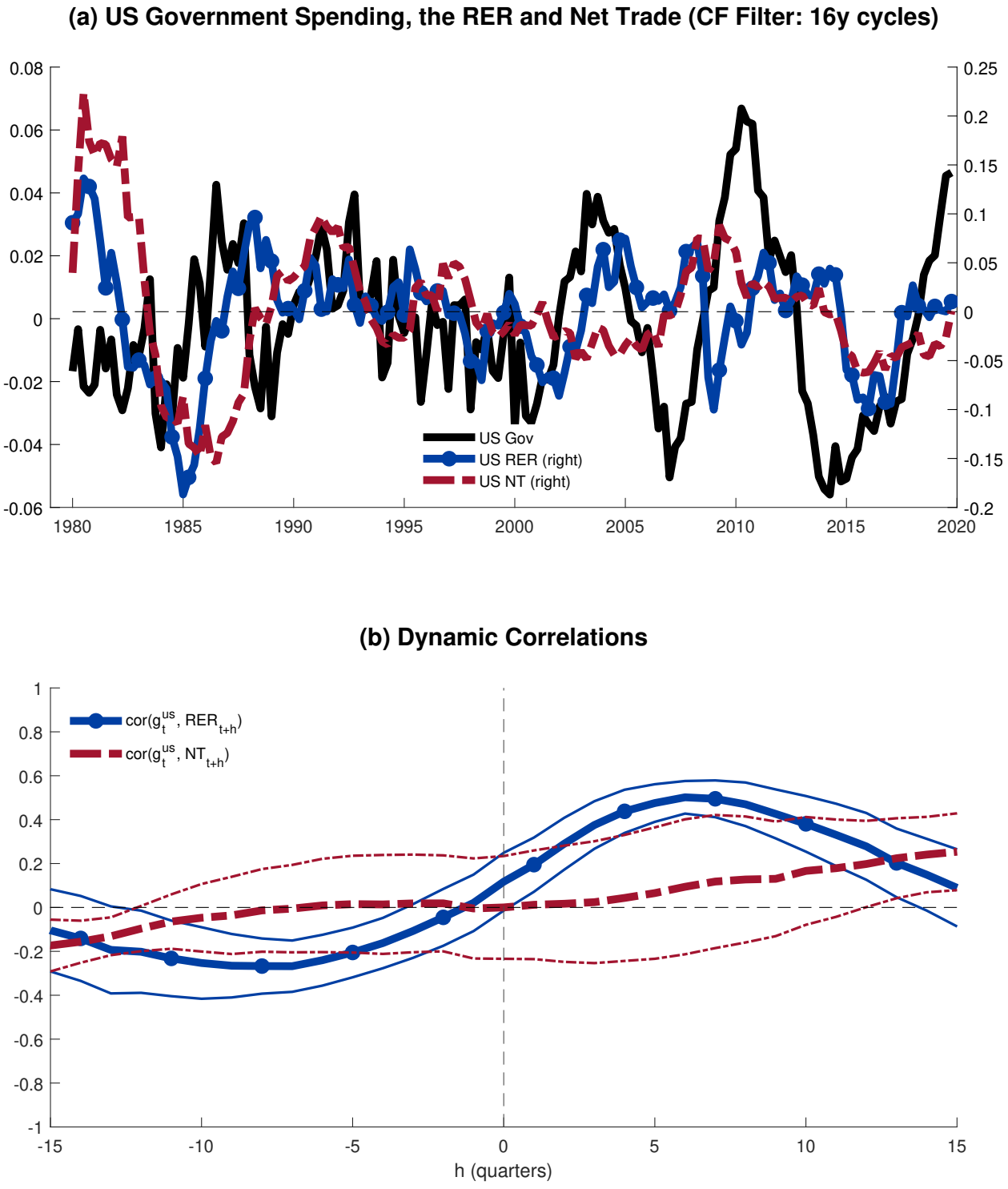


Figure A6: US Government Spending, the RER and Net Trade Flows (CF Filter: 16y cycles)

Notes: Standard error bands are 68% confidence intervals in Panel (b). They are calculated using 80 quarters rolling windows, where the data is de-trended in each sub-sample.

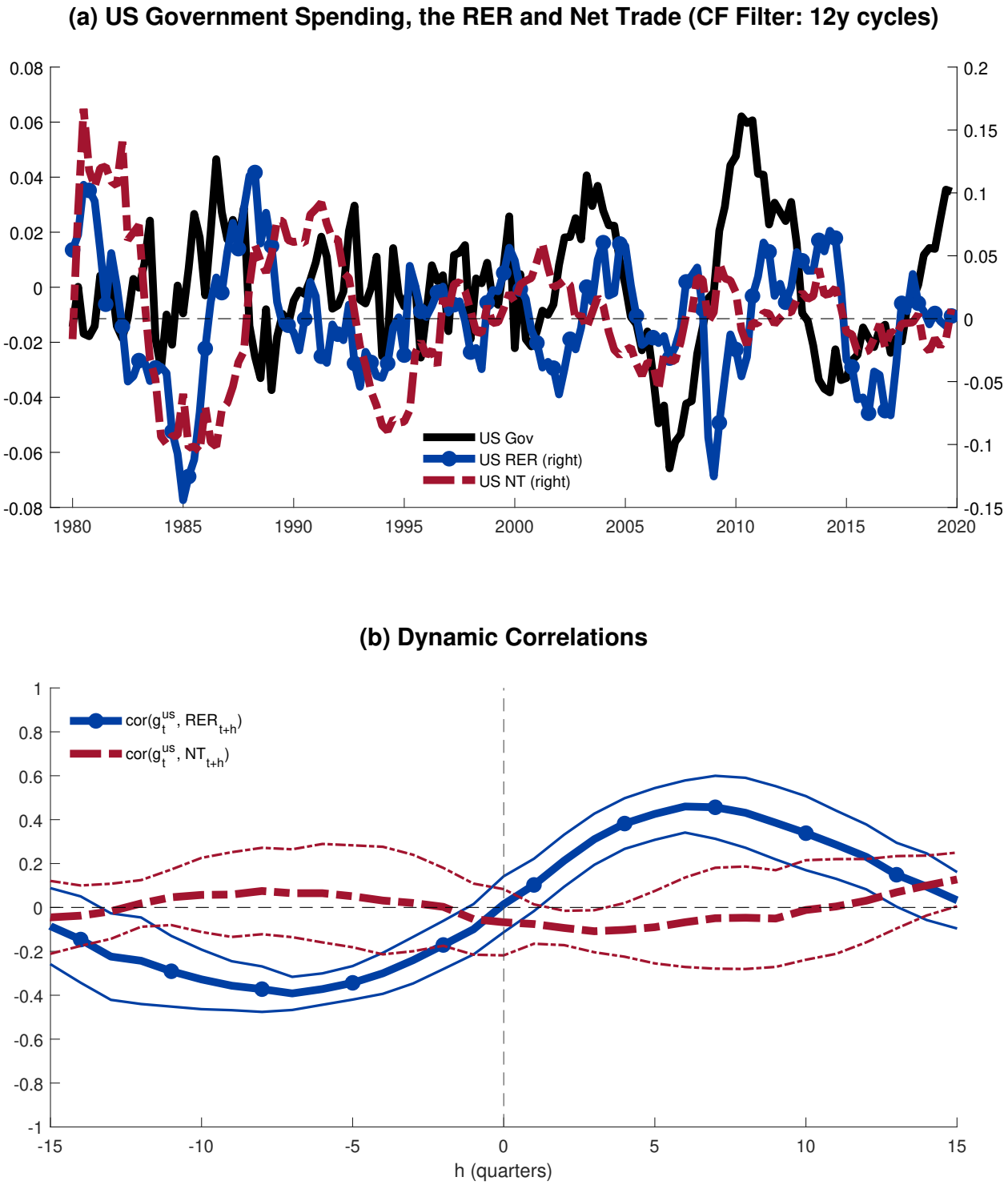


Figure A7: US Government Spending, the RER and Net Trade Flows (CF Filter: 12y cycles)

Notes: Standard error bands are 68% confidence intervals in Panel (b). They are calculated using 80 quarters rolling windows, where the data is de-trended in each sub-sample.

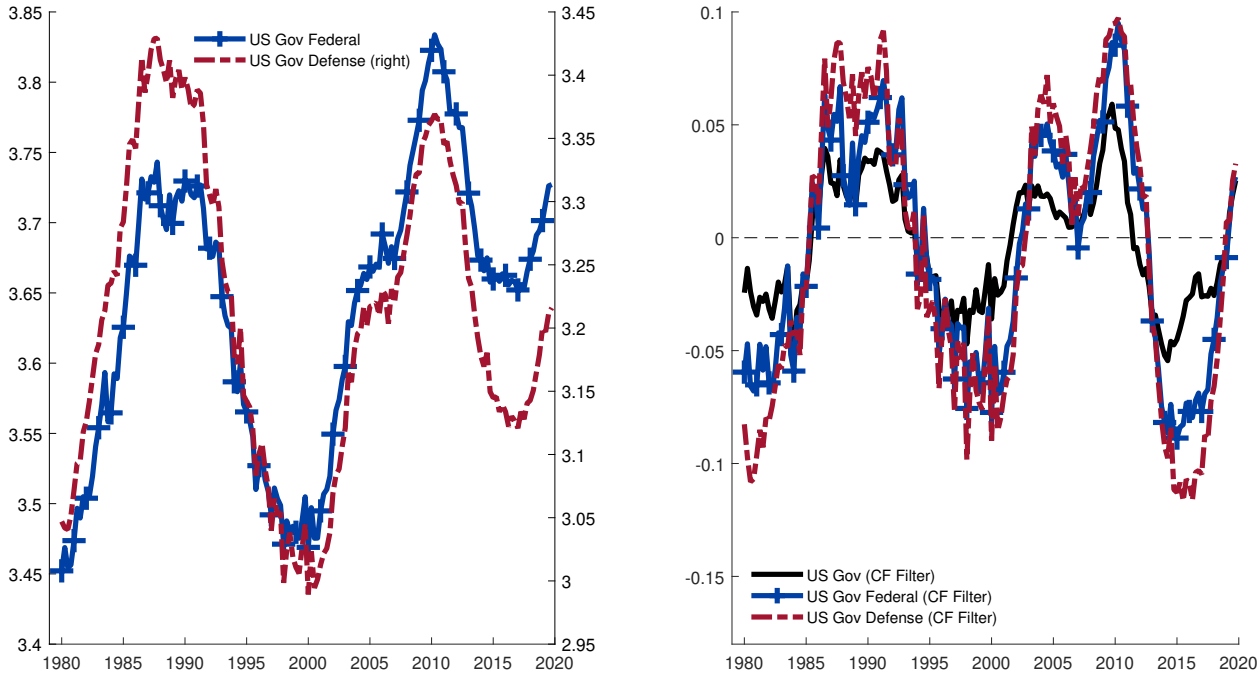


Figure A8: Cyclicality of Different Components of US Government Spending

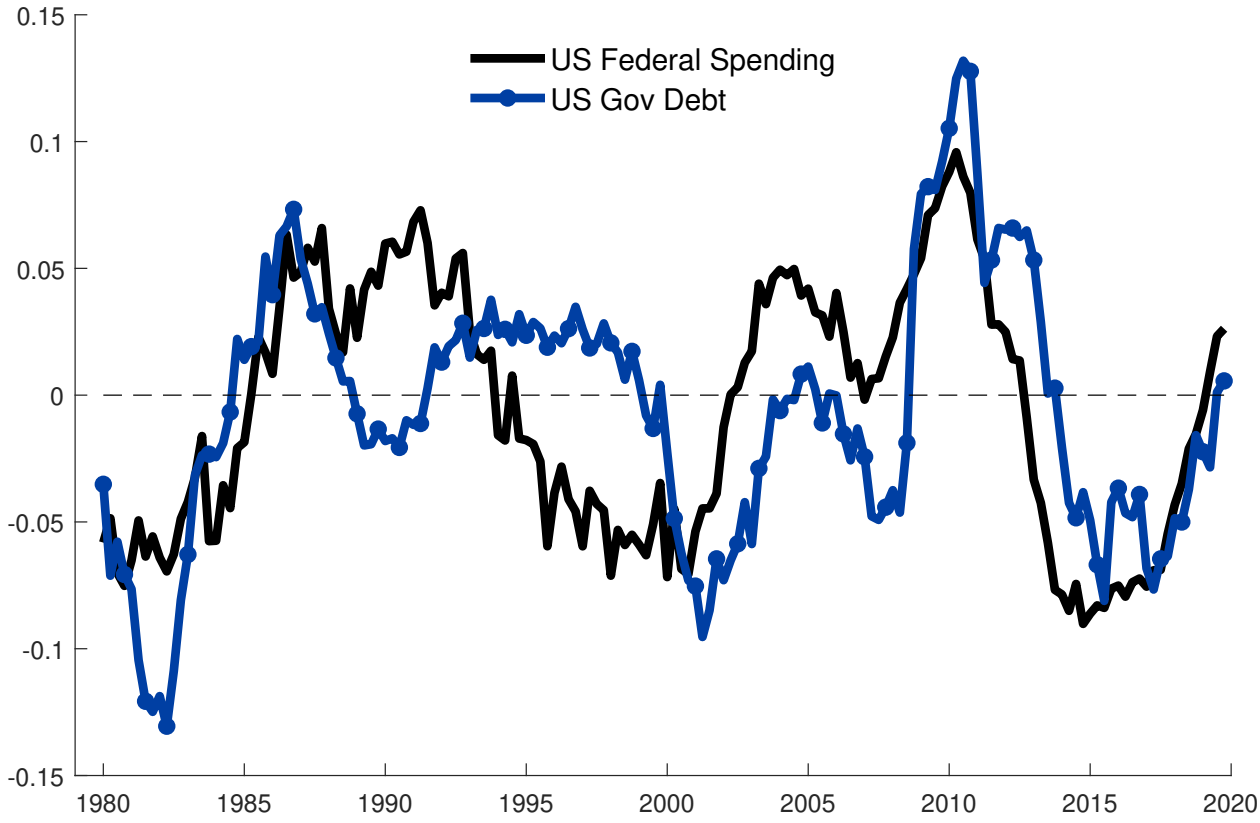


Figure A9: US Federal Spending and US Government Debt

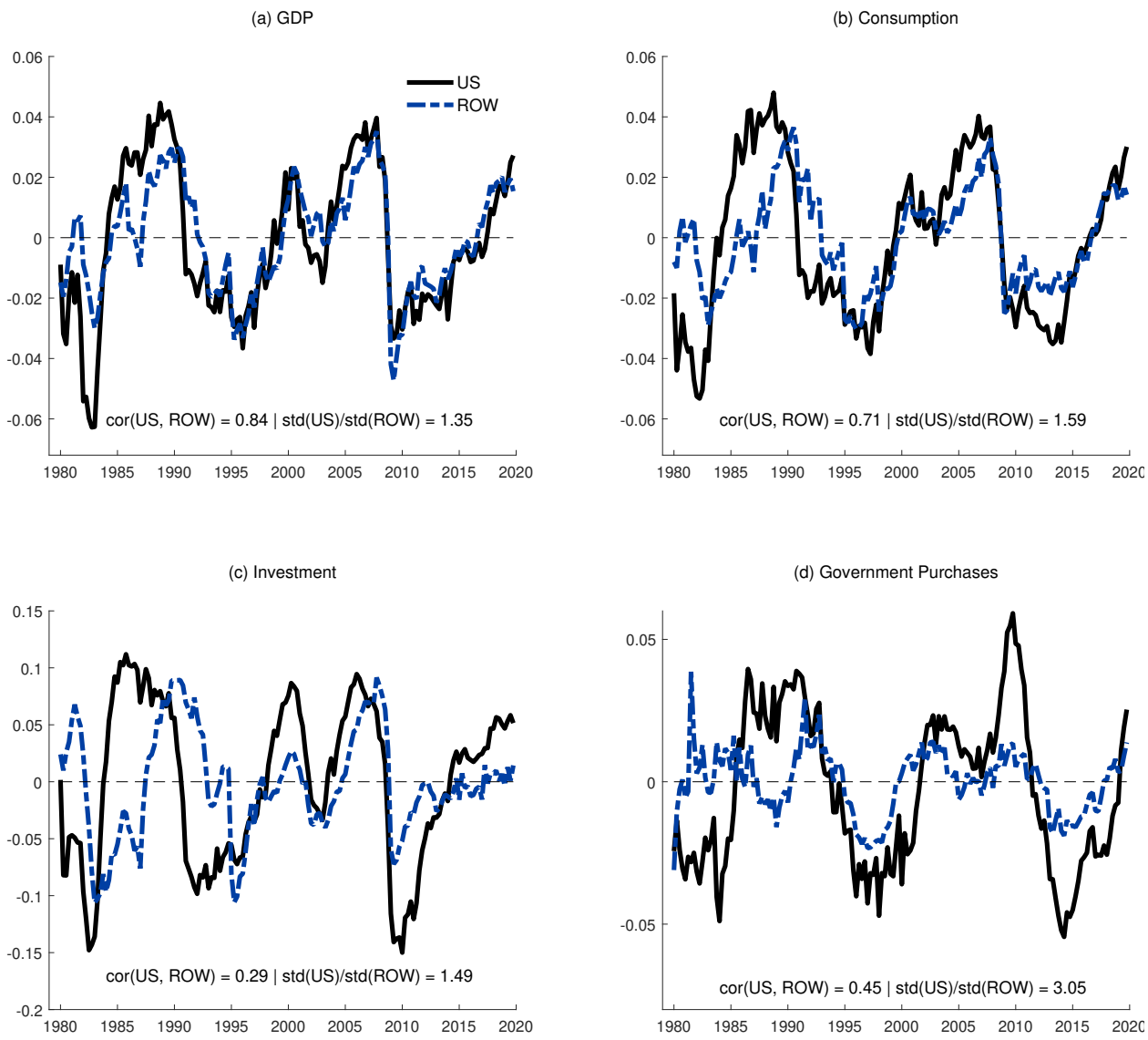


Figure A10: Macro Aggregates in US and ROW (CF Filter)

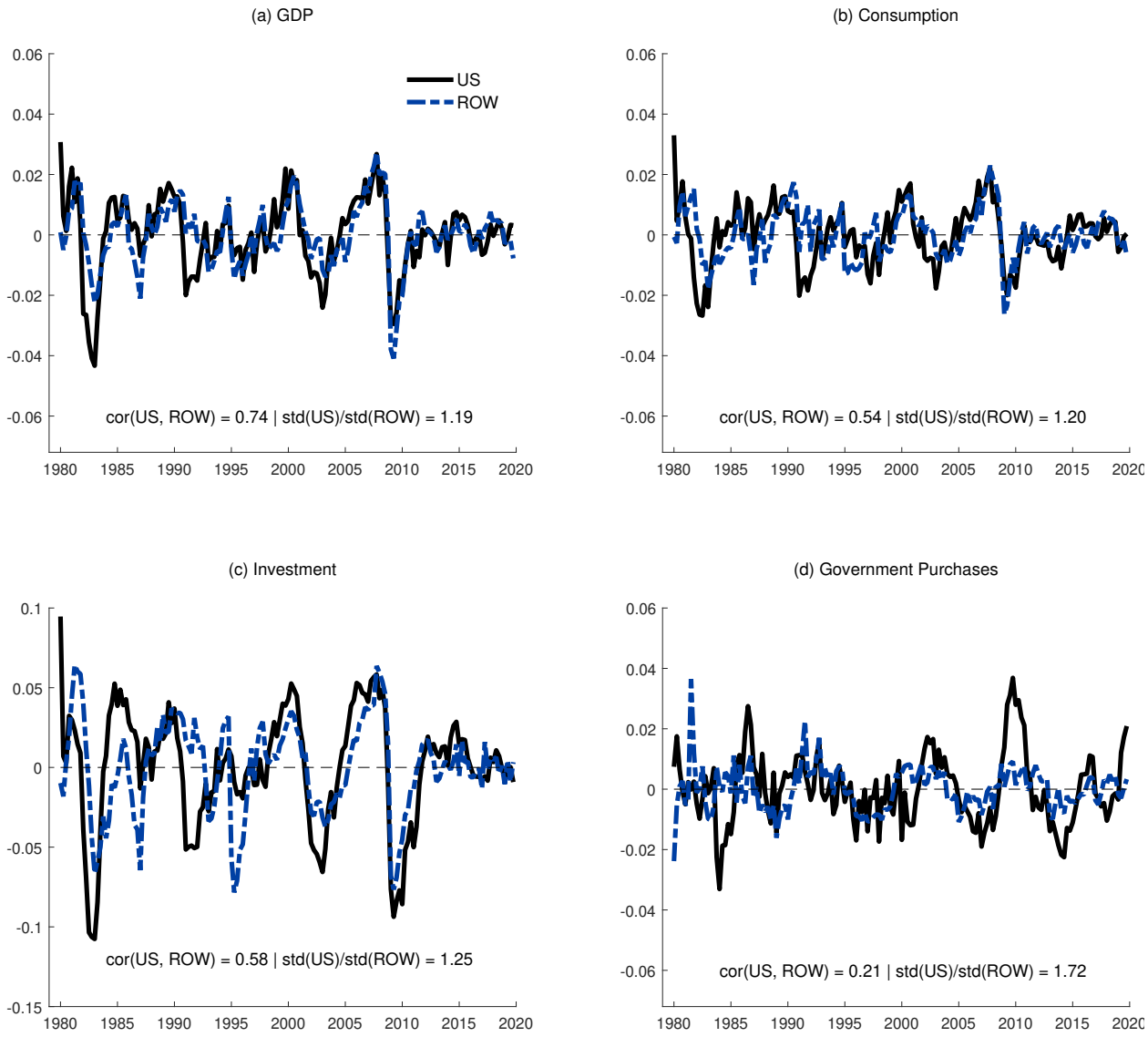


Figure A11: Macro Aggregates in US and ROW (HP Filter $\lambda = 1600$)

B Transmission Mechanisms

To identify the effects on international financial and goods market I estimate the IRFs to a government spending shock under the same strategy as in Section 4. To gain degrees of freedom I drop the net trade flows from the Baseline specification in equation 1, and replace by the variable of interest.[63] The vectors of data in these specifications of the SVAR are given by,

$$Y_t' \equiv \left[FEG_t^{fed,us},\ g_t^{fed,us},\ g_t^{row},\ y_t - y_t^{row},\ inv_t - inv_t^{row},\ r_t - r_t^{row},\ RER_t, D_t^{us\,gov}\right]$$

$$Y_t' \equiv \left[FEG_t^{fed,us},\ g_t^{fed,us},\ g_t^{row},\ y_t - y_t^{row},\ inv_t - inv_t^{row},\ r_t - r_t^{row},\ RER_t, GFL_t, GFA_t\right]$$

$$Y_t' \equiv \left[FEG_t^{fed,us},\ g_t^{fed,us},\ g_t^{row},\ y_t - y_t^{row},\ inv_t - inv_t^{row},\ r_t - r_t^{row},\ RER_t, tot_t\right]$$

$$Y_t' \equiv \left[FEG_t^{fed,us},\ g_t^{fed,us},\ g_t^{row},\ y_t - y_t^{row},\ inv_t - inv_t^{row},\ r_t - r_t^{row},\ RER_t, tot_t^k\right]$$

where $D_t^{us\,gov}$ is US federal debt in hands of US agents, excluding US government institutions, GFL_t are US gross foreign liabilities, GFA_t are US gross foreign assets, tot are the terms of trade of the aggregate of goods in the US, and tot^k are the terms of trade of capital goods in the US.

[63] The data sources are displayed in Appendix A.

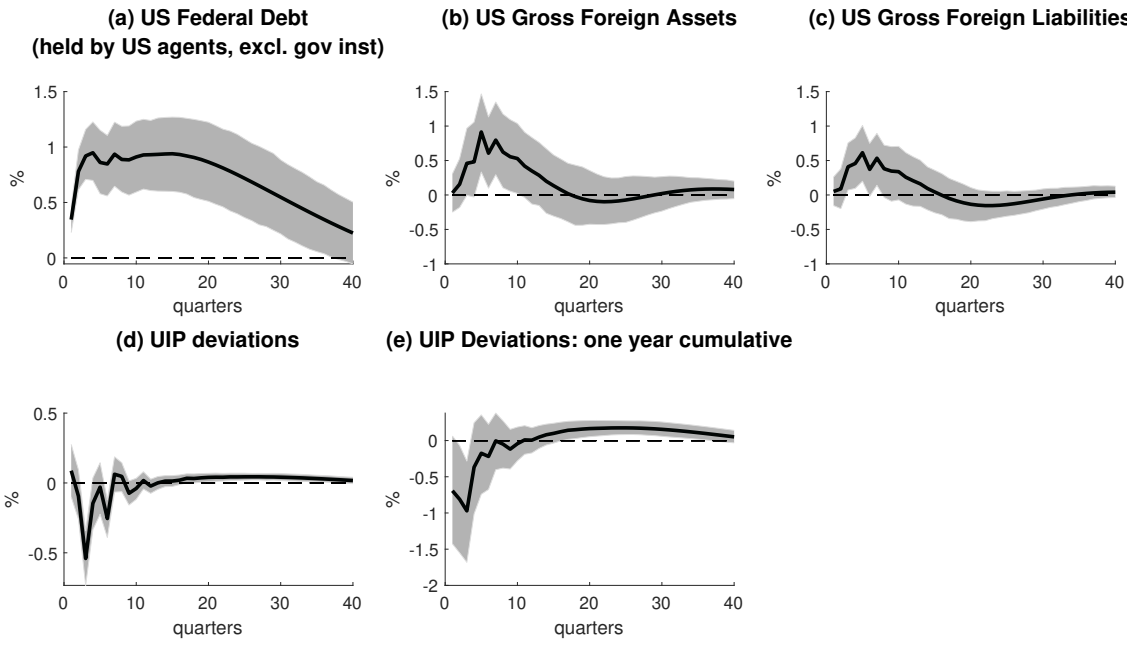


Figure B.1: International Financial Markets Mechanism

Notes: Standard error bands are 68% confidence intervals.

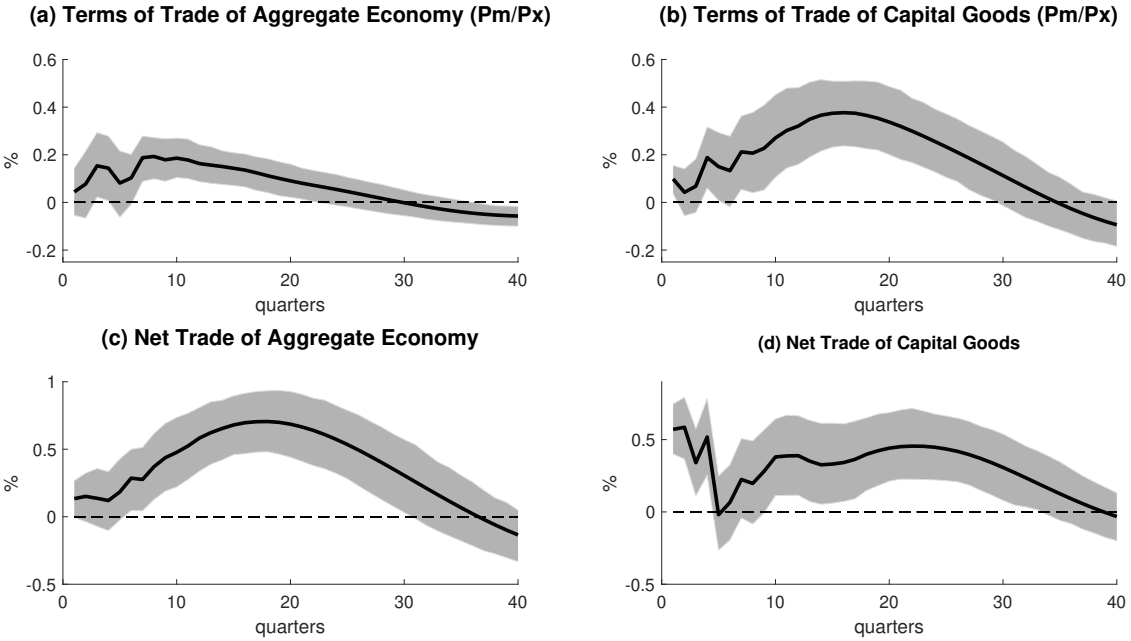


Figure B.2: International Goods Markets Mechanism

Notes: Standard error bands are 68% confidence intervals.

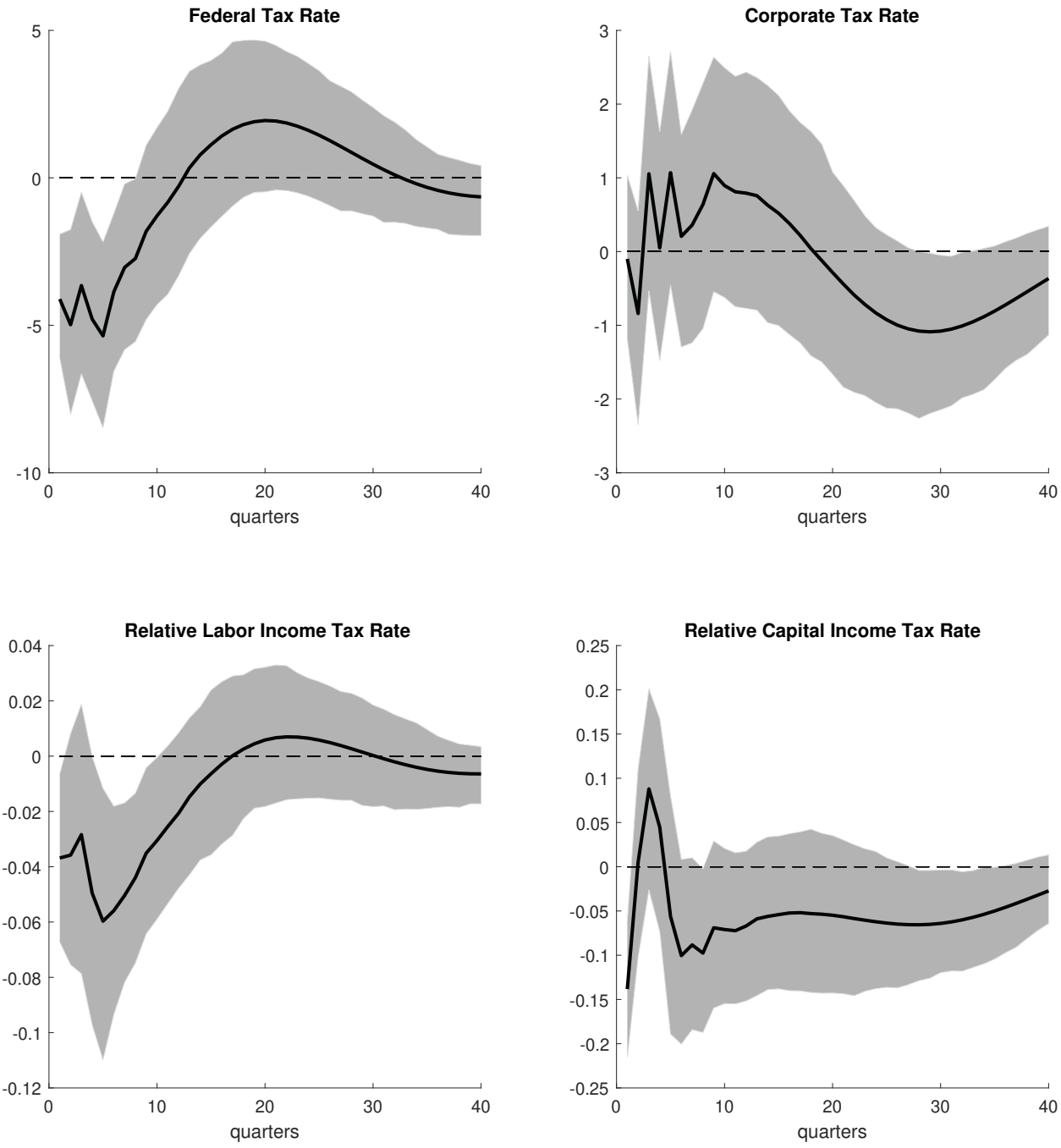


Figure B.3: IRFs other Fiscal Variables

Notes: Standard error bands are 68% confidence intervals.

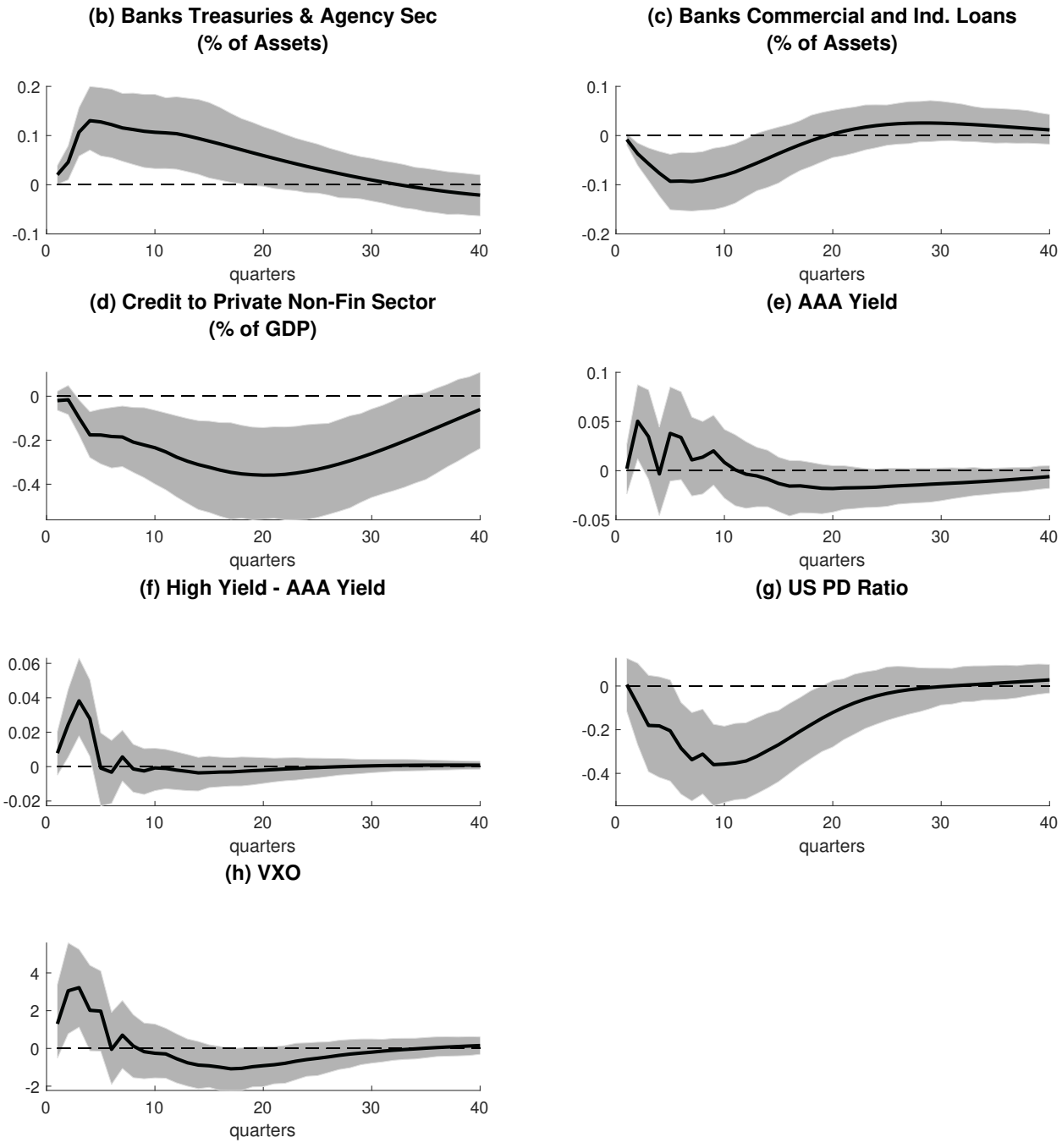


Figure B.4: IRFs of other US Financial Markets and Banking Variables

Notes: Standard error bands are 68% confidence intervals.

C SVAR Robustness

C.1 Alternative Identification Strategies

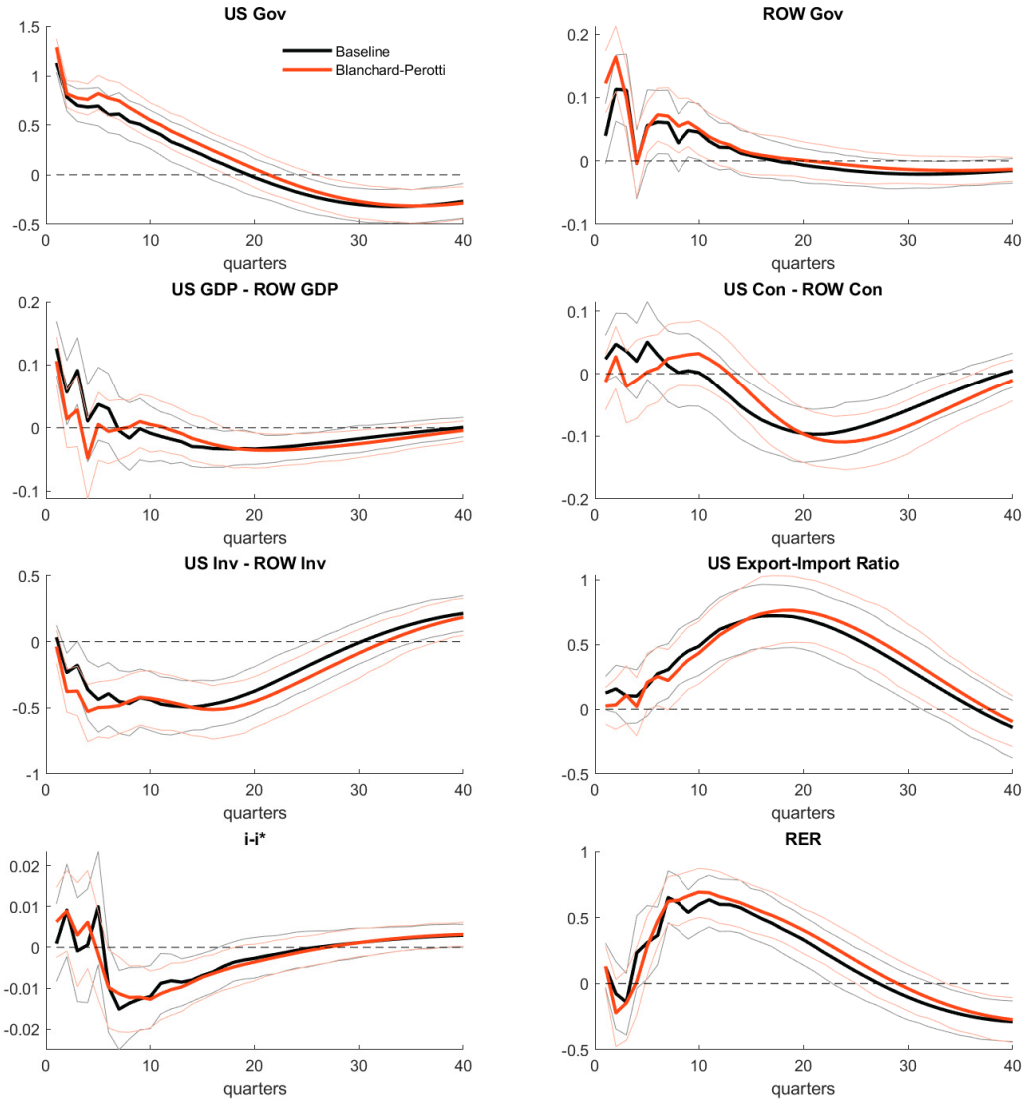


Figure C.1: Blanchard-Perotti

Notes: Standard error bands are 68% confidence intervals.

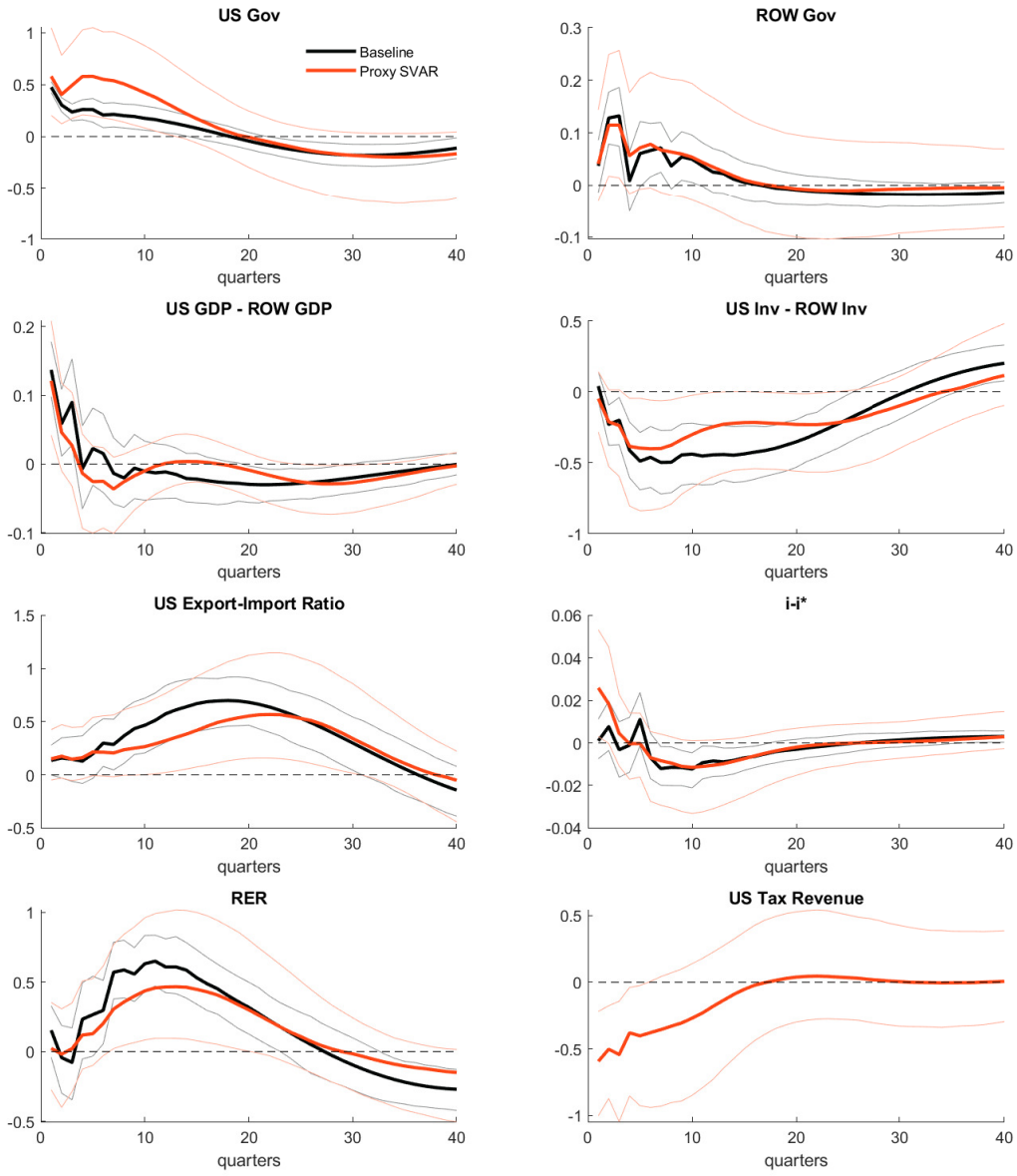


Figure C.2: External Instruments or Proxy SVAR

Notes: Standard error bands are 68% confidence intervals.

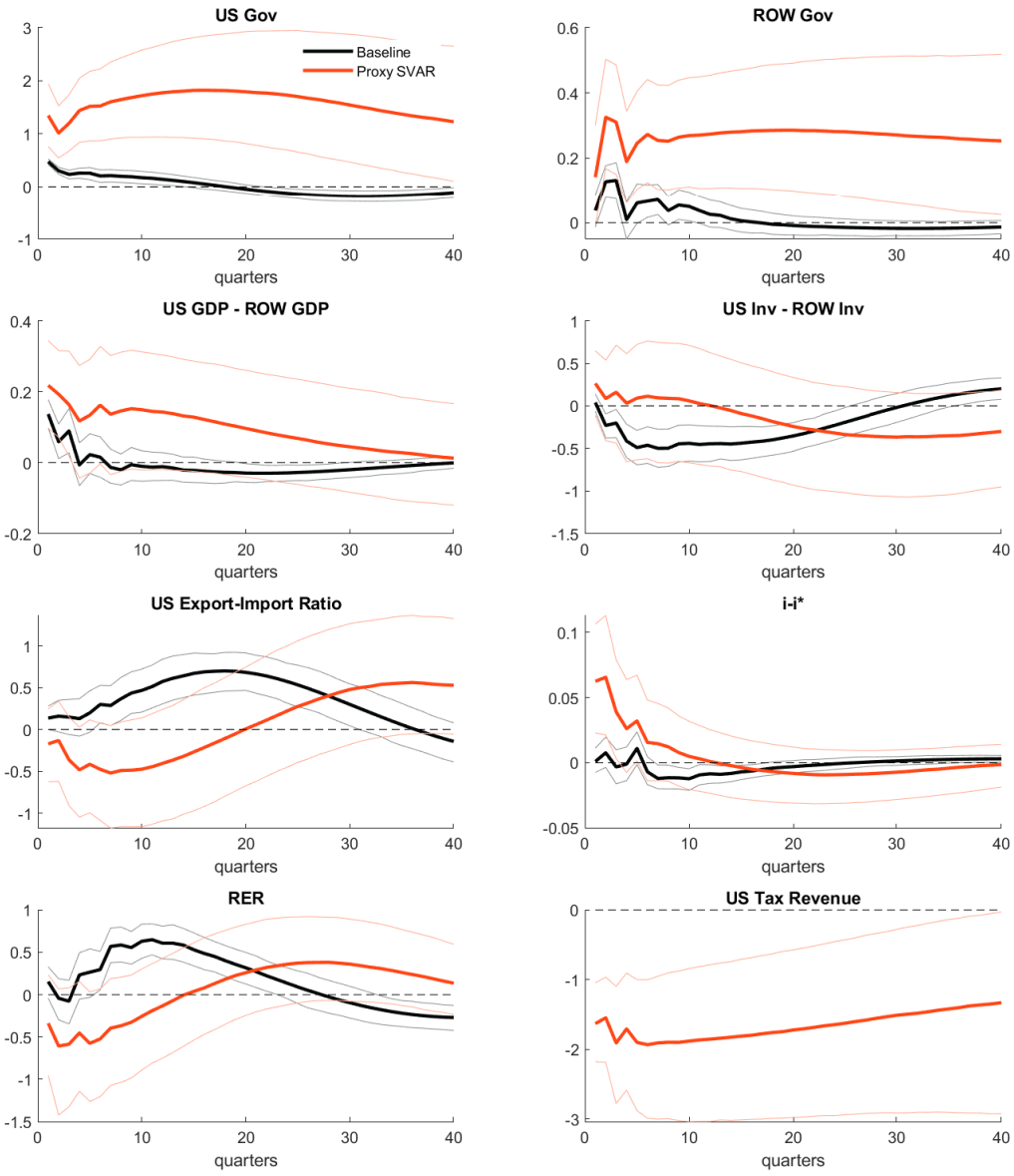


Figure C.3: External Instruments or Proxy SVAR: no trends in Proxy SVAR

Notes: Standard error bands are 68% confidence intervals.

C.2 Alternative Controls and Sensitivity

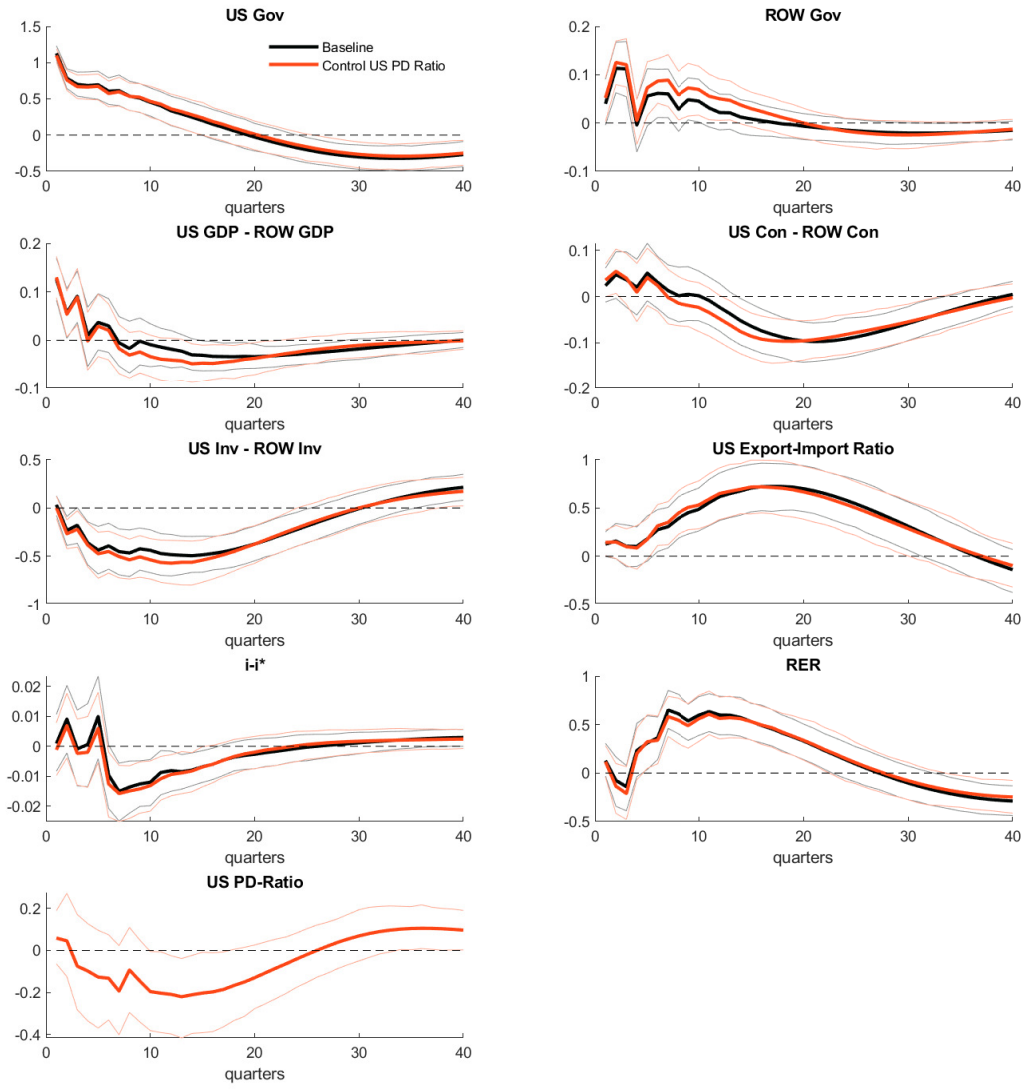


Figure C.4: Control for US Price-Dividend Ratio

Notes: Standard error bands are 68% confidence intervals.

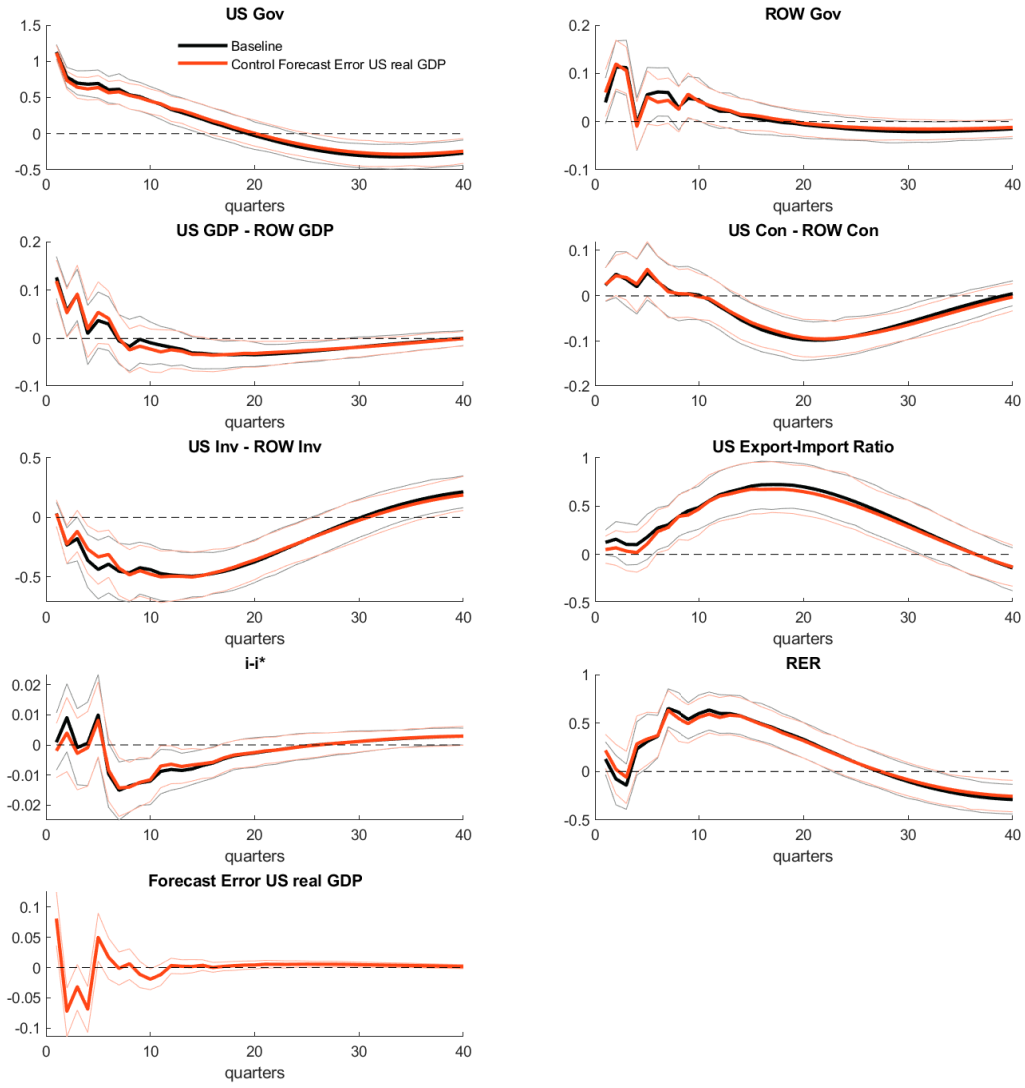


Figure C.5: Control for Forecast Errors of real GDP

Notes: Standard error bands are 68% confidence intervals.

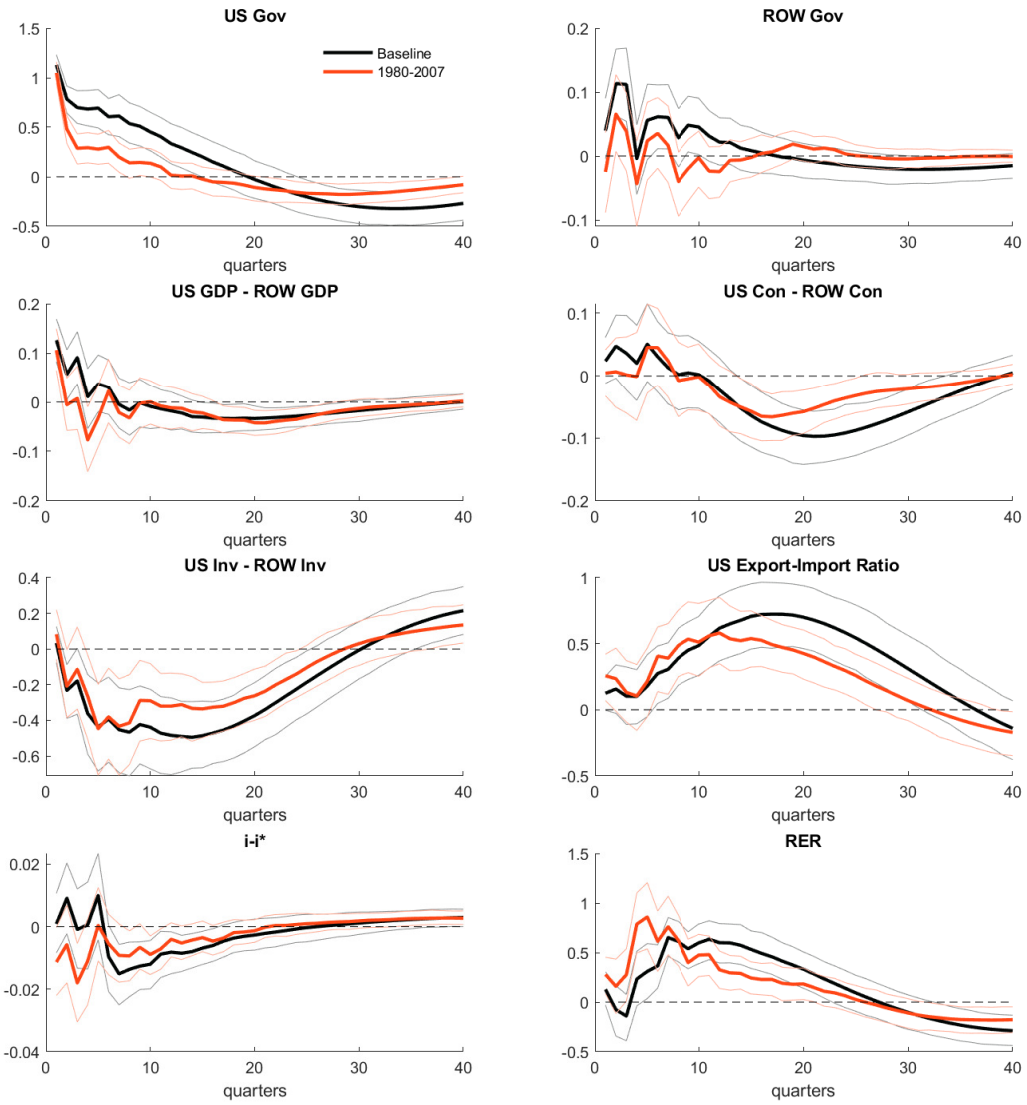


Figure C.6: Sample 1980Q1 - 2007Q4

Notes: Standard error bands are 68% confidence intervals.

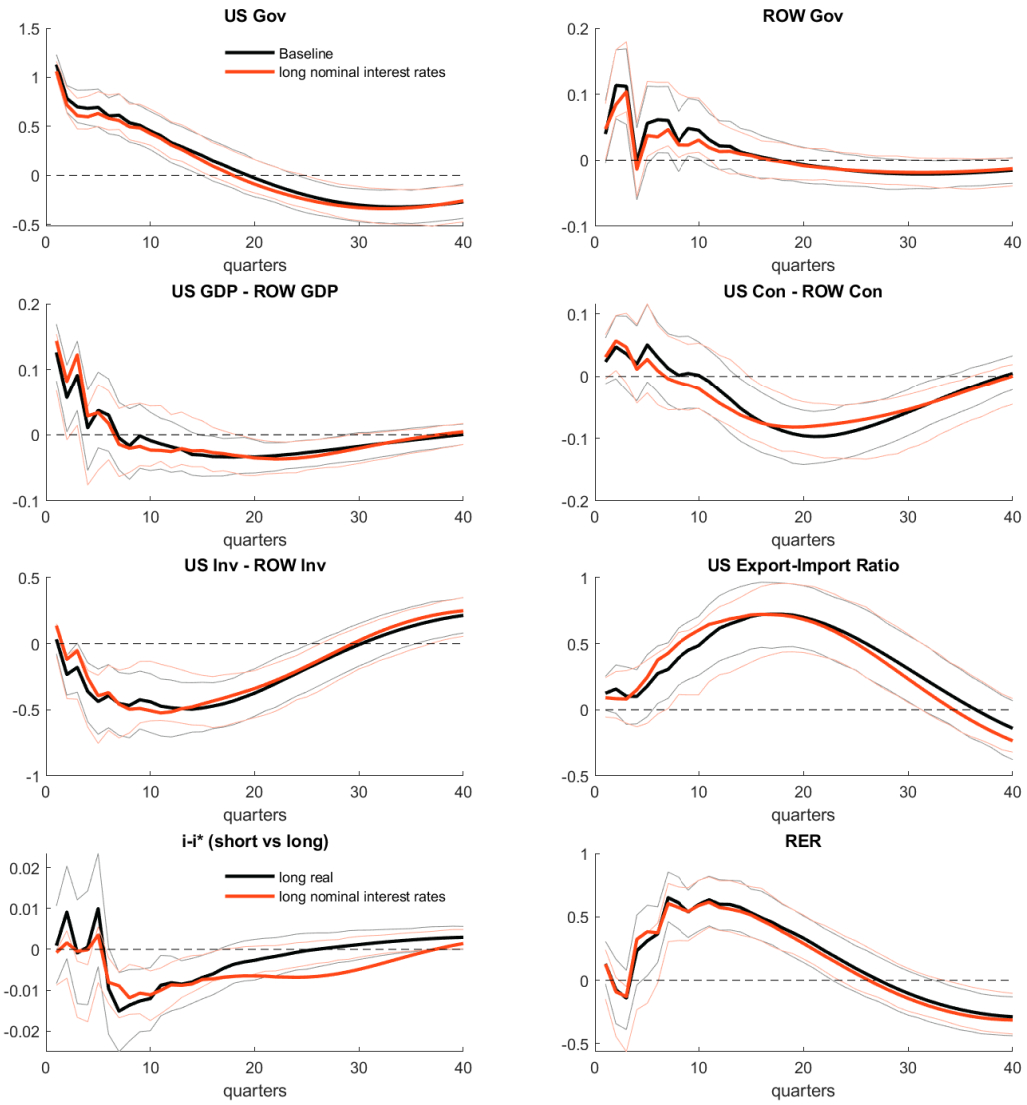


Figure C.7: Long Nominal Interest Rates

Notes: Standard error bands are 68% confidence intervals.

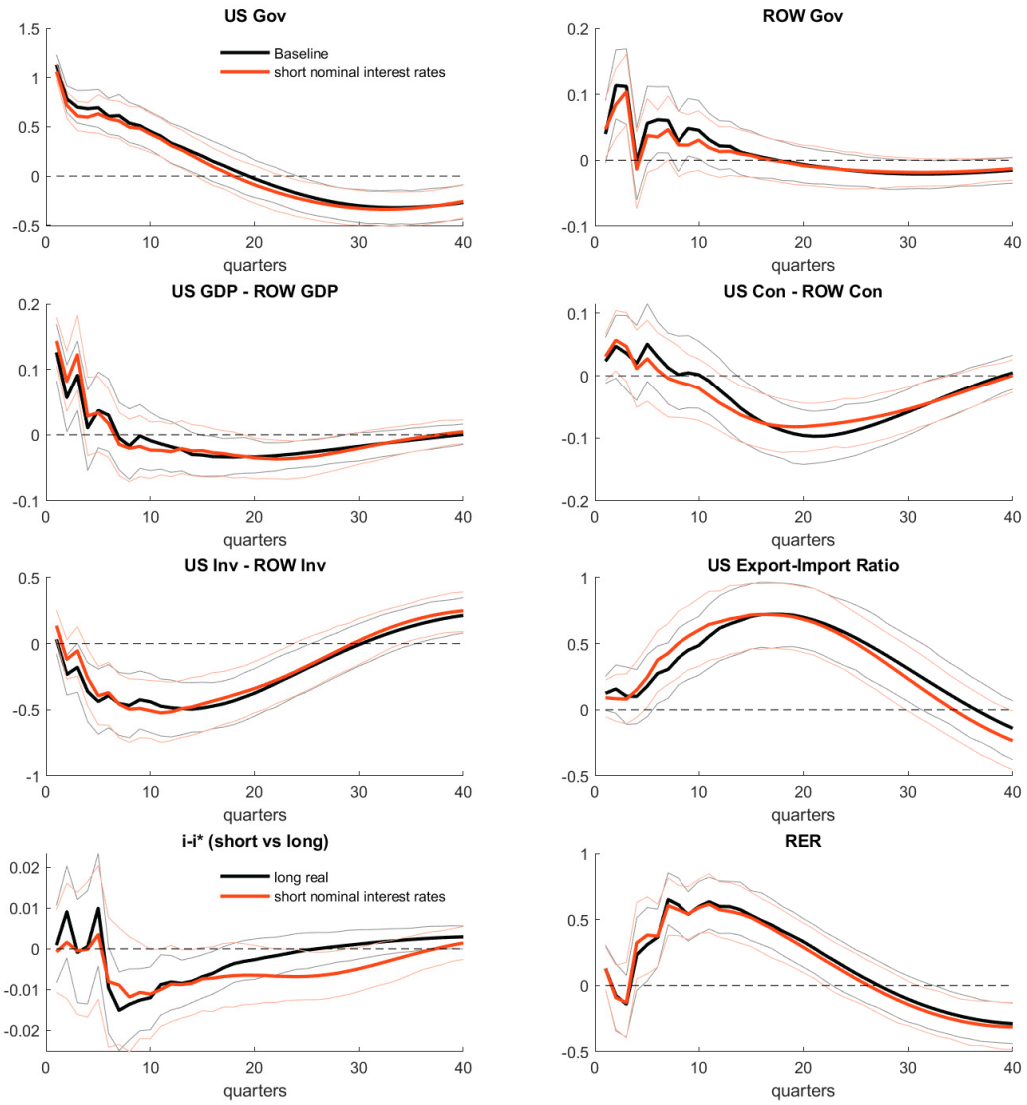


Figure C.8: Short Nominal Interest Rates

Notes: Standard error bands are 68% confidence intervals.

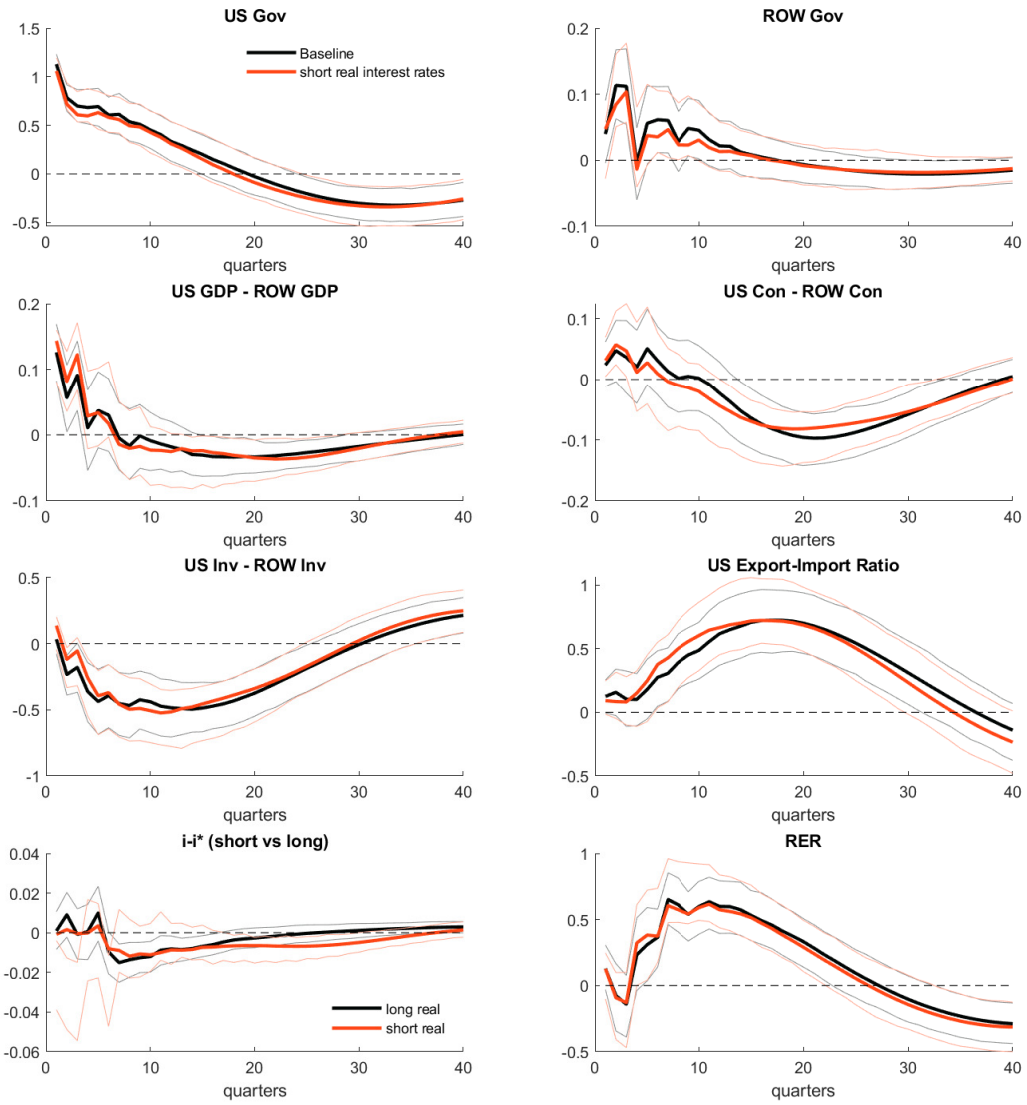


Figure C.9: Short Real Interest Rates

Notes: Standard error bands are 68% confidence intervals.

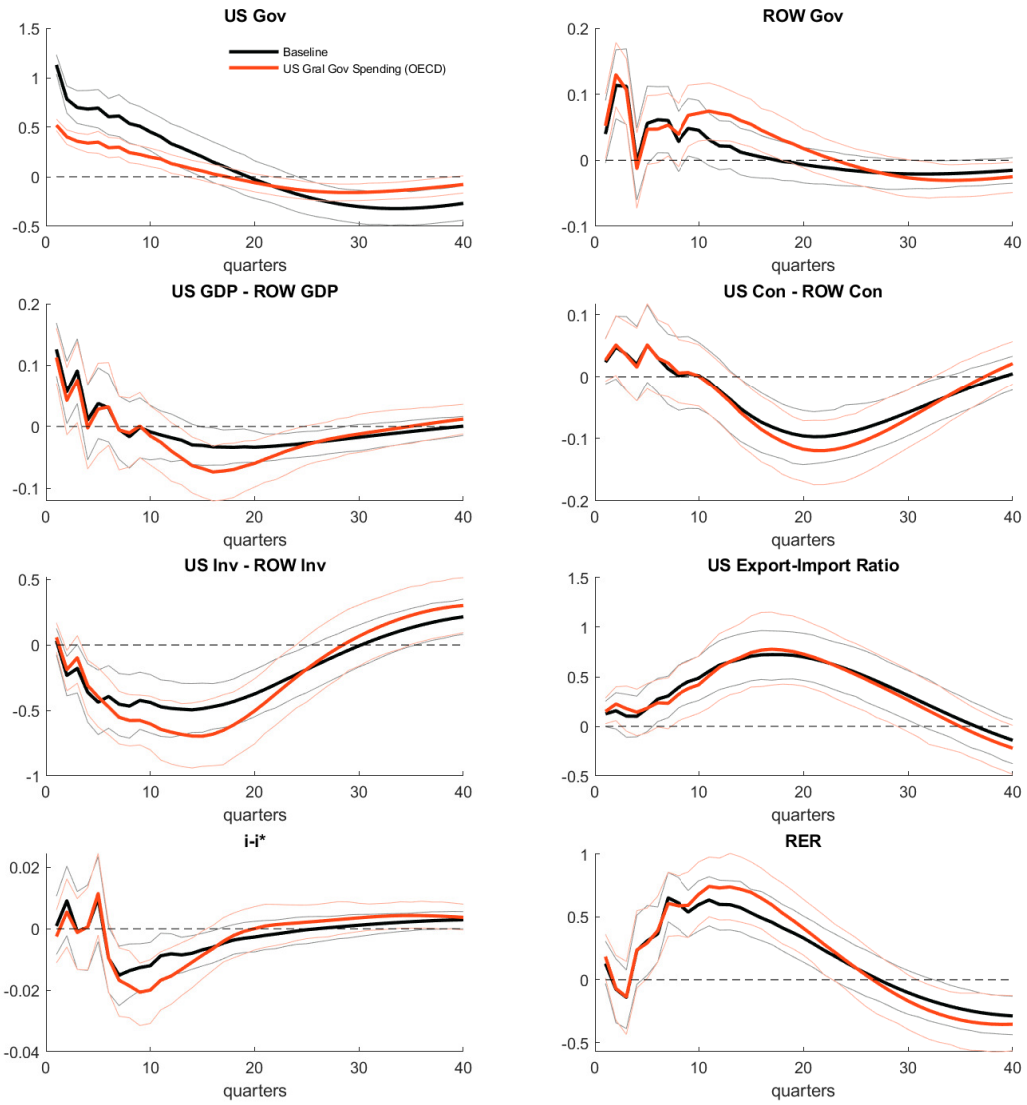


Figure C.10: US Gov Spending from OECD

Notes: Standard error bands are 68% confidence intervals.

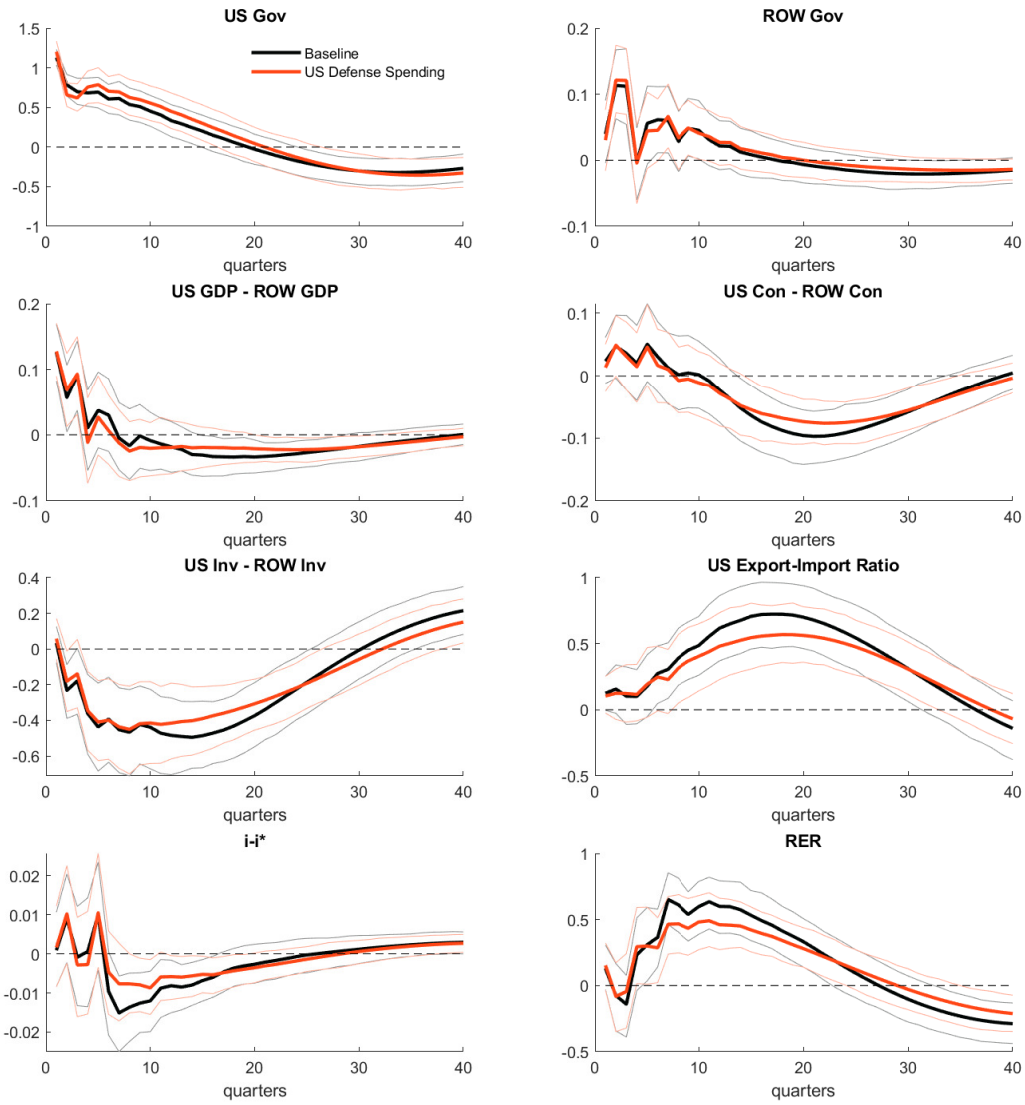


Figure C.11: US Defense Spending (NIPA)

Notes: Standard error bands are 68% confidence intervals.

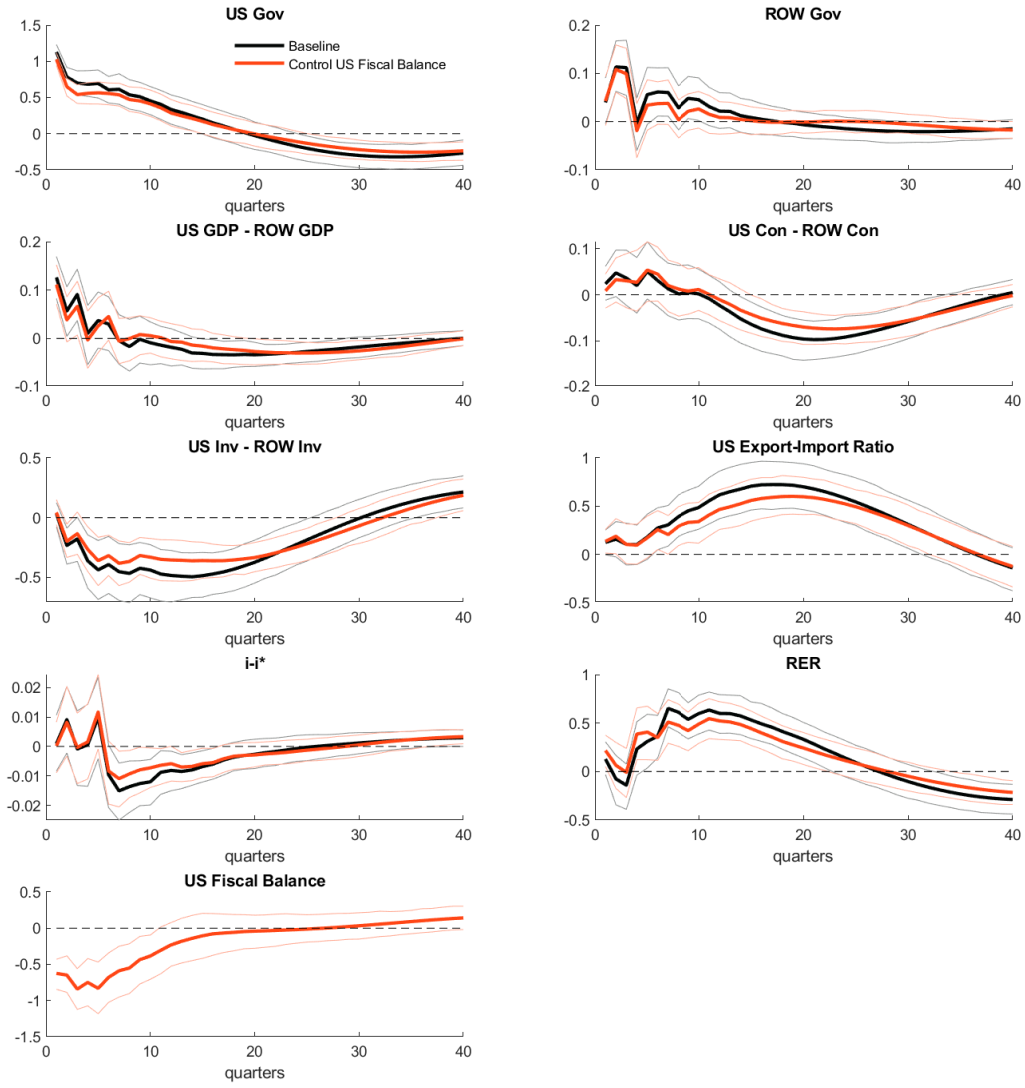


Figure C.12: Control for Fiscal Balance

Notes: Standard error bands are 68% confidence intervals.

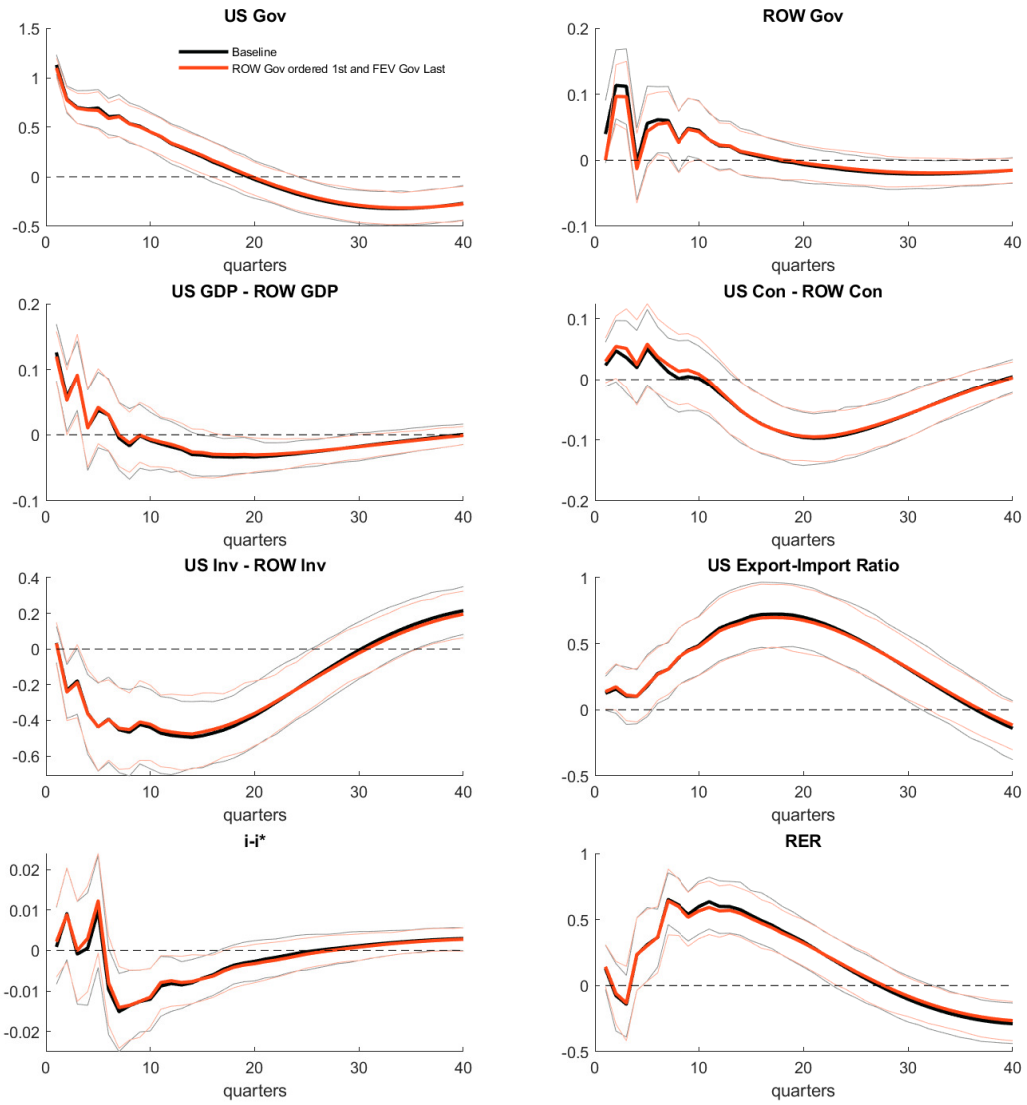


Figure C.13: ROW Gov Spending Ordered First and US Spending Forecast Error Ordered Last

Notes: Standard error bands are 68% confidence intervals.

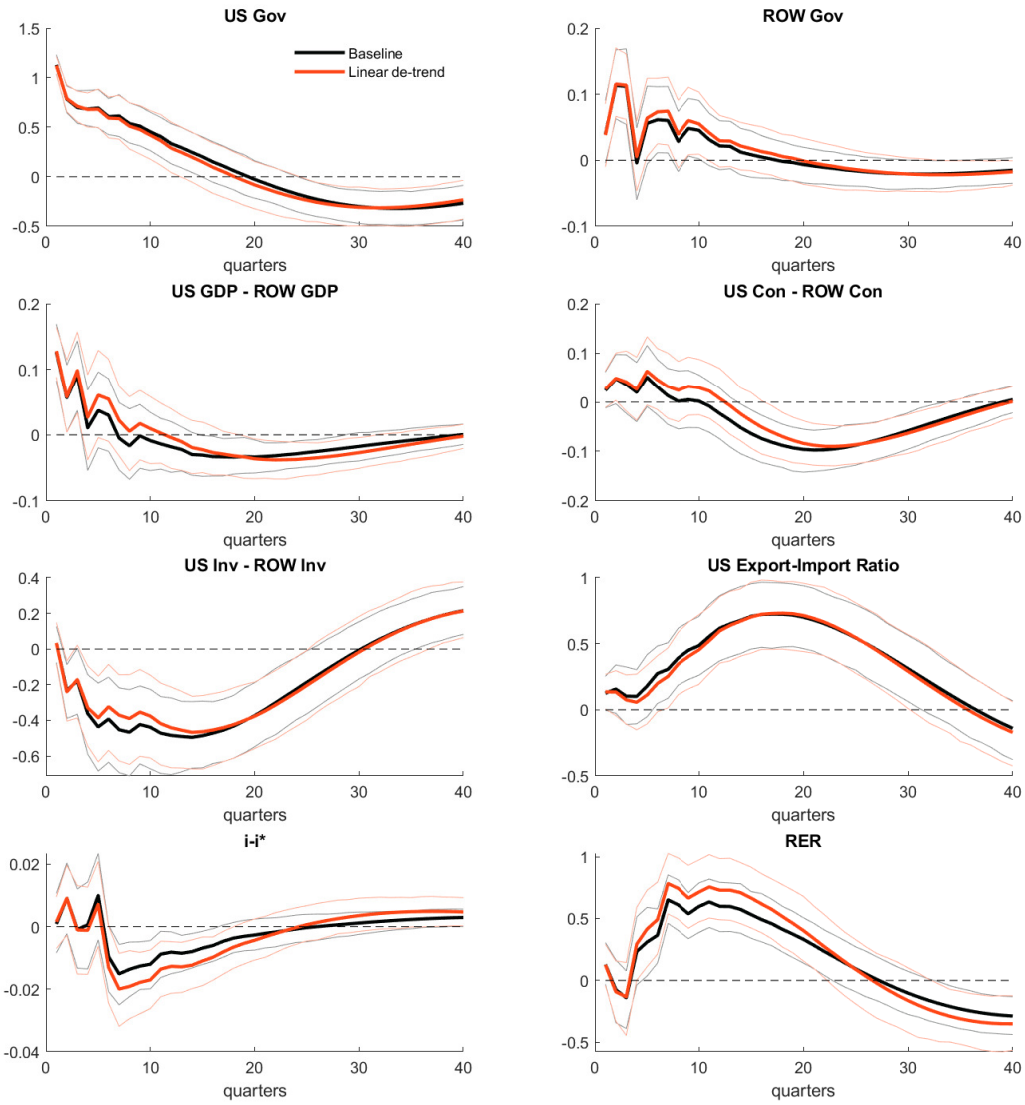


Figure C.14: Linear De-Trend

Notes: Standard error bands are 68% confidence intervals.

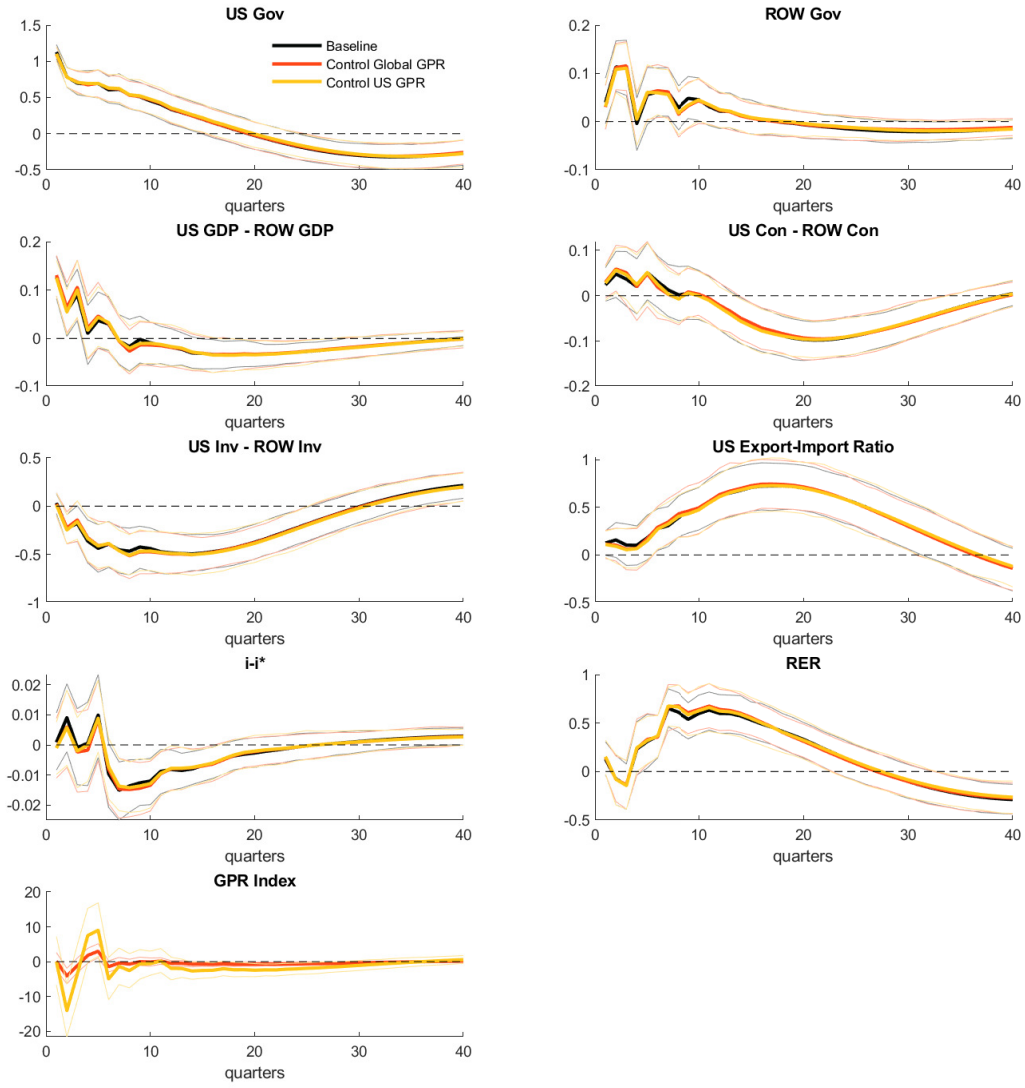


Figure C.15: Control for Geopolitical Risk Index (Caldara and Iacoviello, 2022)

Notes: Standard error bands are 68% confidence intervals.

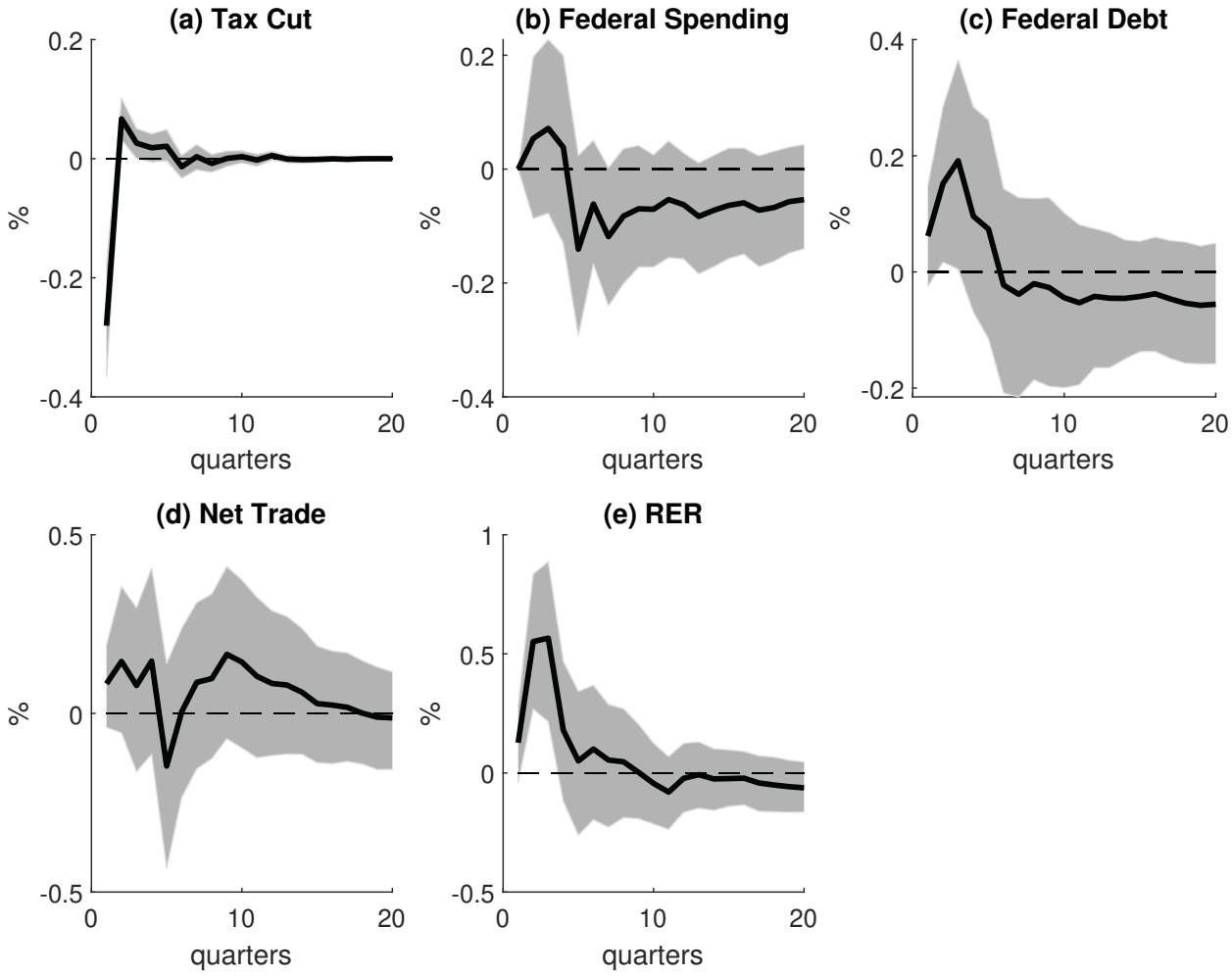


Figure C.16: Unanticipated Tax Cut (Mertens and Ravn, 2012)

Notes: Standard error bands are 68% confidence intervals.

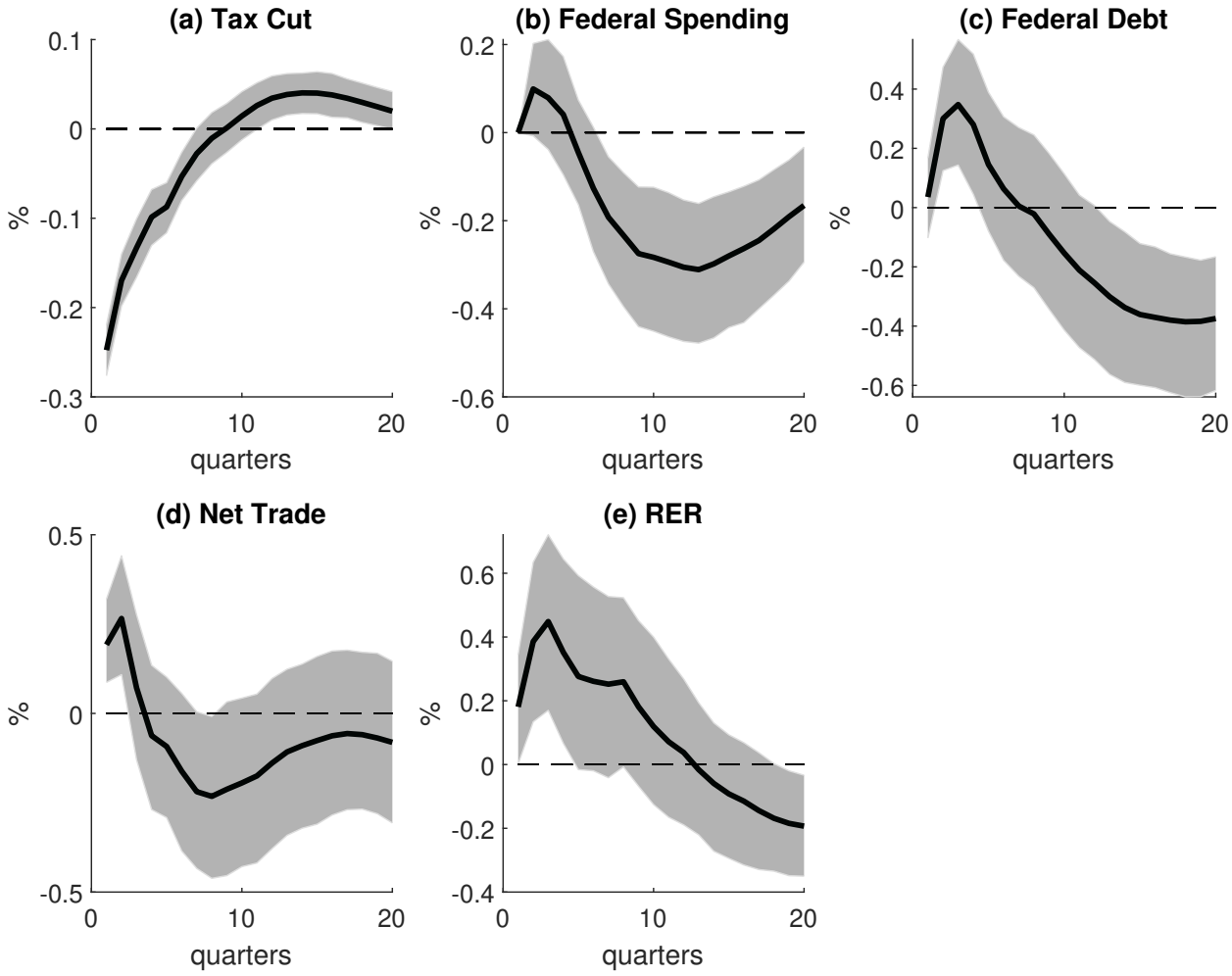


Figure C.17: VAR Federal Tax Cut Shock

Notes: Standard error bands are 68% confidence intervals.

	Baseline	BP	PD-ratio	US Military G
Relative Investment	31	22	36	24
Net Trade	34	26	35	28
RER	33	21	34	21
	Fiscal Balance	G^{row} order 1st	GPR	Linear De-trend
Relative Investment	24	23	29	33
Net Trade	27	32	35	35
RER	27	25	30	25
	Long Nominal Rates	Short Real Rates	Short Nominal Rates	Forecasts US GDP
Relative Investment	24	31	26	26
Net Trade	32	40	36	29
RER	26	34	30	27

Table C.1: Robustness Unconditional Variance Decomposition - Total US Gov (%)

	Baseline	BP	PD-ratio	US Military G
Relative Investment	**19**	-	23	15
Net Trade	**24**	-	16	20
RER	**24**	-	17	13
	Fiscal Balance	G^{row} order 1st	GPR	Linear De-trend
Relative Investment	13	16	17	11
Net Trade	20	24	24	17
RER	14	17	18	15
	Long Nominal Rates	Short Real Rates	Short Nominal Rates	Forecasts US GDP
Relative Investment	14	14	15	17
Net Trade	19	19	24	21
RER	14	14	16	16

Table C.2: Robustness Unconditional Variance Decomposition - Forecast Error US Gov (%)

D Model

D.1 Proof of Proposition I

The log-linearized Euler equation 4 (under $\psi_t^{us} = 0$) is,

$$\Gamma \bar{s}^{row,us}(1 + \hat{s}_{t+1}^{row,us}) = 1 + \hat{\Omega}_{t,t+1} + \mathbb{E}_t \hat{\mathcal{E}}_{t+1} - \hat{\mathcal{E}}_t + \hat{R}_t^{row,us}$$

where $\hat{x}_t$ denotes the log-deviation from the steady state of variable x. Log-linearizing the equation for $s_{t+1}^{row,us} \equiv \frac{P_t B_{t+1}^{row,us} \mathcal{E}_t}{S_{t+1}^{us}}$, gives

$$\bar{s}^{row,us}(1 + \hat{s}_{t+1}^{row,us}) = \bar{s}^{row,us}(1 + \hat{P}_t + \hat{B}_{t+1}^{row,us} + \hat{\mathcal{E}}_t - \hat{S}_{t+1}^{us})$$

Then it holds that,

$$\Gamma \bar{s}^{row,us}(1 + \hat{P}_t + \hat{B}_{t+1}^{row,us} + \hat{\mathcal{E}}_t - \hat{S}_{t+1}^{us}) = 1 + \hat{\Omega}_{t,t+1} + \mathbb{E}_t \hat{\mathcal{E}}_{t+1} - \hat{\mathcal{E}}_t + \hat{R}_t^{row,us}$$

Solve for $\hat{B}_{t+1}^{row,us}$ and multiply each side by β,

$$\beta \hat{B}_{t+1}^{row,us} = \frac{\beta(1 - \Gamma \bar{s}^{row,us})}{\Gamma \bar{s}^{row,us}} + \frac{\beta}{\Gamma \bar{s}^{row,us}}(\hat{\Omega}_{t,t+1} + \mathbb{E}_t \hat{\mathcal{E}}_{t+1} - \hat{\mathcal{E}}_t) - \beta(\hat{\mathcal{E}}_t - \hat{S}_{t+1}^{us}) + \frac{\beta(1 + \Gamma \bar{s}^{row,us})}{\Gamma \bar{s}^{row,us}} \hat{R}^{row,us}$$

The partial equilibrium aggregate demand elasticity for the ROW bond, $\epsilon_{b^{row,us}}^d$, is given by

$$\frac{\partial(\beta \hat{B}_{t+1}^{row,us})}{\partial \hat{R}^{row,us}} = \frac{\beta(1 + \Gamma \bar{s}^{row,us})}{\Gamma \bar{s}^{row,us}} = \epsilon_{b^{row,us}}^d$$

Hence, the value of Γ consistent with the partial equilibrium aggregate demand elasticity is,

$$\Gamma = \frac{\beta}{\bar{s}^{row,us}(\epsilon_{b^{row,us}}^d - \beta)}$$

■

D.2 Other Moments

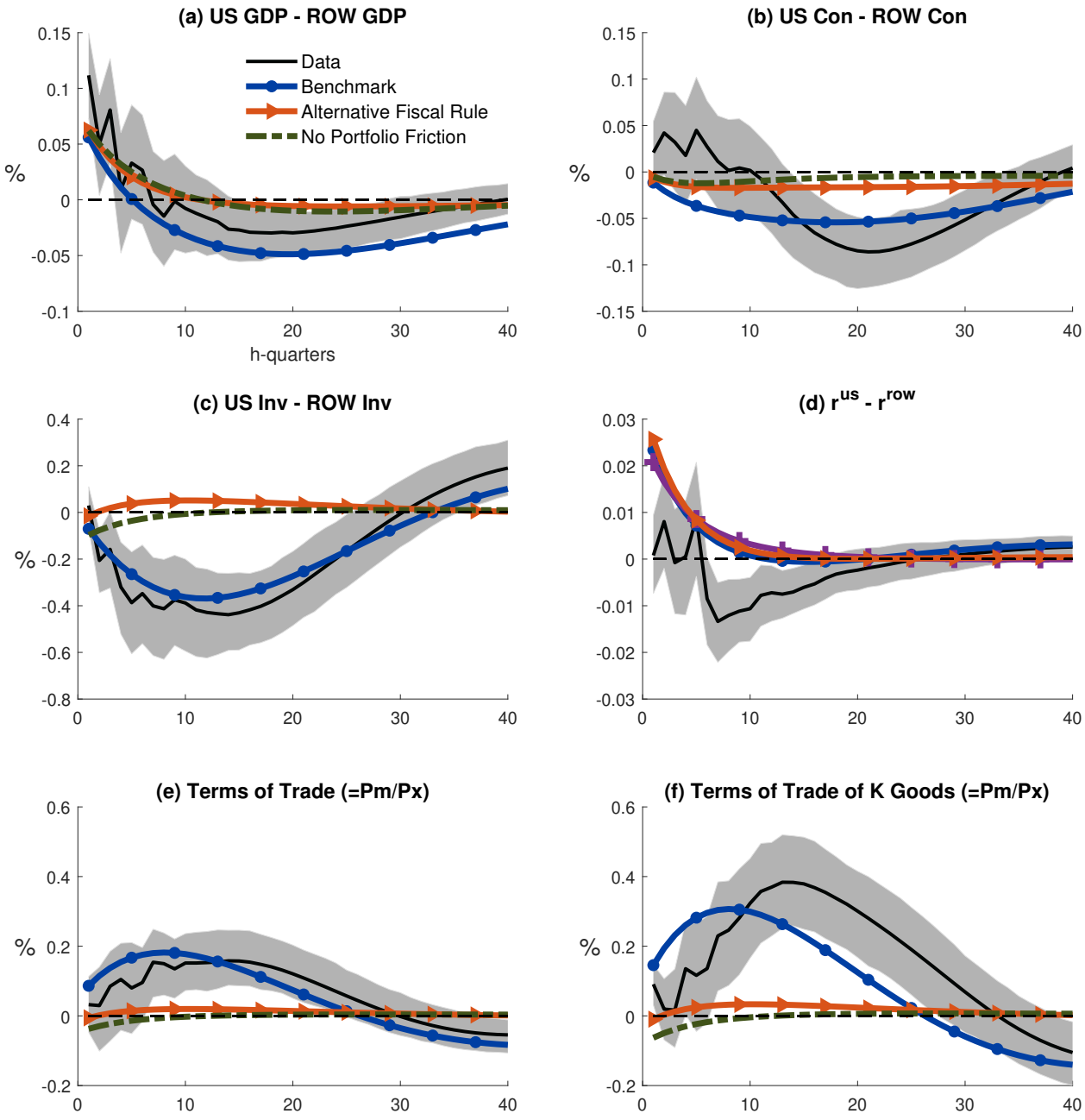


Figure D.1: Impulse Response Functions in Data and Models

Notes: Standard error bands are 68% confidence intervals.

E Sensitivity

E.1 Alternative Models

Parameter		Benchmark	Only G^{us} Shocks	No Dynamic Trade	Internalize Agg Fin Savings	ROW saves in US gov debt
1. Std common prod shock	σ_z^c	0.005	0†	0.006	0.005	0.005
		(0.001)		(0.001)	(0.001)	(0.000)
2. Pers common prod shock	ρ_z^c	0.99	0†	0.99	0.99	0.99
		(0.165)		(0.1450)	(0.291)	(0.015)
3. Pers US gov shock	ρ_g^{us}	0.92	0.92	0.89	0.92	0.93
		(0.032)	(0.036)	(0.042)	(0.032)	(0.029)
4. Std ROW gov shock	σ_g^{row}	0.004	0†	0.001	0.003	0.003
		(0.02)		(0.007)	(0.002)	(0.001)
5. Pers ROW gov shock	ρ_g^{row}	0.84	0.84†	0.95	0.83	0.83
		(0.176)		(0.201)	(0.181)	(0.166)
6. Std differential trade shock	σ_ξ^d	0.016	0†	0.007	0.03	0.018
		(0.005)		(0.007)	(0.010)	(0.006)
7. Pers of differential trade shock	ρ_ξ^d	0.95	0†	0.92	0.64	0.94
		(0.045)		(0.177)	(0.209)	(0.054)
8. Std differential financial shock	σ_ψ^d	0.016	0†	0.0171	0.001	0.01
		(0.005)		(0.005)	(0.003)	(0.002)
9. Pers differential financial shock	ρ_ψ^d	0.75	0†	0.92	0.98	0.80
		(0.222)		(0.073)	(3.17)	(0.140)
10. Std common portfolio shock	σ_ψ^c	0.006	0†	0.006	0.00	0.006
		(0.002)		(0.004)	(0.003)	(0.002)
11. Pers common financial shock	ρ_ψ^c	0.97	0†	0.97	0.93	0.98
		(0.453)		(1.438)	(15.24)	(0.503)
12. Pricing-to-Market friction	ζ	1.22	1.22†	1.80	1.34	1.25
		(0.237)		(0.249)	(0.255)	(0.0234)
13. Adj cost CES	ι	191.5	221.7	0†	333.9	176.3
		(3.888)	(25.75)		(6.333)	(2.976)
14. Response gov spending to debt	$\varphi^{g,b}$	-0.03	-0.03	-0.04	-0.03	-0.03
		(0.010)	(0.010)	(0.021)	(0.0133)	(0.0108)
15. Response taxes to debt	$\varphi^{T,b}$	0.04	0.04	0.03	0.07	0.03
		(0.020)	(0.021)	(0.021)	(0.027)	(0.016)

Notes: standard errors (se) are calculated using the asymptotic Delta function method as in Christiano et al. (2005). The subscript † indicates the parameter is set externally.

Table F.1: SMM Estimated Parameters

Moment	Data	Benchmark	No Dynamic Trade	Internalize Agg Fin Savings	ROW saves in US gov debt
$\sigma(gdp^{us})$	0.02	0.01	0.01	0.01	0.01
$\rho(gdp^{us}, gdp^{row})$	0.84	0.98	0.87	0.97	0.98
$\sigma(gov^{us})/\sigma(gdp^{us})$	2.03	2.19	1.83	2.68	2.41
$\sigma(gov^{row})/\sigma(gdp^{row})$	0.63	0.61	0.60	0.68	0.62
$\rho(gov^{row})$	0.78	0.78	0.99	0.78	0.78
$\sigma(rer)/\sigma(gdp^{us})$	3.32	2.02	2.37	1.51	2.10
$\sigma(nt)/\sigma(rer)$	1.19	0.99	1.90	0.60	1.03
$\sigma(tot)/\sigma(rer)$	0.34	0.42	0.04	0.42	0.41
$\rho(rer)$	0.94	0.89	0.86	0.92	0.88
$\rho(nt)$	0.97	0.99	0.93	0.93	0.98
SR trade elast.	0.17	0.13	1.09	0.35	0.13
LR trade elast.	1.30	1.40	2.24	0.79	1.41
$\sigma(gfa^{us})/\sigma(gdp^{us})$	4.07	4.50	4.35	3.15	4.46
$\sigma(B^{g,us})/\sigma(gdp^{us})$	2.10	3.43	2.91	3.31	3.32
$\sigma(s^{g,us})/\sigma(gdp^{us})$	1.01	0.82	0.89	0.14	0.84
$\sigma(r^{us} - r^{row})/\sigma(gdp^{us})$	0.06	0.07	0.16	0.25^{+}	0.07
$\rho(s^{g,us})$	0.91	0.86	0.86	0.87	0.86
$\rho(r^{us} - r^{row})$	0.87	0.74	0.75	0.80	0.76
β_{Fama}	-1.38	-1.26	-1.57	-0.23	-1.31
$\rho(B^{g,us} - B^{g,row}, rer)$	0.63	0.45	0.08	0.41	0.36
$\rho(gov^{us} - gov^{row}, rer_{-5})$	0.00	0.05	0.03	-0.02	0.04
$\rho(gov^{us} - gov^{row}, rer_{+5})$	0.73	0.50	0.26	0.52	0.43
$\rho(gov^{us} - gov^{row}, nt_{-5})$	-0.35	-0.03	-0.05	-0.35	-0.03
$\rho(gov^{us} - gov^{row}, nt_{+5})$	0.23	0.26	0.30	0.27	0.20

Notes: The subscript $^{+}$ means the moment is not targeted.

Table F.2: Target Unconditional Moments

Moment	Data	Benchmark	No Dynamic Trade	Internalize Agg Fin Savings	ROW saves in US gov debt
BSK: $\rho\left(\Delta rer, \Delta(c^{us} - c^{row})\right)$	-0.17	-0.47	-0.61	-0.80	-0.46
R^2_{Fama}	0.01	0.01	0.06	0.03	0.01
$\rho(tot, rer)$	0.86	0.98	0.77	0.90	0.97
$\rho(r^{us} - r^{row}, rer)$	-0.43	0.16	0.88	-0.21	0.16
Low freq RER spectrum	0.62	0.64	0.45	0.70	0.63
BC freq RER spectrum	0.31	0.28	0.41	0.24	0.29
$\sigma(inv^{us})/\sigma(gdp^{us})$	2.87	2.25	2.30	2.19	2.27
$\rho(inv^{us})$	0.96	0.98	0.98	0.97	0.98
$\rho(con^{us})$	0.96	0.97	0.97	0.97	0.97
$\rho(inv^{us} - inv^{row}, rer)$	-0.62	-0.71	-0.58	-0.67	-0.73
$\rho(B^{g,us})$	0.95	0.98	0.97	0.98	0.99
$\rho(B^{g,us}, g^{us})$	0.60	0.22	0.10	0.27	0.18
$\rho(B^{g,us}, gfa^{us})$	0.23	0.65	0.53	0.98	0.62
$\rho(gfa^{us}, gfl^{us})$	0.87	0.75	0.62	0.80	0.84

Notes: gfa and gfl stand for gross foreign assets and liabilities. BC stands for 'Business Cycle'.

Table F.3: Untarget Unconditional Moments

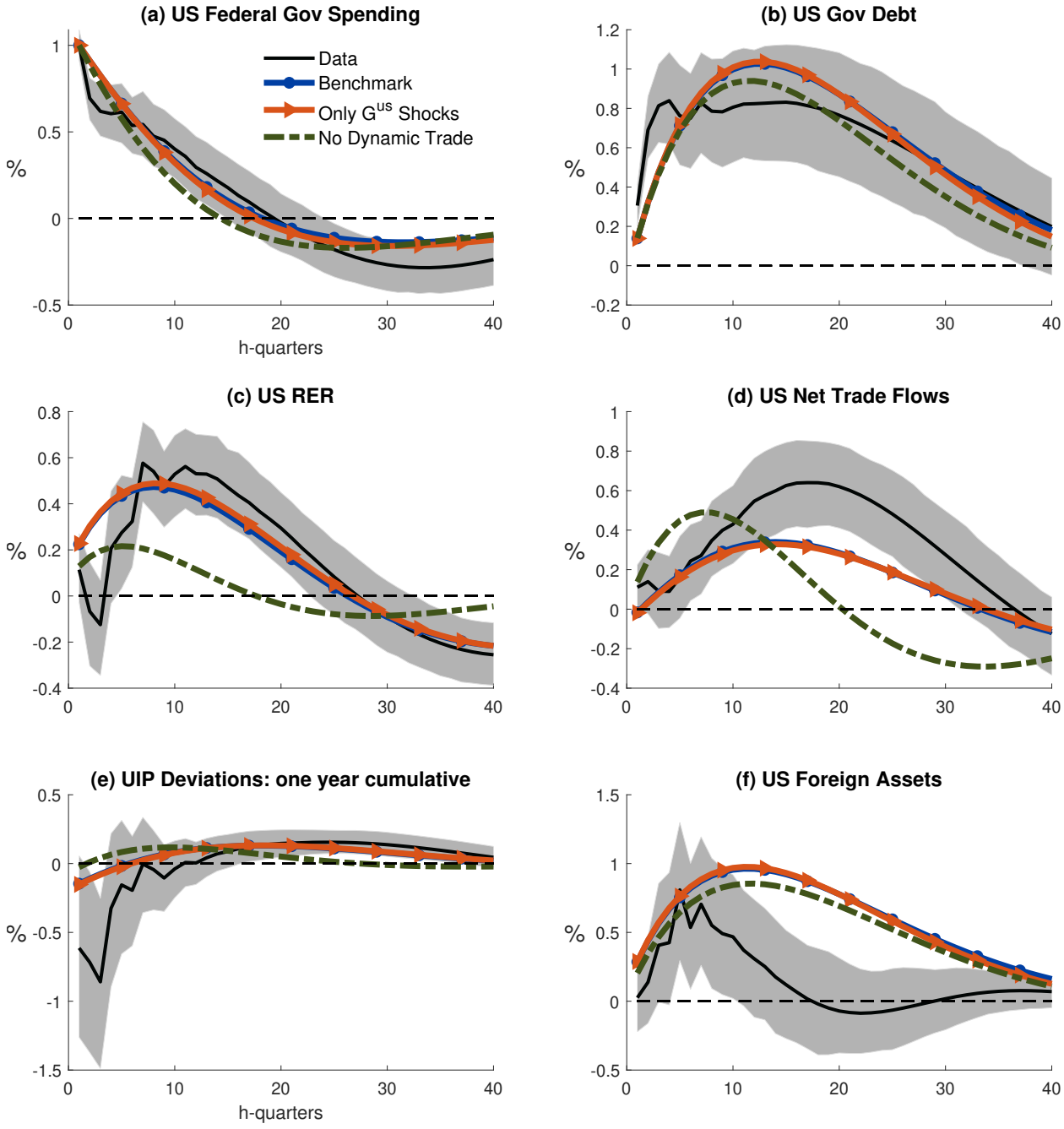


Figure F.1: Impulse Response Functions: SVAR and Models

Notes: Standard error bands are 68% confidence intervals.

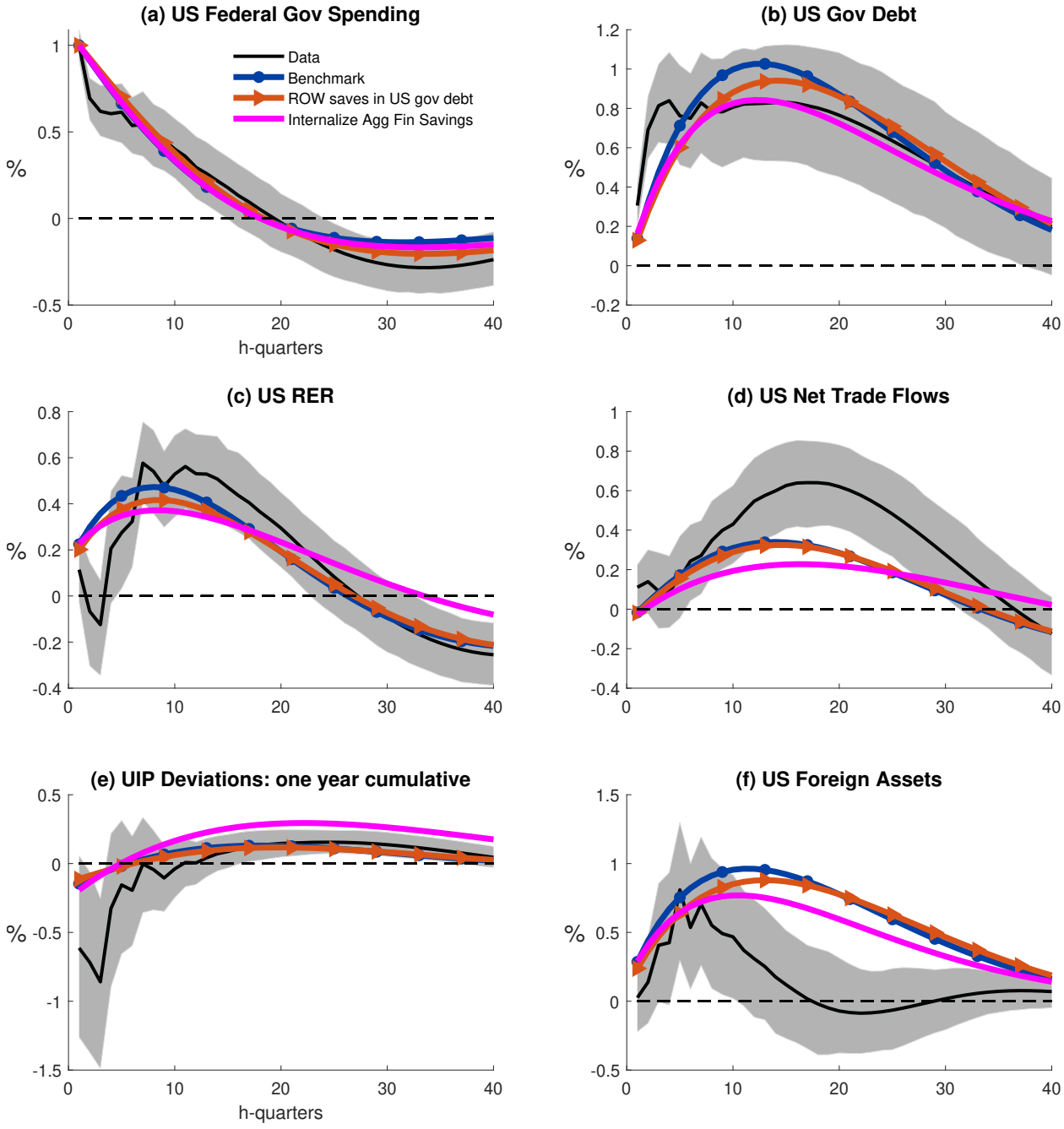


Figure F.2: Impulse Response Functions in Data and Models

Notes: Standard error bands are 68% confidence intervals.

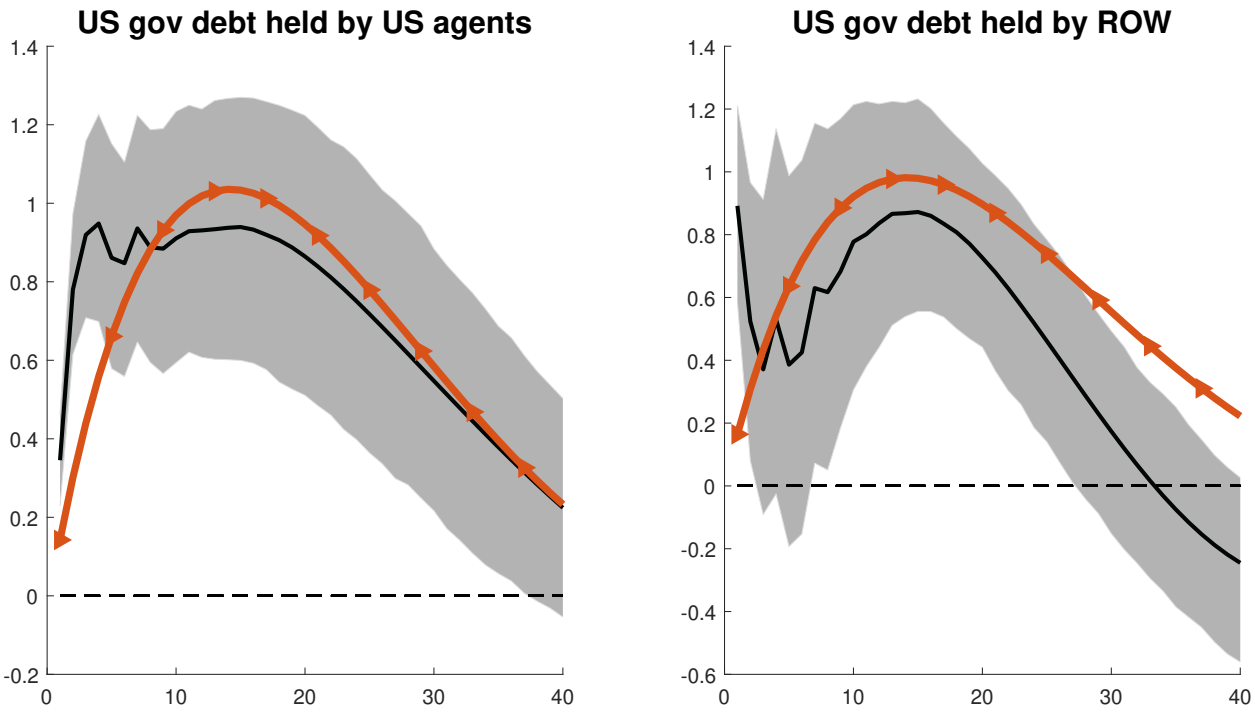


Figure F.3: Impulse Response Functions: SVAR and Models

Notes: Standard error bands are 68% confidence intervals.

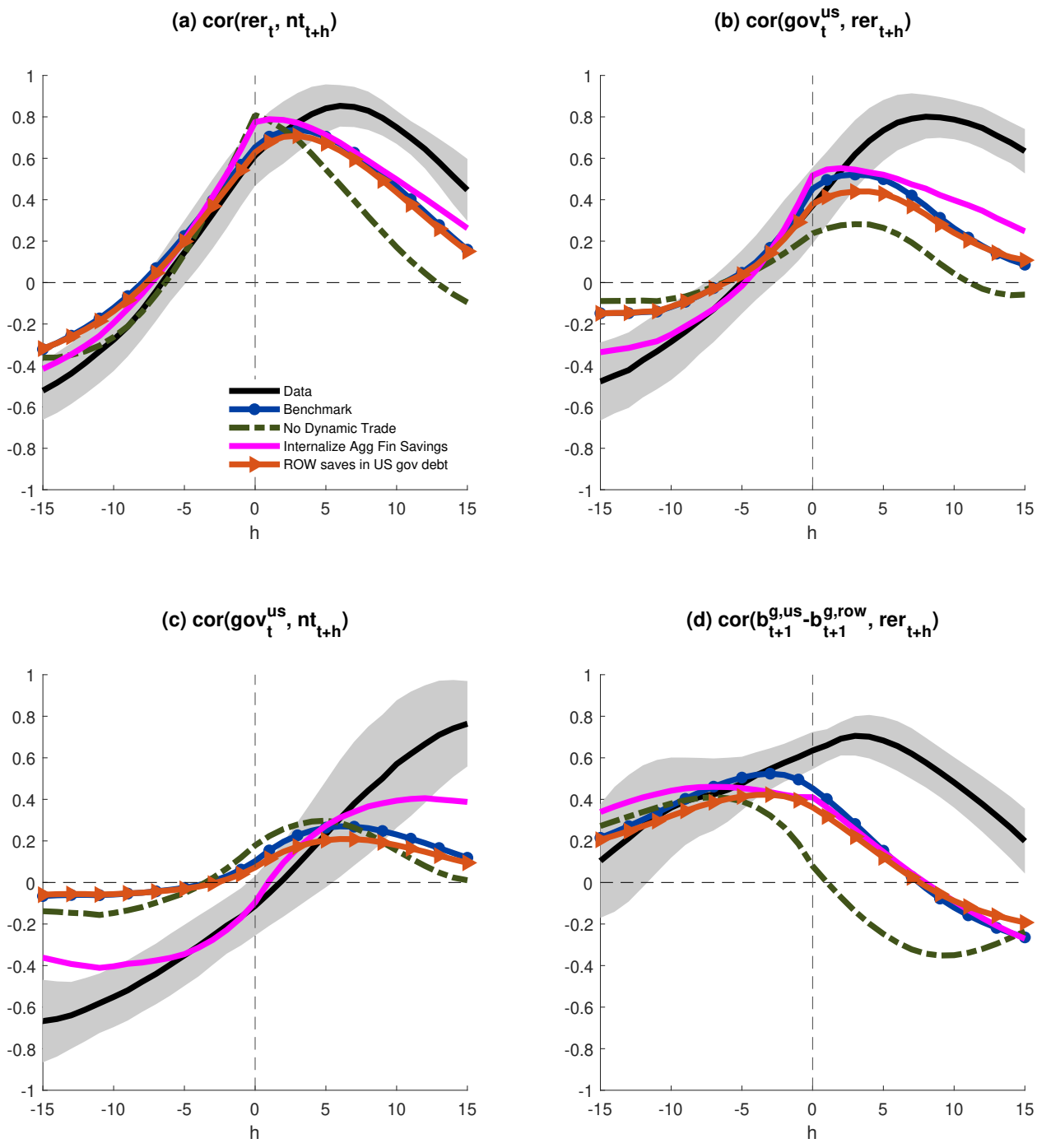


Figure F.4: Unconditional Dynamic Correlations in Data and Models

Notes: Standard error bands are 68% confidence intervals.

E.2 Panel Data Analysis

The role of the fiscal rule in shaping the international transmission of government spending shocks can be further tested empirically. To do this, I use the panel data on military spending shocks from Miyamoto et al. (2019). I show that the predictions of the theory in terms of the fiscal rule are supported by cross-country panel data evidence. That is, countries that experience stronger deprecations of the RER and improvements in net trade are those that rely more heavily on the use of government debt to finance the increase in spending. This is important because the literature has documented cross-country heterogeneity in the responses of the RER and net trade, but there is no existing theory explaining why countries might differ in these dimensions.[64] The mechanisms proposed in this paper can explain some of the heterogeneity in the responses.

To show this, I run local projections contry-by-country. The sample includes 125 countries, where 29 are advanced economies, 60 are developing economies, and 36 poor economies. Let i denote a country, and $h = 0, 1, 2$, the horizon in years. I project the variable of interest $y_{i,t+h}$ on military spending $m_{i,t}$, where $y_{i,t+h}$ can be debt over GDP, RER, current account over GDP. I estimate the following equation for each country-horizon in the sample,

$$\frac{y_{i,t+h} - y_{i,t-1}}{y_{i,t-1}} = \beta_i^y + \beta_{i,h}^y \frac{m_{i,t} - m_{i,t-1}}{m_{i,t-1}} + \text{controls} + \epsilon_{i,t+h}^y$$

for $y \in \{\text{debt}, \text{rer}, \text{ca}\}$ where I control for one lag of military spending growth, GDP growth and the left hand side variable. Figure F.5 Panel (a) shows the scatter plot between $\beta_{i,h}^{\text{debt}}$ and $\beta_{i,h}^{\text{rer}}$, and Panel (b) the scatter plot between $\beta_{i,h}^{\text{debt}}$ and $\beta_{i,h}^{\text{ca}}$. Furthermore, Figures F.6, F.7 and F.8 shows the same results but separately for advanced, developing and poor economies, respectively.

There is a positive relationship between the use of government debt to finance the increase in government spending and the depreciation of the RER and the effect on the current account in the full sample, and each sub-sample. This is consistent with the implications of the theory developed in this paper. Moreover, within advanced economies 63% of the observations have positive increases in government debt, 57% show a depreciation of the RER, and 43% increases

[64] See Corsetti and Müller (2006); Kim and Roubini (2008); Monacelli and Perotti (2010a); Ravn et al. (2012); Corsetti et al. (2012); Kim (2015); Forni and Gambetti (2016); Miyamoto et al. (2019); Ferrara et al. (2021).

in the current account. These numbers are smaller for developing economies (49% for debt, 38% for RER, and 31% for current account), and more so for poor countries (40% for debt, 34% for RER, and 28% for current account). Hence, even across groups one observes that a stronger use of government debt correlated with more cases with deprecations of the RER and increases in net trade. There are two reasons why these numbers differ across country groups: (*i*) advanced economies rely more heavily on debt than taxes relative to advanced and poor economies, and (*ii*) advanced economies rely more on domestic currency debt than advanced and poor economies. The first one is more obvious than the second one. In the model, if the debt is issued in foreign currency there would be no effect on the UIP deviations since the terms where the exchange rate appear in the Euler equations would cancel each other when collapsing the Euler equations for government and foreign bonds.[65]. In this case all the adjustment to compensate for re-balancing costs would operate through the interest rate in the (foreign currency) government bonds.

[65]This is true up to a first order log linearization.

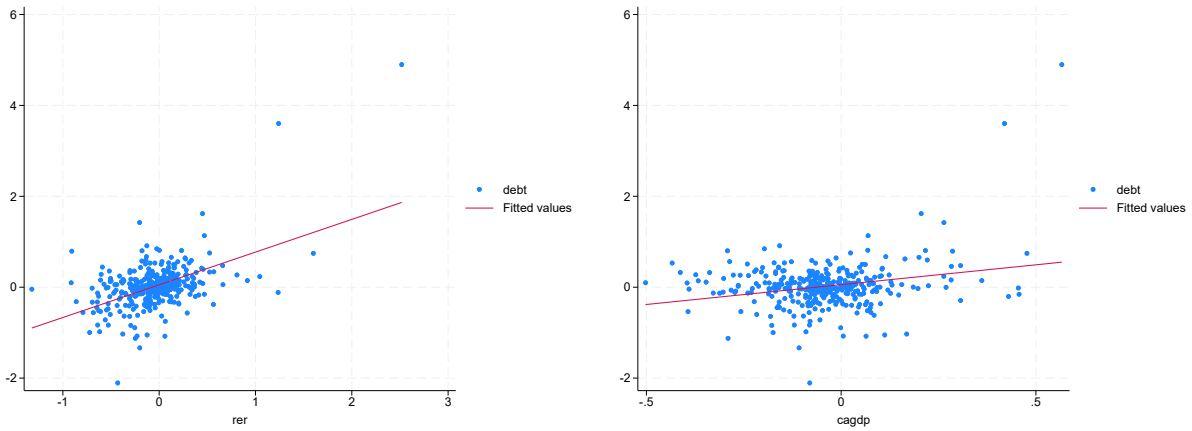


Figure F.5: Cross-country Responses of Government Debt, the RER and Current Account (all countries)

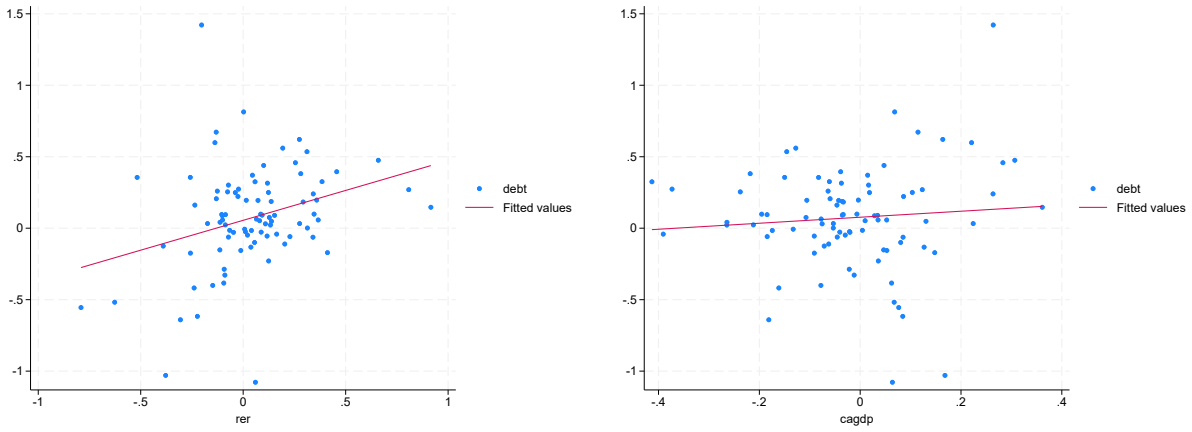


Figure F.6: Cross-country Responses of Government Debt, the RER and Current Account (advanced economies)

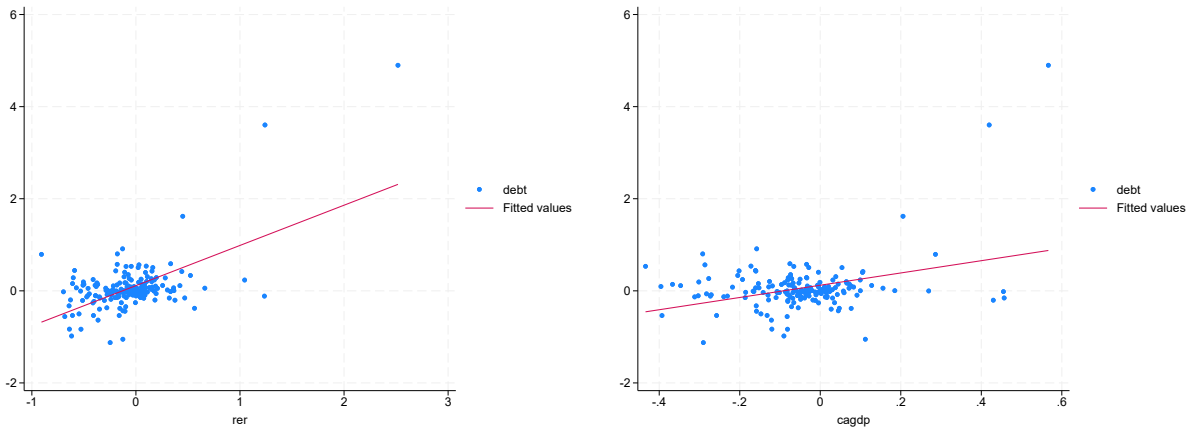


Figure F.7: Cross-country Responses of Government Debt, the RER and Current Account (developing economies)

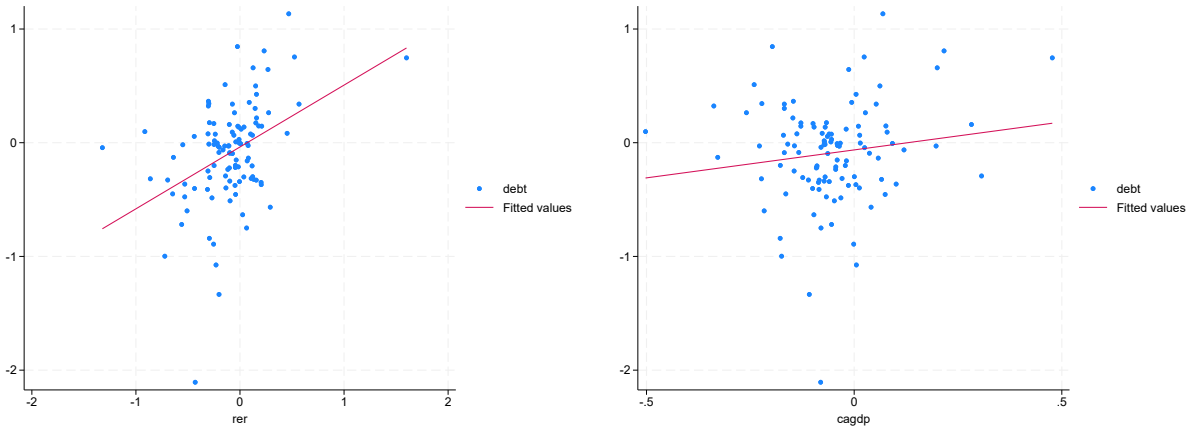


Figure F.8: Cross-country Responses of Government Debt, the RER and Current Account (poor economies)

F Additional Figures and Tables

F.1 Comparison Empirical Results in Literature

Paper	RER	Net Trade or Current Account	Sample	Model (Mechanism)
Corsetti and Müller (2006)	–	< 0 or ≈ 0	US, Aus, Can, UK (1980 - 2006)	Yes (trade openness, but $NT < 0$)
Kim and Roubini (2008)	> 0	> 0	US (1973 - 2004)	No
Monacelli and Perotti (2010b)	> 0	< 0	US, Aus, Can, UK (1973 - 2005)	Yes (GHH pref but unrealistic calib)
Ravn et al. (2012)	> 0	< 0 for Panel (> 0 for US and Can)	US, Aus, Can, UK (1975 - 2005)	Yes (deep habits at good level)
Corsetti et al. (2012)	> 0	> 0	US (1983 - 2007)	Yes (spending reversals)
Kim (2015)	> 0	Panel: > 0; country groups: $\lessgtr 0$	18 Advanced Econs (1981 - 2010)	No
Auerbach and Gorodnichenko (2016)	< 0	–	US (1994 - 2014)	No
Forni and Gambetti (2016)	Surprise: > 0 & News: < 0	Surprise: > 0 & News: < 0	US (1980 - 2015)	No
Miyamoto et al. (2019)	> 0 in Advanced Econs	< 0 in Advanced Econs	29 Advanced Econs (1993 - 2013)	No (discussion of std model)
Boehm (2020)	> 0 or ≈ 0	< 0	17 Advanced Econs (2003- 2016)	Yes (closed economy)
Ferrara et al. (2021)	< 0	< 0	US (1964- 2015)	No

Table G.1: Summary of Findings in the Literature

Notes: for the RER the sign > 0 means depreciation.

F.2 Baseline IRFs in Dollars

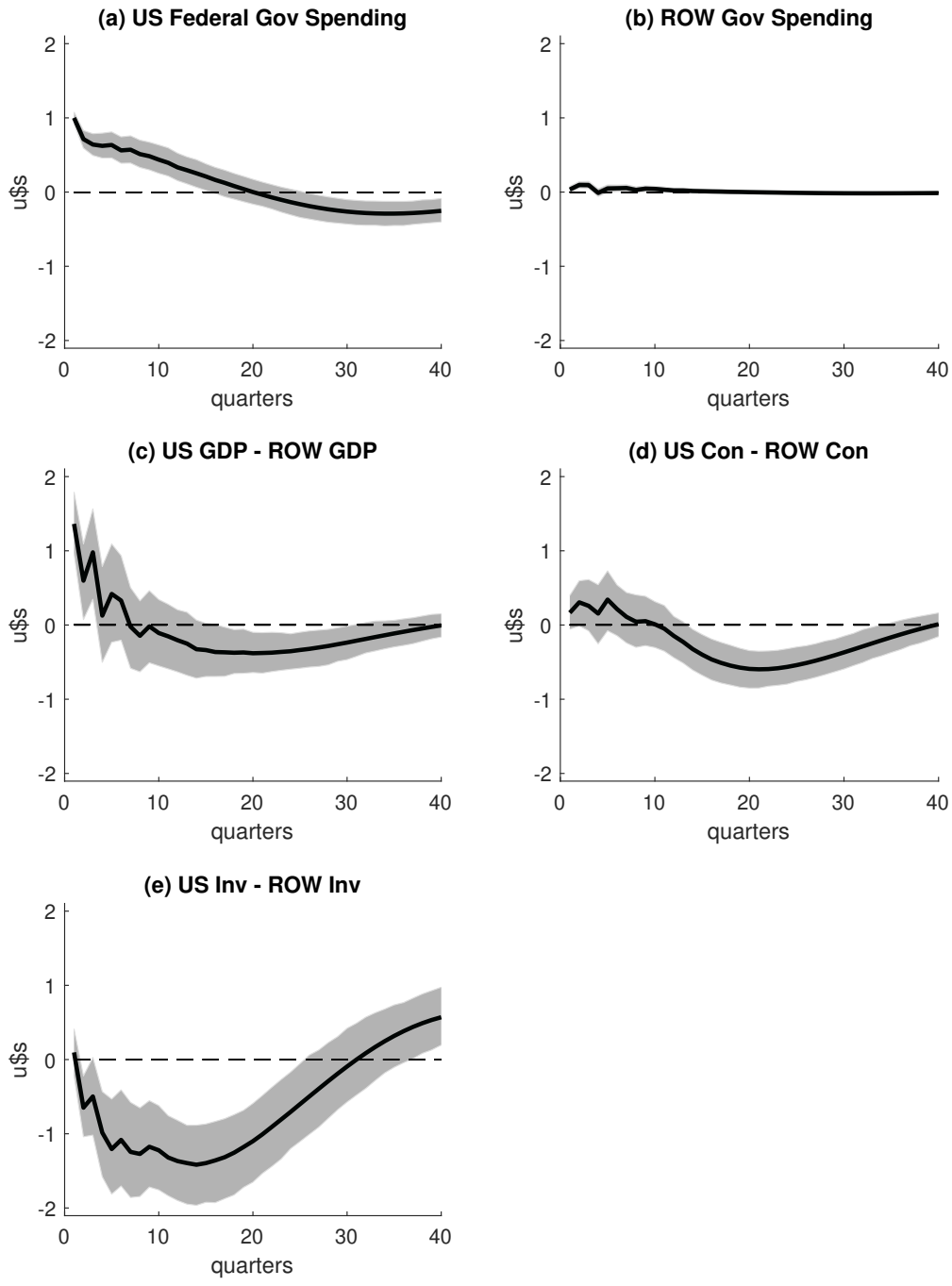


Figure G.1: Baseline IRFs of Macro Aggregates in Dollars

Notes: Standard error bands are 68% confidence intervals.

	SVAR US Gov	Benchmark Model		
		US Gov Shocks	Differential Trade Shocks	Differential Financial Shocks
Relative Investment	31	40	56	2
Net Trade	34	11	87	1
RER	33	39	45	13

Table G.2: Unconditional Variance Decomposition (in %): SVAR vs Benchmark Model.

Notes: The remaining portion of the variance decomposition in the model is explained by the ROW government spending shock.