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To my family, Vytenis, and Marco, who accompanied me in this journey and whose continuous support gave me the will to strive, to seek, to find, and not to yield.

Preface

This work studies the impact of foreign shocks on advanced and emerging small-open economies, along different dimensions.

Chapter 1 studies the pass-through of exchange rates to prices in small-open commodity-exporter economies, taking Canada as a case study. We estimate pass-through on a wide cross-section of disaggregated import, producer, and consumer prices, *conditional* on commodity shocks that explain a major share of the volatility in price and exchange rate series. Our pass-through measure is free from endogeneity concerns between prices and exchange rates and leads, in some cases, to *opposite* inference about the sign of pass-through with respect to standard estimates. By focusing on industry-level producer price indexes, we show that *conditional* pass-through decreases with industry market power, while it increases in the degree of import penetration and persistence of industry-specific shocks.

In Chapter 2, we estimate the response of domestic inflation to a US interest rate shock in a sample of 24 emerging economies, using local projection methods. Our results point out that the sign of the inflation response crucially depends on the monetary policy framework: after a US monetary policy tightening, inflation decreases in peggers; inflation increases in floaters that do not target inflation; the inflation response is not statistically different from zero in floaters that are committed to an inflation target. We rationalize this outcome using a standard DSGE model. We show that targeting inflation yields larger welfare gains compared to the other two monetary policy frameworks, even assuming dominant currency pricing.

Chapter 3 analyses the impact of global risk aversion on the cost of borrowing for emerging market economies. In a sample of five emerging markets we show that in response to risk aversion shocks that lower global risk appetite: spreads rise, at all maturities; and borrowing long term becomes *cheaper*. In fact, on average, emerging markets pay a higher risk premium on long-term than short-term bonds. In periods of high risk aversion the difference across the two risk premia *decreases*. Our result can be rationalized by considering that passing from periods of low to high risk aversion, the risk-reward trade-off (Sharpe ratio) changes in favour of longer maturities. As a consequence, holding long term bonds becomes more convenient for investors. Our results are robust to different specifications of the global risk aversion time series, and to measures of country-specific investor risk aversion.

Chapter 1

Exchange Rate Pass-Through in Small, Open, Commodity-exporter Economies: Lessons from Canada*

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Abstract

We analyze pass-through of exchange rates to prices in small-open commodity-exporter economies, taking Canada as a case study. We estimate pass-through on a wide cross-section of disaggregated import, producer, and consumer prices, *conditional* on commodity shocks that explain a major share of the volatility in price and exchange rate series. Our pass-through measure is free from endogeneity concerns between prices and exchange rates and leads, in some cases, to *opposite* inference about the sign of pass-through with respect to standard estimates. By focusing on industry-level producer price indexes, we show that *conditional* pass-through decreases with industry market power, while it increases in the degree of import penetration and persistence of industry-specific shocks.

Keywords: Time Series, Factor Analysis, Prices, Exchange Rates, Pass-through, Commodity Prices, Oil Shocks.
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1 Introduction

One of the key challenges for monetary policy relies on estimating the Exchange Rate Pass-Through (ERPT); namely, the relationship between exchange rates and prices. In particular, the term "pass-through" is used to capture how fluctuations in exchange rates are transmitted to the price chain, i.e. import, producer and consumer prices. Assessing the degree of ERPT is essential for monitoring and forecasting domestic inflation and, therefore, for setting monetary policy. The literature studying pass-through is vast, but an analysis focusing on small-open commodity-exporter economies has been somewhat neglected (Forbes et al., 2020). In these economies, commodity shocks are a relevant source of fluctuations for key variables included in pass-through; i.e. prices and exchange rates. This study focuses on Canada, an almost perfect example of advanced small-open economy, which is highly integrated into international trade and capital markets.[1] Notwithstanding its nature of fully industrialized economy, Canada can be plausibly described as a commodity exporter: Canadian exports relied for more than one quarter, between 1990 and 2019, on crude oil, basic metals and, stone.[2] As a result of the "small" dimension of the Canadian economy, shocks to commodity prices are truly exogenous. Thus, by focusing on Canada we obtain an ideal "laboratory" to study the impact of commodity shocks on exchange rates and domestic prices, the set of variables included into the estimation of pass-through, in commodity exporters.

The standard notion of pass-through considers that exchange rates vary for exogenous reasons and estimates the responses of the price chain to exchange rate movements, controlling for additional variables relevant for pricing. The standard assessment of the ERPT is based on a distributed lag regression, as in Burstein and Gopinath (2014):

$$\Delta p_{n,t} = \beta_n + \sum_{k=0}^{T} \beta_{n,k} \Delta e_{n,t-k} + \gamma_n X_{n,t} + \epsilon_{n,t}, \tag{1}$$

where $\Delta p_{n,t}$ represents the log difference in the price level index of country n at time t; β_n is a constant coefficient; $\Delta e_{n,t-k}$ refers to the log difference of the nominal effective (i.e. trade-weighted) exchange rate (NEER) for country n;[3] and $X_{n,t}$ defines a vector of controls (including lags) that refer to the cost of production in countries exporting to n

[1] Canada has adopted a floating exchange rate regime since the 1970s and, since 1991, it has been operating an inflation-targeting monetary policy. This implies a focus on domestic inflation for Canadian monetary policy that can be considered a residual claimant for the dynamics of both nominal and real exchange rates, while alternative shocks may explain the majority of exchange rate fluctuations.

[2] This estimation is based on data provided by The Growth Lab at Harvard University.

[3] Henceforth, we define the nominal effective exchange rate in terms of foreign currency per unit of domestic currency. As a consequence, an increase in the NEER represents an appreciation of the trade-weighted nominal exchange rate.

and the level of economic activity in country n. The distributed lag regression comprises lags of the exchange rate and allows for the possibility of a gradual adjustment of the price indexes to changes in the exchange rate. In particular, the short-run pass-through to country n is given by the estimated parameter $\beta_{n,0}$. On the other hand, the long-run pass-through is estimated by $\sum_{k=0}^{T} \beta_{n,k}$, where T is, typically, defined as 1 or 2 years. It is worth stressing that this approach assumes that the change in exchange rates is the shock itself or, alternatively, that changes in the exchange rates are entirely driven by structural exchange rate shocks. This approach has two key drawbacks. First, it obscures the fact that the exchange rate might be driven by other structural shocks, thus, providing little insights for the extent to which the degree of exchange rate pass-through depends on the nature of the structural shocks impinging on the economy. In fact, it treats the ERPT as an unconditional phenomenon, thus estimating an *unconditional* ERPT. Second, it overlooks the endogeneity of the exchange rate with respect to price levels and, thus, may lead to biased estimates of the degree of pass-through. The joint determination of prices and exchange rates is a particular concern for those studies estimating the phenomenon at the macroeconomic level. In fact, such analyses implement exchange rate and aggregate price indexes that respond to the same structural macroeconomic shocks. As pointed out above, empirical macroeconomic level studies on ERPT try to overcome such endogeneity concerns by controlling for exporter production costs, domestic demand conditions and global commodity prices. These additional variables should capture the changes in the economic environment that would simultaneously affect prices and exchange rates. However, given the high number of potential omitted variables, such controls are unlikely to account for the underlying macroeconomic shocks.

A second strand of literature on pass-through estimation, which builds on the seminal contribution of Shambaugh (2008), provides a solution to potential endogeneity concerns by implementing a structural approach that is based on the following strategy: rather than focusing on the correlation between exchange rates and prices, the structural shocks hitting the economy are directly taken into account (e.g. Shambaugh, 2008; Comunale and Kunovac, 2017; Corbo and Di Casola, 2018; Forbes et al., 2018; and Forbes et al., 2020).[4] This approach is based on two steps. First, structural shocks and their effects on exchange rates and prices are estimated. Second, a measure of pass-through is computed from the impulse responses of price indexes and exchange rates and, thus, conditional on the shocks hitting the economy. By considering the relationship between changes in price indexes and exchange rates, this approach closely maps the standard way in which pass-through is usually estimated at the macroeconomic level. However, this second approach

[4]For a recent survey on the different approaches to pass-through estimation see Ortega and Osbat (2020).

has the key advantage of disentangling the role of different shocks and, thus, it is defined as a measure of *conditional* ERPT.[5]

Our analysis follows the *conditional* approach and is conducted by estimating a structural Dynamic Factor Model (DFM), along the lines of Forni et al. (2009) and Forni and Gambetti (2010), for the Canadian economy. This empirical framework for data-rich environment allows considering the cross-section of disaggregated price indexes at consumer, producer and import levels. Hence, it permits to estimate the degree of ERPT on a wide plethora of price levels at different stages of the price chain. Due to its nature of small-open commodity-exporter economy, Canadian exchange rates and price levels are highly responsive to fluctuations in commodity prices. By relying on the contribution of Kilian (2009), we identify two real commodity shocks, such as a Global Demand shock and an Oil Demand shock that account for the innovations in the international demand for all industrial commodities and in the precautionary demand for oil, respectively. These shocks explain a high share of the volatility of price indexes and exchange rates in Canada and, thus, represent a suitable conditioning for pass-through estimation.

We contribute to the ongoing debate on pass-through by thoroughly analyzing commodity-exporter economies subject to commodity shocks and asking the following question. Does an estimate of pass-through conditional on relevant commodity shocks crucially differ from standard estimates in commodity exporters?

By comparing our measure of *conditional* ERPT with the *unconditional* ERPT estimate of a standard model (equation 1), we obtain the following results: they both display a negative pass-through for import and product price indexes (respectively, IPI and PPI), while the sign of ERPT for the consumer price index (CPI) drastically changes across frameworks, with the *unconditional* estimate exhibiting a negative pass-through and the *conditional* measure being positive. Standard *unconditional* analyses find a negative relationship between exchange rate appreciation and CPI inflation, which is consistent with the notion that an exchange rate appreciation leads to lower import prices and, through this channel, lower consumer prices. Our econometric setup shows, instead, a

[5] For an intuition regarding the shock-dependency of the ERPT, consider a standard New Keynesian (NK) small-open economy setup with *variable* mark-up. Absent price rigidities, the (log-linearized) domestic producer's optimal pricing condition reads as:

$$p_t = mkup_t\left(u_t, e_t(u_t)\right) + mc_t\left(u_t, e_t(u_t)\right),$$

where p_t is the optimal price set by domestic producers, $mkup_t$ refers to the mark-up, u_t is the structural shock hitting the economy at time t and $e_t(u_t)$ is the (endogenous) response of the nominal exchange rate. Hence, without price rigidities, the degree of pass-through of exchange rate fluctuations to prices relies on the interplay between the firm-specific rate of cost pass-through and the rate of reaction to market conditions (e.g. competitor prices). Both elements are dependent on the macroeconomic shock hitting the economy. The same result can be obtained in models that do not adopt the NK framework, but in which firms retain some degree of market power (e.g. Dornbush, 1987).

positive *conditional* comovement: the correlation between exchange rate appreciation and CPI inflation is positive, *conditional* on Global Demand and Oil Demand shocks. Our findings can be rationalized by considering the commodity-exporter characteristics of the Canadian economy and the nature of the identified shocks. Both (positive) Global Demand and (positive) Oil Demand shocks induce an increase in the demand for industrial commodities that raises both Canadian exports, thus appreciating the Canadian exchange rate, and commodity prices (e.g. crude oil). As a result of the central role of commodity-related prices, such as gasoline, in the CPI aggregate, its positive response is not surprising. Our results show, for small-open commodity-exporters, that pass-through estimates free from endogeneity concerns may lead to *opposite* inference about the sign of pass-through to consumer prices with respect to standard *unconditional* estimates.

The findings for Canada could be generalized, we believe, to other advanced commodity-exporters, such as Australia, Chile, and Norway, as they share three important characteristics. First, commodities (e.g. crude oil, metals, and stone) represent a substantial component of their exports.[6] Second, they display a rather long history of market-based exchange rate fluctuations, as their monetary authorities are committed to an inflation target. Third, the size of their economy is small compared to the world market for the commodities they export, justifying the assumption that commodity-related shocks are truly exogenous. We leave a detailed analysis of this topic to future research.

Our empirical setup allows to estimate pass-through along a wide cross-section of price series. With a particular focus on producer price indexes, we address a novel set of questions. Does conditional exchange rate pass-through display heterogeneity across industry price levels? Do industry-level characteristics explain the heterogeneity in pass-through?

By focusing on industry-level producer price indexes, we show a great degree of heterogeneity in the *conditional* ERPT across disaggregated price series. In addition, according to our findings, conditional exchange rate pass-through decreases with industry market power, while it increases in the degree of import penetration and persistence of industry-specific shocks. These results contribute to the studies of *conditional* ERPT along one key dimension: we show how the structure of a market and its international integration affect the dispersion into the degree of pass-through. This analysis builds on estimating a measure of pass-through across a wide cross-section of disaggregated price indexes that is feasible by implementing a DFM, but it is precluded in standard studies of *conditional* exchange rate pass-through that rely on small or medium scale VAR models (e.g. Shambaugh, 2008; Forbes et al., 2018; and Forbes et al., 2020).

[6]Over the period 1995-2018, industrial commodities (e.g. minerals, metals and stone) represents 44.4%, 45.4%, and 51% of the exports for Australia, Chile and Norway, respectively. These estimations are based on data provided by The Growth Lab at Harvard University.

To sum up, the contribution of this paper to the empirical literature on the exchange rate pass-through is three-fold. First, it provides new evidences for the pass-through in small-open commodity-exporters, conditional on commodity shocks. Second, it solves the endogeneity bias of the studies implementing *unconditional* ERPT estimation (e.g. Campa and Goldberg, 2005; Gopinath and Itskhoki, 2010; and Burstein and Gopinath, 2014), which do not condition for the shock hitting the economy. Third, it adds novel insights on the cross-sectional dispersion of pass-through to those analyses of *conditional* ERPT estimation that focus on few price aggregates (e.g. Forbes et al., 2018).

Finally, this paper contributes to the literature on *Exchange Rate Disconnect* (Obstfeld and Rogoff, 2000),[7] as it identifies two shocks, such as Global Demand and Oil Demand shocks, that jointly explain a great share of both nominal and real effective exchange rate volatility at all, economically relevant, horizons. This result is quite remarkable if we consider the well-established weak correlation between exchange rate and macroeconomic variables. We do so by relating two different strands of empirical studies on exchange rate behavior. First, we extend the analysis of (unconditional) correlation between exchange rates and (non-energy) commodity prices for commodity-exporting economies that finds a strong explanatory power of commodity prices on commodity currencies (e.g. Chen and Rogoff, 2003). Second, we connect to those studies that analyze the responses of exchange rates to structural macroeconomic shocks. A major share of this second strand of literature attributes to nominal factors a key role in shaping exchange rate behaviors and, thus, focuses on studying the impact of monetary policy shocks on exchange rates (e.g. Eichenbaum and Evans, 1995; Faust and Rogers, 2003; Forni and Gambetti, 2010; Cecioni, 2018; Forbes et al., 2018; Inoue and Rossi, 2019; and Forbes et al., 2020). However, the findings of this literature cast doubts on monetary policy shocks being the main source of exchange rate volatility (Faust and Rogers, 2003). Our findings provide one key contribution to the literature: we show that real structural shocks, related to commodities, are able to explain most of the volatility of both nominal and real exchange rates for small-open commodity-exporters. In other words, our approach considers that fluctuations for commodity currencies mostly derive from real shocks related to commodities, rather than nominal shocks originated by monetary policy or financial cycles.[8]

The paper is organized as follows: Section 2 shows the econometric framework; Section 3 describes the data set implemented; Section 4 shows the empirical analysis and results; Section 5 concludes.

[7]For a recent survey of this literature, see Itskhoki and Mukhin (2017).

[8]Our identification scheme does not allow to identify monetary policy shocks *in addition* to the, already, identified Global Demand and Oil Demand shocks.

2 Econometric Setup

2.1 Factor model

The empirical setup is based on the framework of Forni et al. (2009). Denote $X_N^T = (x_{it})_{i=1,\ldots,N;t=1,\ldots,T}$ as an array of observations for N economic variables over T periods. Each variable (x_{it}) can be defined as the sum of two unobservable and orthogonal components: the common component χ_{it} and the idiosyncratic component ξ_{it}:

$$x_{it} = \chi_{it} + \xi_{it}. \tag{2}$$

The idiosyncratic components are allowed, to some extent, to be mutually correlated.[9] They are related to sources of variation, which refer only to single variables or a group of variables. In this regard, they are not interpreted as macroeconomic shocks, but as either sector-specific shocks or measurement errors. The common component is driven by a small number of macroeconomic shocks and generates the major amount of co-movement between economic variables.

The common component can be represented as a linear combination of r static factors according to:

$$\chi_{it} = a_{1,i}f_{1t} + a_{2,i}f_{2t} + \cdots + a_{r,i}f_{rt} = a_i f_t, \tag{3}$$

where a_i is the vector of loadings of variable i on the static factors, f_t, which evolve according to the following VAR(p) specification:

$$f_t = D_1 f_{t-1} + D_2 f_{t-2} + \cdots + D_p f_{t-p} + \epsilon_t \tag{4}$$

$$\epsilon_t = Ru_t, \tag{5}$$

where R is $r \times q$ and u_t is a q $\times$ 1 vector of dynamic factors, which are orthonormal white noises. In the present setup, we label the *identified* dynamic factors, u_t, as structural macroeconomic shocks.

The static factor are unobserved and are estimated by the first r principal components. Equations (3) - (5) can be rearranged as follows:

$$f_t = (I - D_1 L - D_2 L^2 - \cdots - D_p L^p)^{-1} Ru_t$$

$$\chi_{it} = a_i(I - D_1 L - D_2 L^2 - \cdots - D_p L^p)^{-1} Ru_t = b_i(L)u_t, \tag{6}$$

[9] See assumption 5 of Forni et al. (2009) for a more detailed statement.

with $b_i(L) = a_i(I - D_1L - D_2L^2 - \cdots - D_pL^p)^{-1}R$.
Finally, the observables can be expressed in term of the structural macroeconomic shocks u_t as:

$$x_{it} = b_i(L)u_t + \xi_{it}, \tag{7}$$

where $b_i(L)$ represents the matrix of structural impulse response functions for the variable i.

2.2 Identification

Representation (7) is unique up to an orthogonal $q \times q$ matrix H. In fact, equation (5), can be re-written as:

$$\epsilon_t = RH'Hu_t = Sv_t,$$

where $S = RH'$ and $v_t = Hu_t$.

2.2.1 Discussion

In the present setup, identification is reduced to the choice of the orthogonal matrix H, such that a set of economically motivated restrictions on the matrix $b_i(L)$ are implemented (Forni et al., 2009). Consistently with the structural vector autoregressive (VAR) analysis, the identifying restrictions are imposed on the responses of a set m of (observed) variables. When it comes to the identification strategy, many approaches have been implemented within the structural Dynamic Factor Model (DFM) literature. Among them, and closest to our approach, we can underline: short-run restrictions based on a Cholesky matrix (e.g. Forni and Gambetti, 2010), long-run zero restrictions (e.g. Forni et al., 2009), and sign restrictions (e.g. Barigozzi et al., 2014). In particular, we implement a recursive (i.e. lower triangular) identification scheme on the impact response of a number of variables equal to the number of dynamic factors (i.e. $m = q$: just identification).[10]

Our identification scheme builds on the seminal work of Kilian (2009), who identifies key commodity-related shocks. Accordingly, in this study we implement a lower triangular identification scheme on global and domestic variables, appearing in the following

[10] Technically, within the adopted identification scheme, we need to impose $\frac{q(q-1)}{2}$ restrictions (due to the fact that orthonormality, already, implies $\frac{q(q+1)}{2}$ restrictions), independently of the dimension, n, of the cross-section.

order: (global) oil production, (global) real economic activity (REA), (global) real oil price, Canadian real industrial production, and Canadian CPI.[11] The set of identifying restrictions allows us to distinguish two structural shocks, which broadly affect the whole Canadian economy; namely: (1) innovations in (global) real economic activity, which can not be explained based on changes in (global) oil production, labeled Global Demand shocks; and (2) innovations in the (global) real oil price, which are not explained based on innovations either in (global) oil production or (global) real economic activity (e.g. global business cycle), labeled Oil Demand shocks. Any remaining innovations in Canadian real industrial production or consumer price index are related to the residual dynamic factors, which do not have an economic interpretation and are unrelated to commodity markets.

We focus our empirical analysis on Global Demand shocks and Oil Demand shocks, as they account (see the forecast error variance decomposition in Section 4.4) for a significant share of long run volatility of price indexes and for more than 75% of the long-run variance of both nominal and real effective exchange rates. As a consequence, they provide a significant source of fluctuation of both price levels and exchange rates and, thus, represent a suitable conditioning for pass-through estimations in the Canadian economy. For a further intuition over the identified shocks we can point out that Global Demand shocks capture exogenous movements in the (global) demand for all kind of industrial commodities, as related to world business cycle. On the other hand, Oil Demand shocks can be interpreted as fluctuations in the precautionary demand for oil that are led by uncertainty over future oil supply shortfalls.

Furthermore, it is worth noticing that the block recursive identification scheme implies that the global commodity market is contemporaneously predetermined with respect to other innovations to domestic macroeconomic aggregates (i.e. Canadian consumer price index and real industrial production). This assumption is wide-spread in the empirical studies, which analyze the impact of commodity-related shocks on domestic variables (e.g. Blanchard and Gali, 2010; and Kilian and Vega, 2011) and is consistent with the "small" dimension of the Canadian economy that, plausibly, rules out any feedback effect between the domestic economy and commodity prices, within the same month.[12]

It is worth stressing that our identification scheme only implies restrictions for the contemporaneous (i.e. within a month) response of global commodity variables to key domestic aggregates. In other words, the implemented identification does not rule out potential feedbacks between, say, Canadian real industrial production and (global) real economic activity outside a one month horizon. In this regard, our implemented econo-

[11] In particular, the identification scheme is based on WTI (West Texas Intermediate) real oil price.

[12] In addition, the existence of a contemporary feedback from a wide range of macroeconomic variables, such as consumer price index and industrial production, to commodity prices is rejected for US (a notably big-open economy) at monthly frequency, as underlined by Kilian and Vega (2011).

metric setup is more general than those models that prevent feedback effects from global variables to domestic ones, at any horizon (e.g. Charnavoki and Dolado, 2014).

Finally, our approach benefits from the "blessing of dimensionality" and, thus, avoids concerns of non-fundamentalness (Lippi and Reichlin, 1993) that refers to the impossibility to retrieve the series of the structural shocks that affect the whole economy by observing only a limited number of variables. By enlarging the econometrician information set, the non-fundamentalness related to a limited number of observed variables is solved by adding series on the cross-section that contain additional information.[13]

2.3 Estimation

Consistently with Forni et al. (2009) and Forni and Gambetti (2010), our DFM in state-space form is estimated with the following procedure.[14] First of all, the number of static factors $\hat{r}$ is estimated according to Bai and Ng (2003) methodology, which gives $\hat{r} = 7$ static factors.[15] Then, the static factors, $\hat{f}_t$, are computed by considering the first $\hat{r}$ principal components of the observed series and the factor loadings, $\hat{a}_i$, with the related eigenvectors. In particular, let's define $\hat{\Sigma}^x$ the variance-covariance matrix of the data set; the matrix of loadings, $\hat{A}_n = \left(\hat{a}_1', \hat{a}_2', \ldots, \hat{a}_n'\right)'$, is $n \times \hat{r}$ matrix obtained by displaying on the columns the first $\hat{r}$ normalized eigenvectors related to the highest $\hat{r}$ eigenvalues of $\hat{\Sigma}^x$. The estimated static factors are obtained, according to the principal component analysis, as $\hat{f}_t = \hat{A}_n' \left(x_{1t}, x_{2t}, \ldots, x_{nt}\right)'$.

As a second step, we run a VAR(p) for $\hat{f}_t$ in order to obtain an estimate for the autoregressive parameters, $D(L)$, and the residuals, ϵ_t, that we label $\hat{D}(L)$ and $\hat{\epsilon}_t$, respectively.

Third, we estimate the number of dynamic factors, $\hat{q}$, with the criteria of Bai and Ng (2007), which determines 5 dynamic factors.[16] Then, we compute the variance-covariance matrix of $\hat{\epsilon}_t$, $\hat{\Sigma}^{\varepsilon}$, and estimate the non-structural representation of the common components by implementing the spectral decomposition of $\hat{\Sigma}^{\varepsilon}$. In particular, we estimate the $\hat{q}$ largest eigenvalues of $\hat{\Sigma}^{\varepsilon}$, $\hat{\mu}_j^{\varepsilon}$ with $j = 1, \ldots, \hat{q}$, and compute the diagonal matrix $\hat{M}$ with $\sqrt{\hat{\mu}_j^{\varepsilon}}$ on the main diagonal, and $\hat{K}$ as the $\hat{r} \times \hat{q}$ matrix obtained by displaying on the columns the first $\hat{q}$ normalized eigenvectors related to the highest $\hat{q}$ eigenvalues of $\hat{\Sigma}^{\varepsilon}$.

[13]This information problem may affect those empirical studies, as structural VAR analyses, that aim at identifying macroeconomic shocks by implementing a limited number of variables. On the contrary, this problem does not characterize DFM analyses that implement a large cross-section. For a comprehensive discussion of the issue in Dynamic Factor Model setups, see Forni et al. (2009).

[14]The notation implemented is close to Forni and Gambetti (2010). We refer to Forni and Gambetti (2010) and Lutkepohl (2014) for a survey on the literature on Dynamic Factor Models.

[15]To determine the number of static factors, we implement the Bai and Ng (2003)'s PC1 information criterion.

[16]The dynamic factors are estimated from the residuals of a VAR(7). By applying the Bai and Ng (2007) criteria, we estimate from 5 to 6 dynamic factors. In our preferred estimation, we implement 5 dynamic factors.

By defining $\hat{S} = \hat{K}\hat{M}$, we estimate the reduced form impulse response functions for the n variables in the dataset, as:

$$\hat{C}_n(L) = \hat{A}_n\hat{D}(L)^{-1}\hat{S}.$$

Finally, by implementing the identifying restrictions on the responses of a set m of variables, as:

$$\hat{B}_m(L) = \hat{C}_m\hat{H},$$

we obtain $\hat{H}$ and $\hat{b}_i(L) = \hat{c}_i(L)\hat{H}$, for $i = 1, \ldots, n$. According to the results of Forni et al. (2009), for a fixed i, $\hat{b}_i(L)$ is a consistent estimator of $b_i(L)$. When it comes to inference analysis, confidence intervals are obtained by implementing a recursive bootstrap procedure, with 1000 iterations, on the estimated residuals in the VAR process for the factors.

3 Data

The data set used in the estimation of our DFM is a balanced panel of 775 monthly series for Canada, from January 1997 to July 2018. Due to the fact that a high number of producer price series start in 1997 : 1, the starting date is chosen in order to consider a large number of disaggregated price series. The dataset includes main Canadian macroeconomic indicators, as in Bernanke et al. (2005) for the US economy, such as aggregate measures of price levels, industrial production, interest rates, employment and other key macroeconomic and financial variables. We extend this data set by adding disaggregated series for price levels, real industrial productions and real consumer expenditures, along the lines of Boivin et al. (2009). More specifically, in order to obtain a detailed picture of the *conditional* ERPT measures along the entire price chain, we collect disaggregated price indexes at producer (79 series) and consumer (245 series) levels. In addition, we consider Kilian (2009) global real economic activity (REA) index, as well as data on world oil market, Canadian international trade and exchange rates. Data on Canadian currency are collected both as bilateral nominal exchange rates with major global currencies (i.e. US dollar, Euro, UK Sterling and Japanese Yen) as well as nominal and real effective (i.e. trade-weighted) exchange rates. All data have been transformed in order to ensure stationarity according to the Dickey and Fuller (1979)'s ADF test and Kwiatkowski et al. (1992)'s KPSS test, at 10% level.[17]

[17]For variables displaying a trend, we implement the Kwiatkowski et al. (1992)'s KPSS test, with the null hypothesis of stationarity around a deterministic linear trend.

Besides the series implemented to estimate the DFM, we collect data on industry characteristics in order to validate or reject key assumptions of models for exchange rate pass-through. In particular, we measure the degree of competition of an industry by considering the average profit margin. In addition, we take into account the role of integrated world market with an index of import penetration. The full list of variables, as well as the implemented transformations, are reported in the Online Appendix.

4 Empirical Results

In this Section we report the main empirical results of our structural DFM. First of all, we analyze the source of fluctuation for sectoral price levels and exchange rate growth rates. Building on the DFM framework, we determine to what extent the volatility and persistence in the observed series of price level and exchange rate growth rates is due to common or sector-specific components. Our findings show that macroeconomic factors explain more than 75% of volatility in the growth rates of aggregate series. In particular, the movements in the common components appear to tightly match the ones in the effective exchange rates (both nominal and real) thus showing, contrary to the usual findings of the *Exchange Rate Disconnect* literature, that a major source of exchange rate dynamics is due to commom components (i.e. macroeconomic factors) (Table 1).

These results are confirmed via an historical decomposition analysis, which underlines the significant role of macroeconomic factors in driving the dynamics of the series usually involved into the ERPT estimations; namely, effective exchange rates and aggregate price indexes.

Then, we report the dynamics effects of commodity shocks to the Canadian economy via an impulse response analysis. We restrict our attention to a Global Demand shock and a Oil Demand shock, since they turn out to explain the majority of the volatility of the common component associated to key series describing the Canadian economy, including effective exchange rates and price levels. This finding is shown in the variance decomposition analysis, which is presented next. In particular, the decomposition underlines that the two identified shocks account for a significant share of the long-run volatility of both aggregate price levels and effective nominal and real exchange rates.

Once the effects of the two identified shocks on Canadian business-cycle and, more specifically, on price levels and exchange rates have been analyzed, we introduce our measure of *conditional* ERPT and estimate it across a plethora of disaggregated price levels. Then, we compare our conditional measure with the standard unconditional estimates found in the literature. We show that taking into account the origin of the exchange rate movements is crucial to correctly estimate the comovement between exchange rate and prices. We conclude this Section by focusing on the *conditional* ERPT for disaggregated producer price indexes in the manufacturing sector and implementing a regression analysis to investigate the main explanatory factors for the cross-sectional dispersion in *conditional* ERPT estimates. We show that pass-through decreases with the degree of market power in the industry, while it increases in the level of import penetration and persistence of industry-specific shocks.

4.1 Fluctuations in exchange rates and disaggregated prices: common and idiosyncratic components.

In this Section, we analyze the source of fluctuations for sectoral price level and exchange rate growth rates. In particular, by considering the estimated DFM presented in eq. (2), growth rates in prices (i.e. inflation rates) and exchange rates, π_{it}, can be disentangled as:

$$\pi_{it} = \chi_{it} + \xi_{it}.$$

This framework allows us to determine to what extent the volatility in price levels and exchange rates growth rates is due to common macroeconomic shocks, χ_{it}, and sector specific components, ξ_{it}. In addition, it allows us to infer the degree to which the persistence in inflation rates and exchange rate changes is related to common or sector-specific components. In Table (1) we summarize the findings related to the volatility and persistence of aggregate and disaggregated monthly percentage changes in price levels and exchange rates. Both measures are computed for every series of price levels an exchange rates, as well as for their common, χ_{it}, and idiosyncratic, ξ_{it}, factors. Volatility is measured by computing the standard deviation of the related series. To measure the degree of persistence, we estimate an autoregressive process of order 13, as:

$$w_t = \alpha(L) w_{t-1} + \varepsilon_t, \tag{8}$$

where persistence is measured by the sum of the coefficients on all lags, which we denote as $\alpha(1)$.[18]

4.1.1 Volatility.

Notably, most of the volatility in aggregate series is due to fluctuations in the common component, which accounts for the effects of macroeconomic shocks. In actual fact, the

[18]Our implemented measures are consistent with the estimates computed by Boivin et al. (2009), who implement a similar analysis of disaggregated price dynamics.

Volatility and persistence of monthly inflation rates and exchange rate percentage changes

	Standard Deviation (percent)				Persistence		
	Series	Com. Comp.	Idio Comp.	R^2	Series	Com. Comp.	Idio Comp.
Aggregated Series							
CPI	0.28	0.25	0.11	0.83	0.79	0.79	0.12
PPI	0.69	0.63	0.28	0.83	0.09	0.20	0.16
IPI	0.88	0.78	0.42	0.77	−0.01	−0.01	−0.13
NEER	1.62	1.49	0.64	0.84	0.17	0.17	0.25
REER	1.63	1.48	0.65	0.83	0.18	0.15	0.11
Disaggregated Series: CPI							
Mean	1.09	0.38	1.00	0.14	0.14	0.77	−0.29
1^{st} Quant.	0.44	0.13	0.41	0.04	−0.17	0.68	−0.63
Median	0.84	0.23	0.78	0.08	0.33	0.84	−0.20
3^{rd} Quant.	1.31	0.34	1.24	0.16	0.74	0.95	0.09
St. Dev.	1.18	0.58	1.06	0.17	0.72	0.22	0.53
Disaggregated Series: PPI							
Mean	1.03	0.55	0.81	0.30	0.29	0.61	0.01
1^{st} Quant.	0.45	0.15	0.38	0.08	0.05	0.35	-0.18
Median	0.73	0.38	0.50	0.23	0.26	0.62	0.01
3^{rd} Quant.	1.36	0.83	0.92	0.46	0.56	0.88	0.27
St.Dev.	0.83	0.59	0.67	0.26	0.35	0.29	0.35
Disaggregated Series: IPI							
Mean	2.21	1.46	1.51	0.61	0.02	0.15	-0.07
1^{st} Quant.	1.24	0.87	0.48	0.36	-0.10	0.06	-0.10
Median	1.50	1.25	0.55	0.71	0.11	0.13	-0.01
3^{rd} Quant.	2.44	1.49	2.24	0.85	0.20	0.16	0.21
St. Dev.	2.09	0.97	1.99	0.28	0.27	0.17	0.45
Disaggregated Series: Ex. Rate							
US/CA	1.89	1.78	0.63	0.88	0.23	0.20	0.30
UK/CA	2.13	1.13	1.80	0.28	0.08	0.25	0.19
JP/CA	3.02	1.85	2.38	0.37	0.08	0.20	0.23
EA/CA	2.25	1.01	2.00	0.20	0.04	0.20	0.11

Table 1: Price and exchange rate growth rates are computed as $\pi_{i,t} = y_{i,t} - y_{i,t-1}$, where $y_{i,t}$ represents the log of either the price or exchange rate series. Common components are $\chi_{i,t}$, while idiosyncratic components refer to $\xi_{i,t}$. R^2 statistics measures the variance of the observed series that is explained by the common component. Disaggregated series refer to statistics computed across sectors. In particular, US/CA, UK/CA, JP/CA, and EA/CA denote bilateral foreign exchange rates of Canadian Dollar with United State Dollar, United Kingdom Pound, Japan Yen and Euro, respectively. Sample: $1997:1 - 2018:7$.

R^2 statistic, which captures the share of variance in observed series explained by the common component, χ_i, is above 75% for all the aggregate indexes. In particular, it is worth noticing that 84% of the volatility of NEER and real effective exchange rates (henceforth, REER) can be explained by dynamics in common components.[19] This result is significant if compared with the standard findings of the vast literature on *Exchange Rate Disconnect*, which underlines the lack of robust correlation between exchange rate and shocks to macroeconomic variables (e.g. Itskhoki and Mukhin, 2017). Our results, on the contrary, underline that the major share of fluctuations in the growth rate of effective exchange rates is due to common macroeconomic factors.

However, the picture is quite different when disaggregated series are taken into account. In fact, bilateral nominal exchange rates are much more volatile than the effective (i.e. trade-weighted) ones and, with the exception of Canadian-US exchange rate, the idiosyncratic component captures most of their volatility.[20] With regards to disaggregated PPI series, the average R^2 amounts to 0.30, suggesting that 70% of the average volatility is explained by idiosyncratic (i.e. sector-specific) components. In addition, Table (1) points out a considerable heterogeneity in sectoral inflation rates, which is mainly due to differences in the sector-specific components, as it is shown by the higher standard deviation in the idiosyncratic component than the common factor. As the sectoral components cancel out, aggregate inflation tends to be less volatile than the disaggregated price indexes. Finally, a particular caution should be applied in the interpretation of the idiosyncratic component, ξ_i, which may reflect not only sector-specific fluctuations but also measurement errors in disaggregated series.[21]

4.1.2 Persistence.

When it comes to the degree of persistence, the findings are quite different between price levels and exchange rates. In most of aggregate and disaggregated price series, inflation persistence is captured mainly by the common component, while sector-specific (i.e. idiosyncratic) components do not display, on average, much persistence. These

[19]The Real Effective Exchange Rate is defined as the price of domestic consumption in terms of consumption in the rest of the world. More specifically, in log-linearized terms, $REER_t = NEER_t + p_t - p_t^*$, where $NEER_t$ is the (log) nominal effective exchange rate, p_t and p_t^* denote, respectively, the (log) domestic and foreign consumer price indexes. Thus, an increase in $REER$ defines a real appreciation of the effective exchange rate.

[20]This result, however, is consistent with the prominent role of the United States among Canadian trade partners, as well as with use of US dollar as the invoicing currency of trade in industrial commodities.

[21]However, as pointed out by Boivin et al. (2009) and Forni and Gambetti (2010), the present empirical framework is particularly suited for estimating the impact of common (i.e. macroeconomic) shocks on disaggregated series in presence of measurement errors. In fact, in case errors are sector-specific, the estimated responses to common shocks remain consistent.

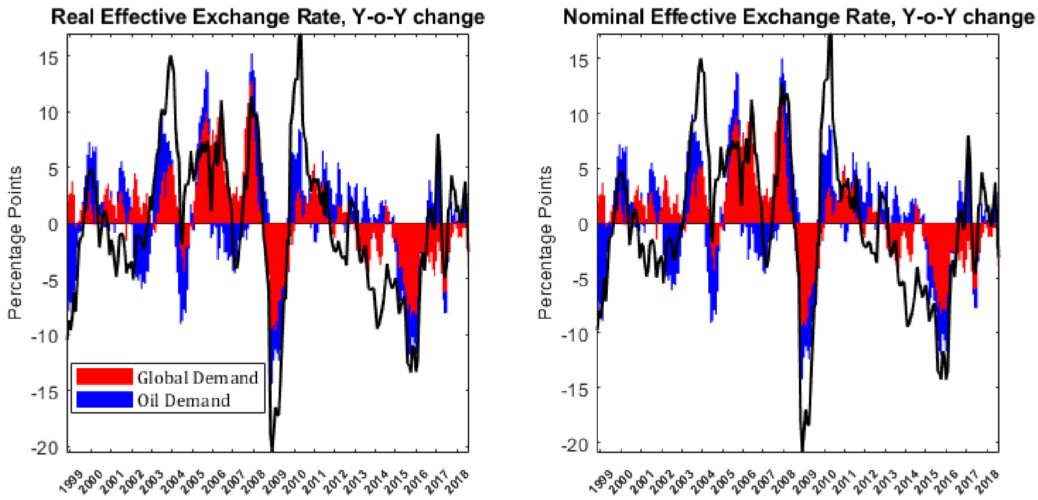

Figure 1: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed. An increase in nominal (real) effective exchange rate denotes a nominal (real) appreciation.

results are broadly in line with the findings of Boivin et al. (2009) for a cross-section of US disaggregated price series.

When it comes to exchange rate growth rates, the observed series display a degree of persistence, $\alpha(1)$, which ranges between 0.23 and 0.04, with effective exchange rates in intermediate positions. Furthermore, the persistence in exchange rate growth rates is due, in a roughly equal manner, to fluctuations in macroeconomic factors and individual components.

We conclude this Section by briefly summarizing the results obtained. First, the volatility of effective exchange rates and aggregate price levels can be mainly explained by common factors. On the other hand, idiosyncratic components explain, on average, a significant share of the volatility for disaggregated price series and bilateral nominal exchange rates. Second, a significant portion of the persistence observed in both exchange rate and price series can be related to the macroeconomic factors.

4.2 Historical decomposition

Additional insights on the source of fluctuations of key series can be obtained by implementing an historical decomposition analysis. Figure (1) and (2) display the contribution of Global Demand (red area) and Oil Demand (blue area) shocks to level or percentage year on year (Y-o-Y) changes of observed macroeconomic variables (black solid line). Additional historical decompositions can be found in Appendix B. One result stands out: the identified shocks explain a significant share of the dynamics in the observed variables usually associated to ERPT estimation, as well as terms of trade (i.e. the ratio of export and import prices) and trade balance (expressed in percentage of GDP).[22] This result is particularly striking for the changes in nominal and real effective exchange rates and is consistent with the forecast error variance decomposition analysis below (Figure 1). Our findings underline the major role of macroeconomic shocks in explaining the dynamics of effective exchange rates, contrary to the standard results found in the *Exchange Rate Disconnect* literature (e.g. Itskhoki and Mukhin, 2017). In addition, we show that the identified shocks can be consistently implemented into the analysis of *conditional* ERPT, as they explain a high share of volatility of both exchange rates and price levels. In order to provide an intuition regarding the effects of Global Demand and Oil Demand shocks on the NEER, it is instructive to focus on specific periods.

Increasing commodity prices were the hallmark of the global economic boom of the early 2000s, when the persistent acceleration of economic growth in emerging and developing countries fuelled the demand for many commodities (both energy and non-energy related) (Helbling, 2012). Consistently with the commodity price booms from 2003 till mid-2008, we find a significant role for Global Demand and Oil Demand shocks in appreciating the nominal effective exchange rate for Canada, whose exports rely for a high share on commodities (e.g. crude oil, basic metal and stone). In addition, the sharp depreciation of the exchange rates in late 2008 appears to be related with Global Demand and Oil Demand shocks. This result is consistent with the sudden drop of commodity prices at the time of the Global Financial Crisis, $2008 - 2010$, which dented the growth performances of the global economy. This period is characterized by a lowered world demand for energy and non-energy industrial commodities as well as a rise in inventories, which consistently reduced the motives for precautionary oil demand. However, the Global Financial Crisis and the Great Recession only partially affected the economic outlook of emerging and developing economies, whose industrial activity rapidly recovered to pre-crisis levels. Such buoyant recovery in emerging markets (e.g. China) sustain the demand for commodities and their prices and may also explain the rapid shift in market assessment of potential oil supply shortfalls, which in turn reduces the precautionary oil demand. These facts are broadly consistent with our findings of Global Demand and Oil Demand shocks inducing an appreciation of the nominal effective exchange rate starting from 2010. In addition, there is a clear evidence of the contribution of Global Demand and Oil Demand shocks to the depreciation of the Canadian nominal effective exchange rate from 2013. Our result is consistent with the fall in metal prices owned to slowing demand from China (Arezki et al., 2015), as well as, to the decision of the Organization of Petroleum Exporting Countries (OPEC) to strongly increase production on account of the Iran nuclear deal in 2015, which might have lowered the precautionary demand for oil. Finally, the

[22] Note that, according to our definition, an increase denotes an improvement in the terms of trade.

appreciation of the Canadian nominal effective exchange rate in the late 2016 appears to be related mainly with Oil Demand shocks. This finding is consistent with the decision of both OPEC and non-OPEC economies to cut oil production in October 2016 (Arezki et al., 2017). Such a resolve might well have increased the concerns of potential oil supply shortfalls and, hence, is fully consistent with the role of Oil Demand shocks, as displayed in Figure (1).

4.3 Impulse responses

In this Section we analyze the dynamic responses of key aggregate and disaggregated variables to both Global Demand and Oil Demand shocks. We show the impact of a Global Demand shock that is associated to an increase in (global) real economic activity (REA), and of an Oil Demand shock that generates an increase in the (global) real oil price, and label them *positive* Global Demand shock and *positive* Oil Demand shock, respectively (see Figure A.16 in Appendix B for a full specification of dynamic responses of REA and real oil price to the identified shocks).

We begin by reporting the effects of the identified shocks on the terms of trade, trade balances and effective exchange rates. In response to both shocks, we show an highly statistically significant improvement in terms of trade and an appreciation the effective exchange rates, both in nominal and real terms (Figure 3). When it comes to terms of trade, our findings are consistent with the standard results in the literature of commodity exporters; namely, a shock that raises the demand for industrial commodities and their prices improves the terms of trade of the commodity exporter economy (e.g. Charnavoki and Dolado, 2014).

Our results show that both shocks induce a significant appreciation of the nominal and real effective exchange rate that persists even in the medium-long run. Before we proceed two comments are in order. First, the nominal and real appreciation of the Canadian currency is consistent with the increasing demand for good exported by Canada, such as commodities (e.g. crude oil, metals, and stone), in response to both a positive Global Demand and a positive Oil Demand shock. Second, the medium-long run effect of both shocks can be rationalized by underlying the real nature of the identified shocks, which may plausibly extend their effects on exchange rates beyond the short-term period. This fact can be related to one of the main criticisms of the *Exchange Rate Disconnect* literature on the monetary approach to exchange rate modeling; namely, the inability of *nominal* (i.e. monetary or financial) shocks to explain both the high volatility of real exchange rates and their persistent deviation from their steady state values, beyond the periods usually associated to price rigidities (Obstfeld and Rogoff, 2000). On the contrary, the identified *real* shocks seem able to explain a high share of of both real and nominal

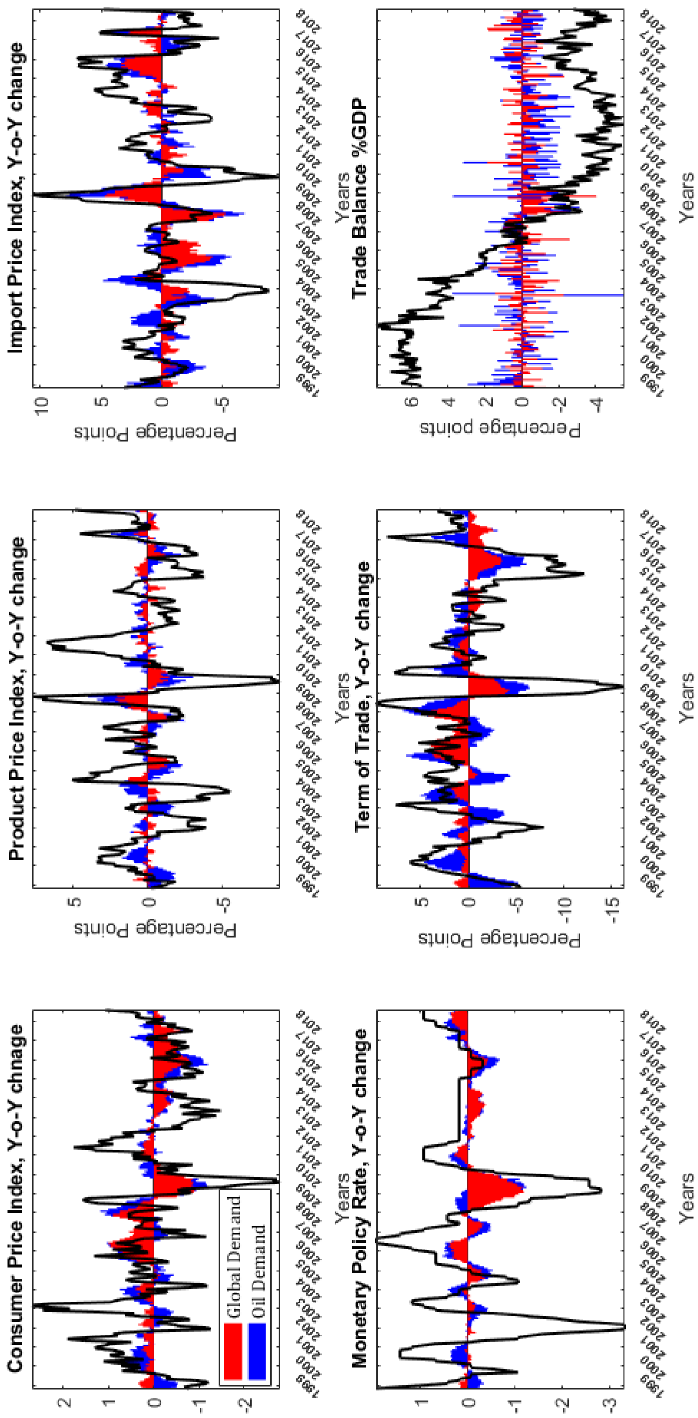

Figure 2: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed. An increase in the terms of trade denotes an improvement.

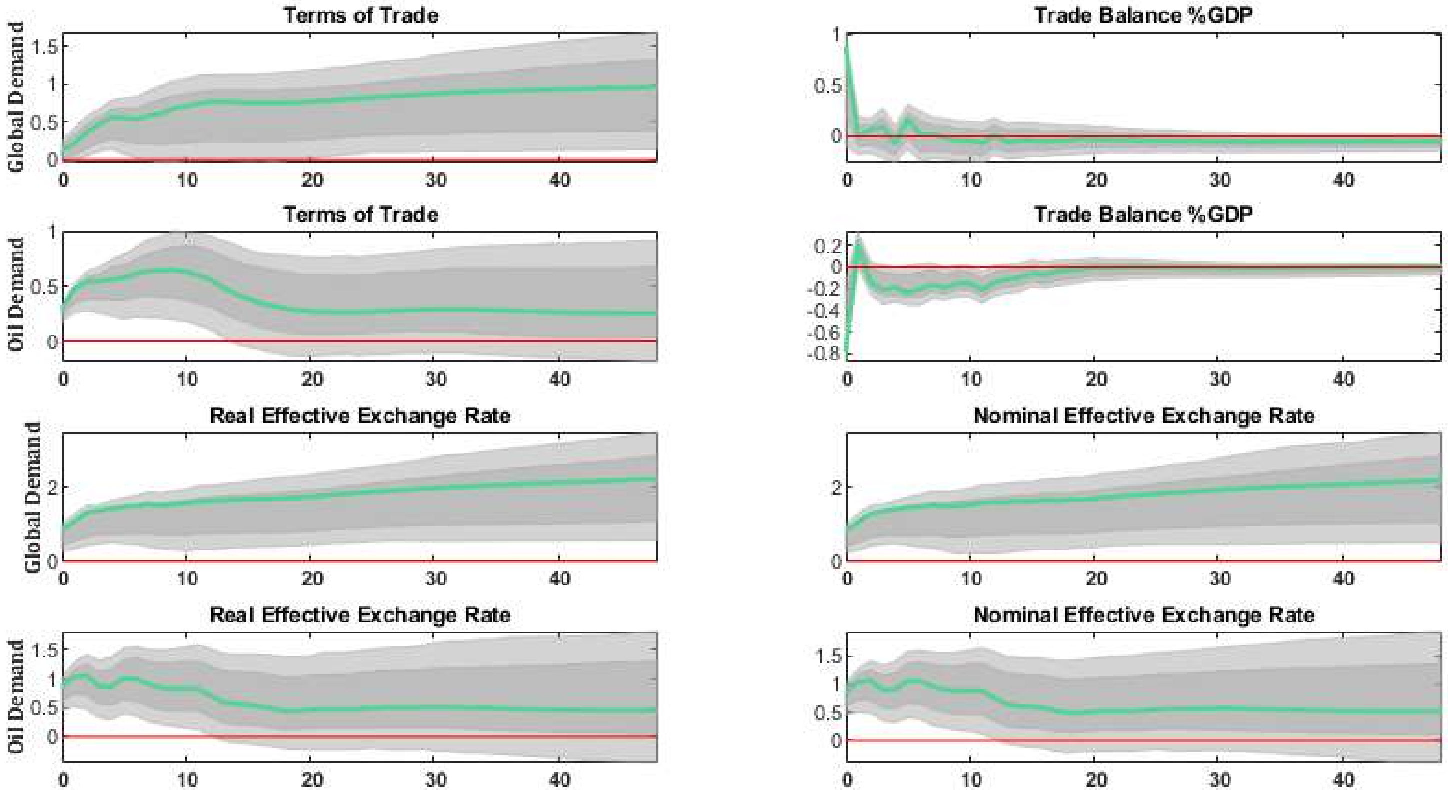

Figure 3: Impulse response functions to, respectively, a positive Global Demand and positive Oil Demand shocks. The size of the shocks is 1 standard deviation. An increase in nominal (real) effective exchange rate denotes a nominal (real) appreciation. Point estimates (green solid line) together with 68% confidence intervals (dark gray shaded area), and 90% confidence intervals (light gray shaded area). The confidence intervals are constructed with bootstraap techniques. Unit of measure: percentage points.

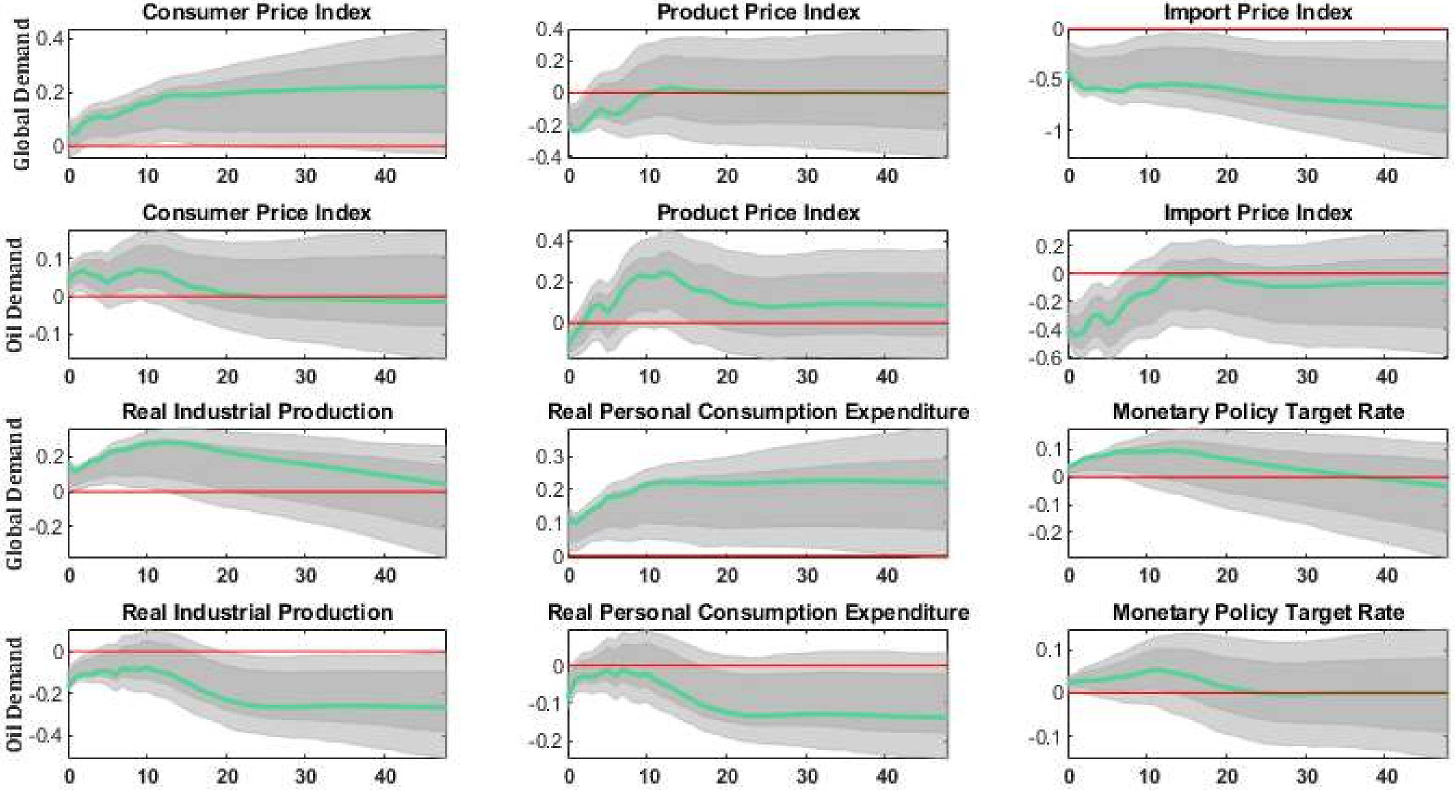

Figure 4: Impulse response functions to, respectively, a positive Global Demand and positive Oil Demand shocks. The size of the shocks is 1 standard deviation. Point estimates (green solid line) together with 68% confidence intervals (dark gray shaded area), and 90% confidence intervals (light gray shaded area). The confidence intervals are constructed with bootstraap techniques. Unit of measure: percentage points.

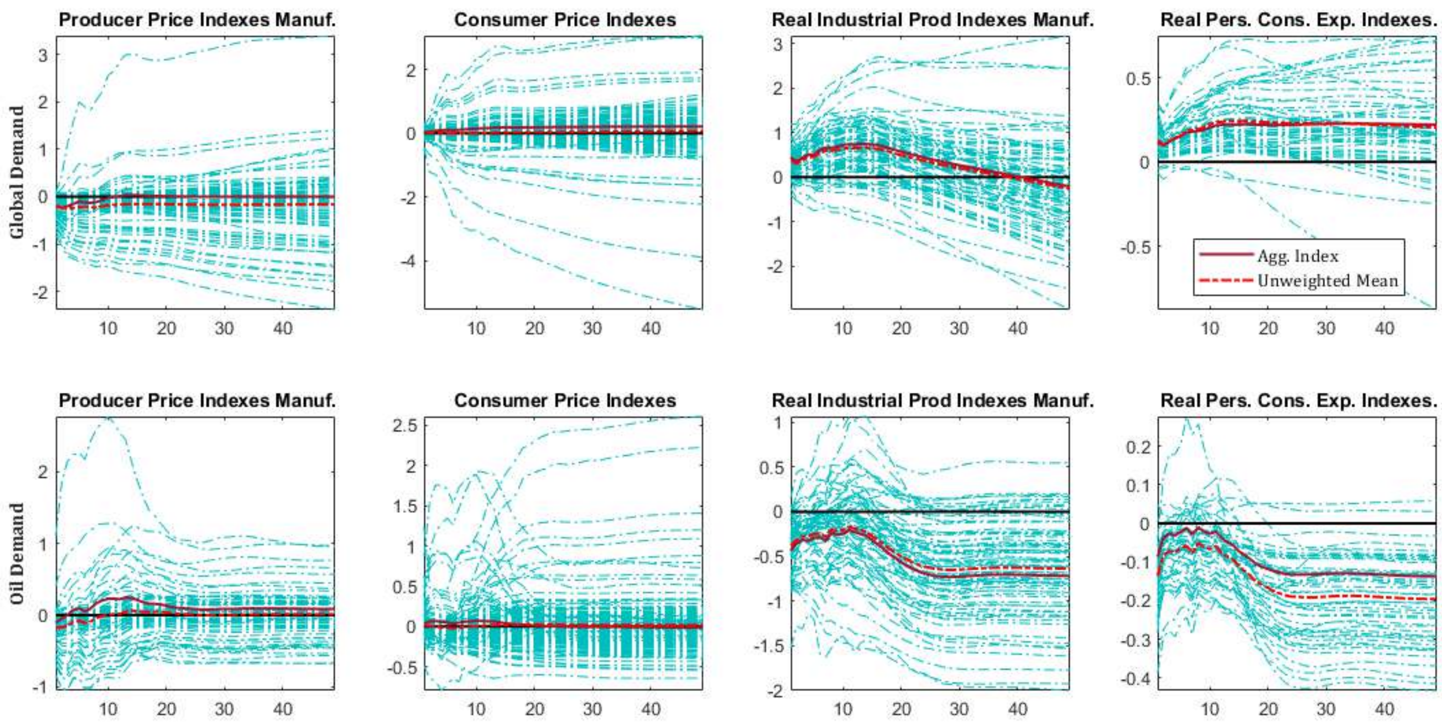

Figure 5: Impulse response functions of disaggregated indexes (cian dotted lines), aggregate index (red solid line) and unweighted mean (red dotted line) to positive Global Demand and positive Oil Demand shocks. The size of the shocks is 1 standard deviation. Disaggregated series are related to: manufacturing producer price indexes, consumer price indexes, manufacturing real industrial production indexes, and real personal consumption expenditure indexes. Unit of measure: percentage points.

effective exchange rate variability (see the forecast error variance decomposition below) and generate responses consistent with a long-run deviation of real effective exchange rate from its steady state. Thus, at least for commodity currencies, our results may provide good news for the resolution of the *Exchange Rate Disconnect Puzzle*.

For external balances, our statistically significant results differ across shocks, with positive Global Demand shocks inducing an improvements and positive Oil Demand shocks determining a worsening. These results might be rationalized by considering that positive Global demand shocks lower the competitiveness of domestic producers by inducing a real appreciation but, at the same time, increase Canadian exports via their positive effects on (global) real economic activity (see the Appendix B for the impulse responses of Canadian exports and imports). This second counterbalancing effect seems no longer active in case of an Oil Demand shock that, instead, worsens Canadian external balances.

Figure (4) shows the responses of key price aggregates to the identified shocks. It is straightforward to notice that both shocks have a similar effect on all price aggregates. In particular, both shocks induce a statistically significant increase in Canadian consumer price index (CPI), which is sustained in the long-run in case of a positive Global Demand shock. As a result of the central role in the CPI aggregate of commodity-related prices, such as gasoline, its positive response to shocks that increase the prices of commodities, it is not surprising.[23]

In addition, both positive Global Demand and positive Oil Demand shocks reduce the product price index (PPI) within the same month, with the negative effect remaining significant for few months. This result could be rationalized by considering that both shocks induce a nominal (and real) appreciation in the effective exchange rate that, in turn, reduces the competitiveness of domestic producers, thus activating a price reduction. The PPI drop is partially counterbalanced by the increase in energy production costs, as proxied by the real oil price, in response to a positive Oil Demand shock (Figure A.16).

The import price index (IPI) shows a, statistically significant, negative response to both shocks for a prolonged number of months. It is straightforward to see that, as a result of the nominal (and real) appreciation of the effective exchange rate in response to both identified shocks, the domestic (i.e. Canadian dollar) price of imports invoiced in foreign currency decreases.

It is worth stressing that the displayed responses imply, on impact (i.e. within the same month), a positive *conditional* correlation between CPI and the nominal effective exchange rate (NEER) and a negative *conditional* correlation between PPI or IPI and the NEER. This insight will be proven useful when we present our measure of *conditional*

[23]Our findings are consistent with Charnavoki and Dolado (2014), who show an increase of the Canadian consumer price index in response to shocks raising the demand for commodities.

ERPT in the following Sections.

To further investigate the result above, we estimate a simple VAR including: (global) oil production, (global) real economic activity (REA), (global) real oil price, Canadian real industrial production, Canadian CPI, and NEER. The VAR is estimated with 12 lags over the period January 1997 - July 2018 and its impulse responses are compared with the ones obtained in a suitably "extended" DFM (Figure A.17). In both models identification is achieved by assuming a standard recursive scheme that extends the strategy employed above by considering the NEER.[24] We show that a positive *conditional* correlation between CPI and NEER is obtained also in the VAR and, thus, depends on the identification of commodity-related structural shocks, rather than on the econometric setup. However, and perhaps interesting, this finding could be rationalized only by estimating responses across disaggregated price series (Figure 5), as it allows to disentangle the increase in key CPI components, such as gasoline, in response to the identified shocks. This insight underlines an additional advantage of our econometric setup over standard *conditional* ERPT analysis implementing small or medium scale VAR models (e.g. Forbes et al., 2018).

A positive Global Demand shock significantly increases real industrial production and real personal consumption expenditure. On the contrary, a positive Oil Demand shock displays a negative, statistically significant, impact on both variables. These outcomes are fully consistent with the response of trade balances and clearly show the opposite impact of the identified shocks on the global demand for non-commodity related goods (i.e. manufacture goods) produced in Canada. A further inspection of the responses of CPI and real industrial production highlights that Global Demand and Oil Demand shocks behaves "as" standard demand and supply shocks for the Canadian economy: after a Global Demand shock output and inflation increase; after an Oil Demand shock output decreases and inflation increases. This fact, we believe, adds additional emphasis on the role of commodity shocks, whose identification is consistent with the standards in the literature, for Canada.

Consistently with the positive response of CPI, we observe an increase in the monetary policy target rate in response to both shocks (Figure 4). This finding is consistent with the pursue of an inflation targeting monetary policy, which takes into account the price level outlook and sets (endogenously) its main instrument to respond to external shocks. A similar insight could be obtained by the analysis of monetary aggregates, such as the monetary base and M3, that decrease in response to both shocks, thus confirming the restrictive (endogenous) response of the domestic monetary policy stance to positive

[24]Our identification strategy assumes that the NEER does not affect contemporaneously the (global) oil production, (global) real economic activity (REA), (global) real oil price, Canadian real industrial production, and Canadian CPI.

commodity-related shocks (Figure A.12 and Figure A.15 in Appendix B).[25]

We now turn to the responses of more disaggregated price and quantity series to the identified Global Demand and Oil Demand shocks. The structural DFM provides a suitable framework to implement this exercise, as it allows a direct estimation of the responses of all the variables in the data set. Figure (5) displays the disaggregated responses of producer price indexes, within the manufacturing sector, and consumer price indexes to the identified shocks (column 1 and 2, respectively). It is immediate to notice that price responses, both at the consumer and producer level, display a great degree of heterogeneity. In addition, for both price levels, departures from the aggregate index (red solid line) or unweighted mean (red dotted line) are related, almost equally, to positive and negative disaggregated price responses. Moreover, Figure (5) shows the responses of real industrial production, within the manufacturing sector, and real personal consumption expenditure to the identified shocks (column 3 and 4, respectively). While we can observe heterogeneous responses, a striking feature is that, in most cases, the dynamic of disaggregated series closely matches the response of the aggregate index. In addition, the wide majority of sectoral production and consumption expenditure levels displays a sustained increase (decrease) in response to a positive Global Demand (positive Oil Demand) shock.

4.4 Forecast error variance decomposition

In this Section we describe the forecast error variance decomposition (FEVD), for different horizons, related to the identified shocks. Table (2) - (5) show the decomposition of the common component, χ_i, associated to key macroeconomic variables, as related to both Global Demand and Oil Demand shocks (see the Appendix A for the decomposition of other macroeconomic and financial variables). At a six month horizon, the two identified shocks explain more than 50% of volatility in crucial business cycle indicators for a small-open economy, such as real industrial production (IP), real personal consumption expenditure (PCE), terms of trade (ToT), trade balance (TB) and monetary policy target rate (MPR). This high explanatory power tends to persist in the long run for all the series, but the monetary policy instrument. This finding can be rationalized by considering an endogenous short-run response of the main policy instrument to external shocks. On the other hand, most of its long-run volatility is determined by other shocks (e.g. monetary policy shocks). When it comes to aggregate price levels, the two identified shocks jointly explain between 8% and 63% of their volatility at a 6 month horizon. This range widens in the long run (i.e. 48 month horizon), when the two identified shocks jointly explain the

[25]The Bank of Canada has been operating under inflation targeting since 1991. For a full list of inflation targeters see Ilzetzki et al. (2019).

majority of IPI variance (60%) and a significant share of the volatility of both CPI (35%) and PPI (5%). Finally, we take into account the variance decomposition of effective exchange rates (similar results hold for main bilateral nominal exchange rates, as shown in Appendix A). It is immediate to see that the two identified shocks explain more than 75% of volatility of both real and nominal effective exchange rates, at all horizons. This result is particularly significant in light of the standard weak connection between exchange rates and macroeconomic variables, as crucially underlined by the vast literature on *Exchange Rate Disconnect*. It is worth noting that the decomposition above refers to the common component, i.e. χ_{it}, of the variables expressed in log-levels and, thus, does not consider the volatility coming from the idiosyncratic part, i.e. ξ_{it}. However, we obtain similar results for the monthly growth rate of the observed variables, even upon including the idiosyncratic component. In fact, the two identified shocks explain the 11.8%, 21.4%, 52.3%, 66.9%, 68.9%, 49.6%, and 45.9% of the long-run (48 month horizon) volatility of the monthly growth rates in: CPI, PPI, IPI, NEER, REER, IP, and PCE, respectively.[26] To briefly summarize, our findings show that the two identified shocks explain a significant share of volatility of main business cycle variables for Canada.[27] In particular, the two commodity shocks seem to drive the dynamics both for (effective) exchange rates and price levels. As a consequence, they provide a suitable background for the *conditional* ERPT analysis, which is described in the next Section.

Forecast error variance decomposition. Global Demand shock

Horizon	REER	NEER	CPI	PPI	IPI
0	49.20	45.87	5.01	18.71	41.76
6	59.12	53.96	11.98	7.25	44.33
12	59.27	52.73	21.58	4.23	44.29
24	67.46	59.94	31.27	2.32	49.03
48	76.46	69.40	34.49	1.27	57.57

Table 2: Horizon is expressed in number of months since the shock.

[26] These results are obtained via a "back of the envelope" calculation multiplying the share of variance of each series explained by the common component (i.e. the R^2 in Table 1) by the share of long-run variance of the common component explained by both shocks (Table A.5 and A.10). When it comes to the monthly growth rate of real industrial production (IP) and real personal consumption expenditure (PCE) the share of variance explained by the common component is 0.74 and 0.80, respectively.

[27] In addition, our results are consistent with the Canadian business cycle being also driven by other sources of fluctuations, such as productivity, fiscal policy, and monetary policy shocks.

Forecast error variance decomposition. Global Demand shock

Horizon	ToT	TB	MPR	IP	PCE
0	3.95	46.10	57.94	33.08	37.41
6	21.40	36.32	58.68	41.36	56.85
12	27.90	28.78	40.47	47.16	62.84
24	38.54	25.56	25.49	44.48	67.81
48	51.33	26.56	14.90	28.25	69.71

Table 3: Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Oil Demand shock

Horizon	REER	NEER	CPI	PPI	IPI
0	47.75	47.09	3.57	4.63	38.38
6	31.69	31.74	4.09	1.29	19.24
12	23.28	23.44	4.80	5.69	11.92
24	14.50	15.11	2.50	5.68	6.80
48	8.78	9.70	1.06	4.07	3.60

Table 4: Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Oil Demand shock

Horizon	ToT	TB	MPR	IP	PCE
0	24.33	36.64	24.88	43.66	21.63
6	31.60	37.90	10.44	18.08	4.83
12	28.95	35.64	9.09	10.46	2.77
24	19.11	31.89	4.62	21.14	11.29
48	12.13	30.87	2.49	37.18	18.65

Table 5: Horizon is expressed in number of months since the shock.

4.5 Conditional exchange rate pass-through

In this Section we present our measure of *conditional* ERPT. As underlined above, our approach differs from the standard one that estimates the pass-through in a partial equilibrium set-up by adopting a single equation approach, thus providing an *unconditional* ERPT measure (equation 1). On the contrary, our analysis implements a system approach and is made conditional on the shock hitting the economy, thus estimating a *conditional* ERPT. However, some caution is necessary in comparing the two measures, as the *unconditional* ERPT refers to the impact of exchange rates on prices under ceteris paribus conditions, i.e. keeping other variables constant, while the *conditional* ERPT is based on the comovement of prices and exchange rates through the various transmission channels of the structural shocks identified, i.e. Global demand and Oil demand shocks.[28] As these shocks represent a major source of fluctuations for Canadian exchange rates, applying a system approach that takes into account their feedback effects might prove useful to understand and predict exchange rate pass-through.

Our notion of *conditional* ERPT builds on the contribution of Bouakez and Rebei (2008) and measures pass-through as the (weighted) average of the ratio of the impulse responses of prices and exchange rates. By considering the relationship between the changes in price indexes and exchange rates, our approach is close to the standard way in which pass-through is usually estimated at the macroeconomic level. However, it allows us to disentangle the role of different shocks and, thus, we consider it as a *conditional* ERPT estimate. We define *conditional* ERPT (CERPT) at horizon $t+\tau$ as in Bouakez and Rebei (2008):

$$CERPT_{t+\tau} \equiv \frac{cov_{t-1}\left(p_{t+\tau}, e_{t+\tau}\right)}{var_{t-1}(e_{t+\tau})}, \tag{9}$$

where $p_{t+\tau}$ and $e_{t+\tau}$ represent, respectively, the (log) price index and the (log) nominal effective exchange rate at period $t+\tau$. Our notion of pass-through measures the expected conditional relationship between prices and exchange rates, at horizon $t+\tau$, as of the information available $\tau+1$ periods in advance. Notice that price index, $p_{t+\tau}$ and exchange rate, $e_{t+\tau}$, can be expressed as:

$$p_{t+\tau} = f(p,\tau,t-1) + \sum_i \sum_{j=0}^{\tau} \omega_{j,i} u_{i,t+\tau-j}$$

$$e_{t+\tau} = f(e,\tau,t-1) + \sum_i \sum_{j=0}^{\tau} \varphi_{j,i} u_{i,t+\tau-j},$$

where $f(\cdot,\tau,t-1)$ represents the forecast conditional on the information available

[28] For a thorough analysis of the differences between the conditional and unconditional approach in empirical and theoretical models, see Burlon et al. (2018) and Ortega and Osbat (2020).

as of period $t-1$, $u_{i,t}$ represents the structural shock i hitting the economy at period t; and $\omega_{j,i}$, $\varphi_{j,i}$ are the (impulse) responses of (log) prices and (log) exchange rate to structural shocks. Thus, *conditional* ERPT at horizon $t+\tau$ can be obtained by the following rearrangements:[29]

$$\begin{aligned} CERPT_{t+\tau} &= \frac{\sum_i \sum_{j=0}^{\tau} \omega_{j,i}\varphi_{j,i}\sigma_i^2}{\sum_i \sum_{j=0}^{\tau} \omega_{j,i}^2 \sigma_i^2} \\ &= \sum_i \sum_{j=0}^{\tau} \frac{\omega_{j,i}}{\varphi_{j,i}} \frac{\varphi_{j,i}^2 \sigma_i^2}{\sum_i \sum_{j=0}^{\tau} \varphi_{j,i}^2 \sigma_i^2}, \end{aligned} \tag{10}$$

where σ_i^2 is the variance of shock i and $\frac{\omega_{j,i}}{\varphi_{j,i}}$ is the ratio of the responses of p and e at horizon j to shock i. Note that the contribution of $\frac{\omega_{j,i}}{\varphi_{j,i}}$ to pass-through is weighted by a convolution of parameters referring to both the variance of the structural shocks and the squared of exchange rate impulse response parameter. As a consequence, the *sign* of our *conditional* ERPT measures crucially depends on the responses of prices and exchange rates to structural shocks (i.e. $\frac{\omega_{j,i}}{\varphi_{j,i}}$).

It is worth noting that, consistently with the previous analysis, we estimate the pass-through conditional on the two identified shocks; namely, Global Demand and Oil Demand shocks. In particular, since both shocks are a significant source of fluctuation for exchange rates, our main estimate of ERPT is made conditional on both shocks *jointly*, i.e. $i \in \{\text{Global Demand, Oil Demand}\}$ in eq. (10). However, in order to describe the role of individual shocks, we also present measures of ERPT conditional on either Global Demand or Oil Demand shock *separately*, i.e. $i = \{\text{Global Demand}\}$ or, alternatively, $i = \{\text{Oil Demand}\}$ in eq. (10) (Figure A.8).

Estimates of ERPT into consumer, product and import price indexes are presented in Figure (6), up to a twelve-month horizon. The left hand side shows the estimates (blu solid line) of the *unconditional* ERPT that are obtained via the distributed-lag regression (1) considering the relevant series for Canada over the period January 1997 - July 2018.[30] Our findings show a negative relationship between nominal effective exchange rate changes and inflation along the whole price chain. In addition, the degree of pass-through is incomplete in the twelve-month horizon and decreases (in absolute value) along

[29]For a full derivation we refer to Bouakez and Rebei (2008).

[30]The selected controls, X_n, are the contemporaneous growth rate of real GDP for Canada, the $(0-T)$ log differences in the (trade-weighted) foreign PPI (in foreign currency) and (world) real oil price, and $(0-T)$ lagged levels of (global) real economic activity (REA). T is defined at a 1 year horizon. The trade-weighted foreign PPI is computed by considering: the PPI of trade partners (in foreign currency) for Canada and the associated trade weights (broad index). The choice of invoicing PPI of trade partners in foreign currency is standard in the pass-through literature (e.g Burstein and Gopinath, 2014). Sources are Datastream and BIS.

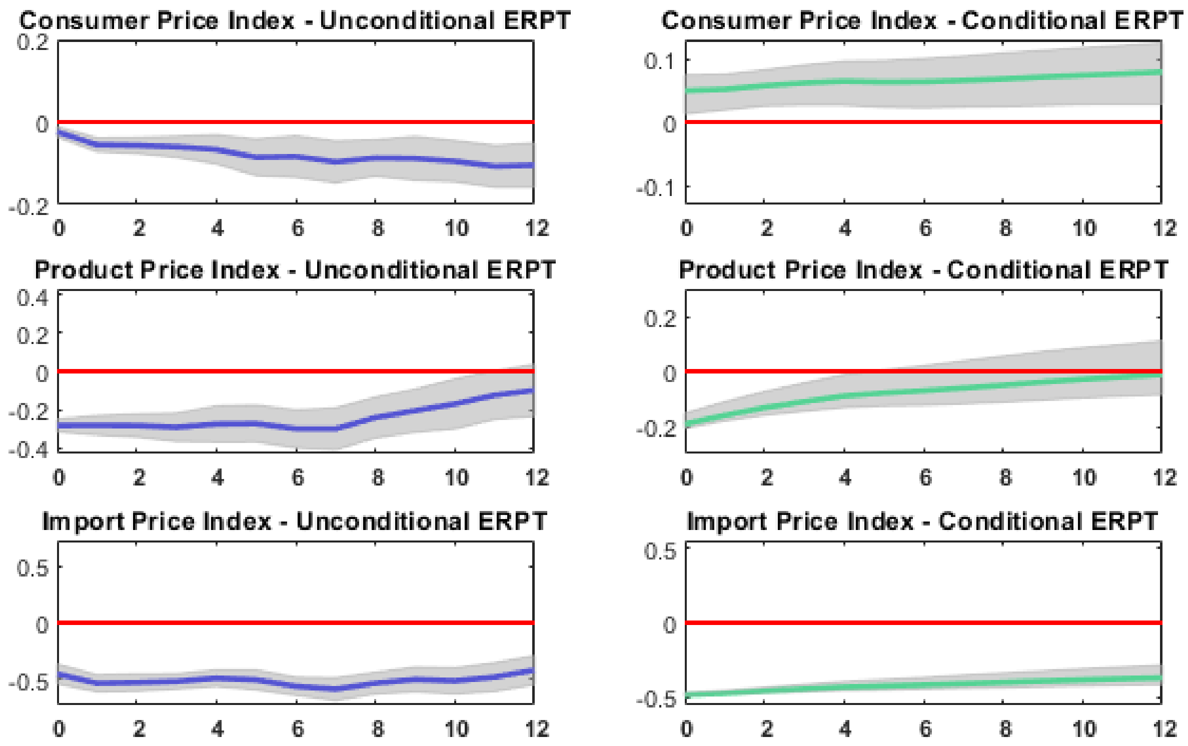

Figure 6: Conditional exchange rate pass-through (ERPT) measures are obtained by considering positive Global Demand and positive Oil Demand shocks jointly. Solid lines represent point estimates of exchange rate pass-through, both unconditional (blue solid line) and conditional (green solid line). Gray shaded areas refer to the 90% confidence intervals. Unit of measure: percentage points.

the price chain, with CPI showing a lower degree of ERPT than IPI. These results denote a stronger adjustment of the prices at the border with respect to consumer prices, for a given change in the nominal effective exchange rate, and are standard in the literature that finds a negative *unconditional* pass-through for both import and consumer prices for Canada (Burstein and Gopinath, 2014).

On the right hand side of Figure (6) we display our shock-dependent measure of ERPT, which is made conditional on both identified shocks, i.e. Global Demand and Oil Demand. Consistently with the literature, the degree of pass-through to CPI is lower (in absolute value) than to IPI. However, it is immediate to notice the opposite sign of *conditional* CPI ERPT with respect to the *unconditional* CPI ERPT measure. This result builds on the positive response of CPI and nominal effective exchange rate (NEER) to both the identified shocks (Figure 3 and Figure 4), which reflects the commodity exporter nature of the Canadian economy, and can be further rationalized by considering the positive pass-through for commodity-related items included into the consumer price index (Figure A.9). This finding would not occur in commodity-importer economies, as in response to shocks increasing commodity prices (e.g. *positive* Global Demand and Oil Demand shocks) inflation would increase, and exchange rates would depreciate. According to our estimates, the exchange rate depreciation in commodity-importers would be determined by the appreciation of commodity-exporter currencies after the shock. As a consequence, the pass-through to consumer prices would be negative for commodity-importers conditional on commodity shocks, consistently with standard unconditional estimates.

Our results contribute to the studies of pass-through along two dimensions. First, it provides novel evidences on the pass-through in commodity-exporters, conditional on two major shocks hitting the economy. Second, by considering the joint determination of prices and exchange rates, we show that pass-through estimates free from endogeneity concerns may lead to *opposite* inference about the sign of pass-through with respect to standard *unconditional* estimates.

Our measure of *conditional* ERPT has further advantages over standard *unconditional* ones. First, it suggests a measure of the relationship between price changes and exchange rate changes, which is based on the comovement of the two (endogenous) sets of domestic and international prices, without any causal interpretation. Second, by directly considering the responses to price and exchange rate variables to structural shocks, we manage to account for the comovement between exchange rate and price dynamics, without assigning the lion share of the movements in the exchange rates to, disputable, exchange rate shocks. In actual fact, as pointed out by the forecast error variance decomposition above, our identified commodity shocks explain a significant share of the long-run volatility of both aggregate price indexes and nominal exchange rate (75%) and, thus, represent a suitable source of conditioning in the pass-through estimation. In addition, these shocks induce responses of CPI and NEER that are incompatible with the standard view linking an exchange rate appreciation with a drop in consumer prices.

In order to describe the role of individual shocks, we compare our measure of pass-through conditional on both shocks *jointly* (Figure A.8, first row), with the pass-through estimates conditional on either Global Demand shocks or Oil Demand shocks *separately* (Figure A.8 second and third row, respectively). It is immediate to see that, for every aggregate price index, the *joint* measure of conditional pass-through exhibits the same dynamics of *separate* conditional estimations.

We conclude this Section by providing our *conditional* ERPT measure for a wide plethora of price indexes (Figure 7). In particular, we focus on the pass-through to producer price indexes in the manufacturing sector, thus referring to the price indexes of manufacturing establishments located in the Canadian territory (a similar analysis for disaggregated consumer price indexes is available in Appendix B). It is immediate to notice that pass-through estimates display some degree of heterogeneity, with many price series exhibiting a negative *conditional* ERPT. This result can be rationalized by considering that both identified shocks induce an appreciation of the nominal (and real) effective exchange rate that reduces the average competitiveness of domestically produced goods, thus inducing an average producer price reduction. It is not surprising, then, that manufacturing non-commodity industries (e.g. aerospace products and parts) display a strongly negative *conditional* ERPT. Among the price series that exhibit a positive *conditional* ERPT (i.e. an increase in producer prices associated with an appreciation of the nominal effective exchange rate), we account those series related to commodity industries (e.g. petroleum and coal production), whose market demand tends to increase in response to commodity shocks. Appendix B provides further evidences related to disaggregated producer and consumer price pass-through measures conditional on positive Global Demand and positive Oil Demand shocks.

4.6 Cross-sectional analysis

In this Section we aim at providing evidence of key explanatory factors that can account for the dispersion of conditional exchange rate pass-through, as measured in response to Global Demand and Oil Demand shocks *jointly.* In particular, we focus on the pass-through to producer price indexes in the manufacturing sector, thus referring to the price indexes of manufacturing establishments located in the Canadian territory, across industries with a similar degree of product differentiation. Our interest on the pricing behavior of domestic producers in response to shocks, which may affect both

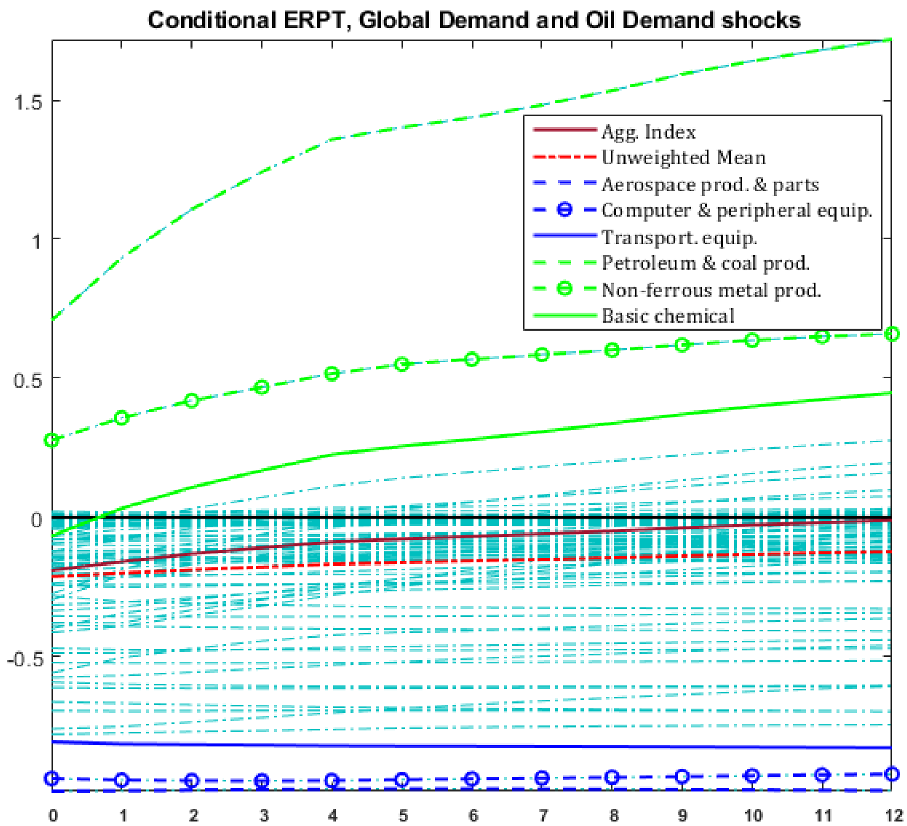

Figure 7: Exchange rate pass-through (ERPT) estimates for disaggregated manufacturing producer price indexes conditional on positive Global Demand and positive Oil Demand shocks jointly, at different horizons. Unit of measure: percentage points.

their cost structure and demand conditions, is in line with a vast theoretical and empirical literature (e.g. Dornbush, 1987; and Boivin et al., 2009). The analysis focuses on the producer pricing behaviour at the sectoral level, and does not take into account potential amplification effects coming from the production network.[31] We leave a detailed analysis of this topic to future research. Our findings contribute to the studies of *conditional* exchange rate pass-through along one key dimension: we show how the structure of a market and its international integration affect the dispersion into the degree of pass-through (Figure 7). In order to explain differences in Conditional ERPT, as related to industry characteristics, we implement the following regression:

$$CERPT_h^j = \beta_0 + \beta_1 \text{Profit Margin}_j + \beta_2 Persistence_j + \beta_3 Penetration_j + \varepsilon_j,$$

where $CERPT_h^j$ refers to *conditional* ERPT for price index in industry j, at horizon h of 6 months, but also we note that the results are robust to alternative horizons. In addition, Profit Margin_j represents the (net) profit margin in industry j.[32] We interpret a higher level of Profit Margin as a lower degree of competition in industry j (i.e. higher market power on behalf of operating firms).[33] We also implement two variables from the factor analysis; namely, $Persistence_j$ and $Volatility_j$ (Table 6). These variables measure, respectively, the persistence and (log) volatility of the idiosyncratic component in industry j, as presented in Section 4.1. The degree of import penetration in industry j is given by $Penetration_j$.[34] Finally, we consider three dummy variables (one is omitted due to multicollinearity), which control for potential different average dynamics. In particular, we implement three industry (i.e. NAICS) broad category: food and textiles (NAICS code starting with 31; dummy denoted with $Dummy_{31}$); paper, wood and chemicals (NAICS code starting with 32; dummy denoted with $Dummy_{32}$); metallurgy, electronics and machinery (NAICS code starting with 33; dummy denoted with $Dummy_{33}$).

In order to analyze results of our estimations, it is crucial to point out that our measures of pass-through are conditional on shocks, which determine an appreciation (i.e. increase) of the nominal effective exchange rate for Canada. On the other hand, the response of producer price indexes is mixed, thus resulting in pass-throughs of different signs, as evident from Figure (7). However, due to the fact that the *average* exchange

[31] For a recent analysis of this topic, see Ghassibe (2021).

[32] In the present study we compute Profit Margin_j as the (percentage) ratio between net profits and revenues in industry j. See the Online Appendix for further details.

[33] The same approach is implemented by Boivin et al. (2009).

[34] Import penetration is defined, for industry j and time t, as:

$$Penetration_{j,t} = \frac{Imports_{j,t}}{Imports_{j,t} + Production_{j,t} - Exports_{j,t}}.$$

See the Online Appendix for further details.

Cross-sectional dispersion of conditional exchange rate pass through: regression analysis

	Dependent variable: CERPT			
	Horizon of 6 months			Horizon of 12 months
	(1)	(2)	(3)	(4)
Const	-0.058	-0.066	-0.056	-0.042
	(0.037)	(0.031)**	(0.234)	(0.036)
Profit Margin	0.004	0.008	0.003	0.004
	(0.002)*	(0.002)**	(0.002)	(0.002)*
Persistence	-0.131	-0.114	-0.131	-0.1220
	(0.061)**	(0.052)**	(0.066)**	(0.07)
Penetration	-0.382	-0.234	-0.382	-0.365
	(0.091)**	(0.073)**	(0.093)**	(0.091)**
Dummy_{32}		0.004		
		(0.041)		
Dummy_{33}		-0.147		
		(0.079)*		
Volatility			0.0004	
			(0.040)	
R2 adj.	0.09	0.12	0.08	0.06
Mean Cond. ERPT		-0.172		-0.142

Table 6: Dependent variable: exchange rate pass-through of disaggregated producer price indexes conditional to Global Demand and Oil Demand shocks jointly, at horizon of 6 and 12 months. Heteroskedasticity and autocorrelation (HAC) robust standard errors by Newey and West (1987) are in parenthesis. Ordinary Least Squares methods are implemented to obtain the estimations. * (**) denotes significance at 10 (5) percent level. The following regression is implemented:

$$CERPT_h^j = \beta_0 + \beta_1 \text{Profit Margin}_j + \beta_2 Persistence_j + \beta_3 Penetration_j + \varepsilon_j,$$

where $CERPT_h^j$ refers to *conditional* ERPT for the price index in industry j, at horizon h; Profit Margin_j represents the (net) profit margin in industry j; $Persistence_j$ and $Volatility_j$ measure, respectively, the persistence and (log) volatility of the idiosyncratic component in industry j; the degree of import penetration in industry j is given by $Penetration_j$. $Dummy_{32}$ and $Dummy_{33}$ control for (average) distinct dynamics across broad industry categories.

rate pass-through is negative, positive regression coefficients implies a lower, in absolute value, degree of ERPT. In particular, positive (negative) coefficients imply less (more) price flexibility; i.e. less (more) rapid price adjustments. In what follows, we consider column (1), of Table 6, as our benchmark estimation and focus on its findings.

When it comes to Profit Margin$_j$, column 1 reports a positive, and significant, coefficients, thus pointing out that profits are positively correlated with pass-through estimates. In particular, a 1% increase in profit margins *lowers* the pass-through by 0.4% in absolute value. Our result can be rationalized by considering that firms with higher market power tend to adjust their mark-ups in response to exchange rate and cost changes in order to keep constant their market shares. Thus, high market power (i.e. low competition) is associated with a lower degree of pass-through.

When it comes to the persistence of the idiosyncratic components, the negative coefficient underlines that an increase in the persistence of sector-specific disturbances is associated with a higher (in absolute value) degree of pass-through. This finding can be rationalized by considering that in industries characterized by more persistent idiosyncratic components, firms adjust faster to both macroeconomic (i.e. common component) and idiosyncratic shocks. On the other hand, in those industries where we observe transient idiosyncratic components, firms may adopt a behavior of "wait and see" if the current shock is persistent (macroeconomic) or transient (idiosyncratic), and adjust with a delay.

Finally, $Penetration_j$ captures the role of integrated world markets play in the estimated conditional pass-through. In particular, in line with the seminal contribution of Dornbush (1987), we expect that larger share of imports in total sales (i.e. an higher value of $Penetration_j$) would induce domestic producers to augment their price adjustment in case a shock appreciates the nominal (effective) exchange rate and, thus, makes domestic products less competitive. According to this insight, we can rationalize the negative sign on $Penetration_j$ coefficient, which points out faster price adjustments in those industries where the share of imports over total sales is larger. In particular, our findings underline that a 1% increase in $Penetration_j$ raises (in absolute value) the degree of *conditional* ERPT by 0.38%.

The results above are robust to a change in horizon, as underlined by column (4) that reports the baseline regression for the 12 month horizon. Furthermore, adding dummy variables (column 2), while improving the fit of the model, it does not alter the significance of previous results and underlines a limited difference in average dynamics across industries. Perhaps interesting, we find no evidence of significant effects of idiosyncratic volatility on our measure of conditional pass-through (column 3). As a consequence, we discard this variable from our baseline estimate.[35]

[35]These findings could be, presumably, generalized to commodity-importer economies, whose currencies would depreciate in response to positive Global Demand and Oil Demand shocks, thus inducing a substitution from imported to domestically produced goods and, hence, an increase in the prices charged by local producers; i.e. negative average pass-through to producer prices. Symmetrically, also for these economies, the *degree* of pass-through would: decrease in the industry market power; increase in the degree of import penetration and persistence of sector-specific shocks.

5 Conclusions

This study provides an estimate of the pass-through of exchange rates to prices in small-open commodity-exporter economies, taking Canada as a case study. We use a Dynamic Factor Model (DFM) that solves the endogeneity between prices and exchange rates by estimating pass-through conditional on structural commodity shocks. By comparing our measure of *conditional* exchange rate pass-through with the *unconditional* estimate of a standard model, we obtain the following results: they both display a negative pass-through for import and product price indexes, while the sign of ERPT for the consumer price index drastically changes across approaches, with the *unconditional* estimate exhibiting a negative pass-through and the *conditional* measure being positive. Thus, our econometric setup shows a positive correlation between exchange rate appreciation and CPI inflation *conditional* on commodity shocks that increase the price of commodities, i.e. positive Global Demand and Oil Demand shocks. Our findings can be rationalized by considering the commodity-exporter characteristics of the Canadian economy, as the identified shocks induce an appreciation of Canadian exchange rates and increase commodity prices (e.g. crude oil). As a result of the central role in the CPI aggregate of commodity-related prices, such as gasoline, its positive response is not surprising. Our results contribute to the studies of ERPT along two key dimensions. First, we provide novel evidence on the pass-through in small-open commodity-exporters, conditional on commodity shocks. Second, by considering the joint determination of prices and exchange rates, we show that pass-through estimates free from endogeneity concerns may lead to *opposite* inference about the sign of pass-through with respect to standard *unconditional* estimates.

Resorting to a structural DFM also permits to estimate the degree of pass-through, conditional to the identified shocks, on a wide plethora of price levels at different stages of the price chain. By focusing on industry-level producer price indexes, we show that *conditional* ERPT decreases with industry market power, while it increases in the degree of import penetration and persistence of industry-specific shocks. Our findings contribute to the studies of *conditional* exchange rate pass-through along the cross-sectional dimension: we show how the structure of a market and its international integration affect the degree of pass-through.

Finally, the present empirical analysis builds on the identification of two shocks that jointly explain 75% of both nominal and real effective exchange rate volatility at all, economically relevant, horizons. This result provides a contribution to the literature on *Exchange Rate Disconnect*: we show that real structural shocks, related to commodities, are able to explain a great share of the volatility of both nominal and real exchange rates in small-open commodity-exporter economies. Thus, at least for commodity currencies, our findings provide good news for the resolution of the *disconnect puzzle* between exchange rates and macroeconomic factors.

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A Additional Tables

A.1 Forecast error variance decomposition for key variables. Global demand shock

Forecast error variance decomposition. Global Demand shock

Horizon	Earnings M.	Orders M.	House Starts	MB	Gb Yields-3M	Gb Yields-1Y	Real Rate
0	27.52	4.18	0.02	3.83	71.93	29.85	50.01
6	50.96	4.66	10.27	0.74	55.60	41.41	47.18
12	58.37	10.69	12.60	2.43	36.88	30.44	32.03
24	65.13	11.87	15.26	7.99	24.45	21.99	19.74
48	71.19	6.62	21.38	17.24	15.84	14.91	12.00

Table A.1: Forecast error variance decomposition related to: manufacturing sector earnings (Earning M.), manufacturing sector orders (Orders M.), house starts, monetary base (MB), government bond yields at 3 months (Gb Yields - 3M), government bond yields at 1 year, and real rate. Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Global Demand shock

Horizon	M	X	UK/CA NER	US/CA NER	JP/CA NER	EA/CA NER
0	59.91	15.80	36.20	45.94	28.98	50.15
6	62.07	14.58	37.71	54.51	39.01	52.21
12	61.24	19.06	36.94	53.93	35.05	45.62
24	55.80	14.99	40.58	62.26	37.45	42.34
48	37.90	9.24	49.75	72.22	42.89	39.65

Table A.2: Forecast error variance decomposition related to: imports (M), exports (X), UK Pound - Canadian Dollar bilateral nominal exchange rate (UK/CA NER), US Dollar - Canadian Dollar bilateral nominal exchange rate (US/CA NER), Japanese Yen - Canadian Dollar bilateral nominal exchange rate (JP/CA NER), and Euro - Canadian Dollar bilateral nominal exchange rate (EA/CA NER). Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Global Demand shock

Horizon	Inventories Manuf.	Hours	Hours Manuf.	Unemp.	Unemp. Rate	Emp.	M3
0	53.63	2.30	44.36	20.17	18.93	17.60	31.77
6	39.22	6.85	59.09	33.28	31.82	30.01	46.22
12	31.64	9.16	63.66	27.27	25.72	32.78	28.37
24	35.13	7.08	70.04	21.06	18.82	26.39	10.96
48	51.64	5.74	74.89	15.29	12.15	16.19	4.45

Table A.3: Forecast error variance decomposition related to: manufacturing sector inventories (Inventories Manuf.), hours, manufacturing sector hours (Hours Manuf.), unemployment (Unemp.), unemployment rate (Unemp. Rate), employment (Emp.), and M3 monetary aggregate. Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Global Demand shock

Horizon	EPI	PPI Manuf	Ind Prod Manuf.	World Oil Prod	REA	Oil Price
0	13.21	41.56	18.56	0	47.82	8.46
6	3.13	41.82	7.13	9.08	25.72	29.47
12	2.26	45.73	4.15	13.20	27.94	35.80
24	2.47	40.15	2.28	13.93	31.78	46.75
48	2.71	20.31	1.24	12.37	39.97	58.44

Table A.4: Forecast error variance decomposition related to: export price index (EPI), manufacturing sector producer price index (PPI Manuf.), manufacturing sector real industrial production (Ind Prod Manuf.), global oil production (World Oil Prod), global real economic activity (REA), and global oil price (Oil Price). Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Global Demand shock

Horizon	ΔREER	ΔNEER	ΔCPI	ΔPPI	ΔIPI	ΔIP	ΔPCE
0	49.20	45.87	5.01	18.71	41.76	33.08	37.41
6	44.57	41.59	7.11	16.29	36.51	32.24	34.47
12	42.50	39.61	8.47	16.20	34.14	30.60	33.35
24	41.93	39.10	8.42	15.88	33.31	29.51	32.00
48	42.05	39.24	8.43	15.87	33.36	29.88	31.91

Table A.5: Forecast error variance decomposition related to the monthly growth rate (Δ). Horizon is expressed in number of months since the shock.

A.2 Forecast error variance decomposition for key variables. Oil Demand shock

Forecast error variance decomposition. Oil Demand shock

Horizon	Earnings M.	Orders M.	House Starts	MB	Gb Yields-3M	Gb Yields-1Y	Real Rate
0	1.51	41.62	5.03	31.91	3.60	24.30	1.19
6	3.69	12.80	19.10	30.67	4.28	13.17	2.54
12	1.76	7.11	19.12	49.16	4.74	9.20	2.05
24	2.80	12.90	15.03	44.69	2.24	4.28	1.41
48	4.14	20.61	13.61	32.33	1.29	2.31	2.93

Table A.6: Forecast error variance decomposition related to: manufacturing sector earnings (Earning M.), manufacturing sector orders (Orders M.), house starts, monetary base (MB), government bond yields at 3 months (Gb Yields - 3M), government bond yields at 1 year, and real rate. Horizon is expressed in number of months since the shock. Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Oil Demand shock

Horizon	M	X	UK/CA NER	US/CA NER	JP/CA NER	EA/CA NER
0	23.80	55.06	34.09	48.64	58.14	23.18
6	5.85	33.77	23.23	33.13	40.90	17.64
12	3.04	21.24	20.86	24.41	32.28	13.71
24	11.87	30.38	18.05	15.50	23.90	8.76
48	27.21	36.06	13.94	9.52	19.15	6.43

Table A.7: Forecast error variance decomposition related to: imports (M), exports (X), UK Pound - Canadian Dollar bilateral nominal exchange rate (UK/CA NER), US Dollar - Canadian Dollar bilateral nominal exchange rate (US/CA NER), Japanese Yen - Canadian Dollar bilateral nominal exchange rate (JP/CA NER), and Euro - Canadian Dollar bilateral nominal exchange rate (EA/CA NER). Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Oil Demand shock

Horizon	Inventories Manuf.	Hours	Hours Manuf.	Unemp.	Unemp. Rate	Emp.	M3
0	18.58	6.18	4.87	18.08	24.15	26.93	24.69
6	6.60	1.41	10.44	1.05	1.36	2.77	7.46
12	3.94	0.66	5.98	0.85	0.63	1.48	6.65
24	2.44	4.44	3.79	1.11	1.39	11.02	7.79
48	0.87	11.10	4.24	3.13	4.22	26.00	7.20

Table A.8: Forecast error variance decomposition related to: manufacturing sector inventories (Inventories Manuf.), hours, manufacturing sector hours (Hours Manuf.), unemployment (Unemp.), unemployment rate (Unemp. Rate), employment (Emp.), and M3 monetary aggregate. Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Oil Demand shock

Horizon	EPI	PPI Manuf	Ind Prod Manuf.	World Oil Prod	REA	Oil Price
0	1.65	38.86	4.62	0	0	37.72
6	3.26	18.23	1.31	7.94	26.07	35.18
12	9.46	10.65	5.75	11.62	23.54	29.60
24	8.25	20.33	5.72	7.03	17.48	18.84
48	5.93	34.06	4.09	4.22	14.44	11.67

Table A.9: Forecast error variance decomposition related to: export price index (EPI), manufacturing sector producer price index (PPI Manuf.), manufacturing sector real industrial production (Ind Prod Manuf.), global oil production (World Oil Prod), global real economic activity (REA), and global oil price (Oil Price). Horizon is expressed in number of months since the shock.

Forecast error variance decomposition. Oil Demand shock

Horizon	ΔREER	ΔNEER	ΔCPI	ΔPPI	ΔIPI	ΔIP	ΔPCE
0	47.75	47.09	3.57	4.63	38.38	43.66	21.63
6	42.18	41.58	4.90	7.94	34.71	38.74	24.58
12	41.10	40.49	5.03	9.31	35.06	37.73	24.97
24	41.17	40.59	5.81	9.95	34.66	38.04	25.81
48	41.02	40.44	5.82	9.97	34.61	37.22	25.57

Table A.10: Forecast error variance decomposition related to the monthly growth rate (Δ). Horizon is expressed in number of months since the shock.

B Additional Figures

The following figures are displayed:

- Figure (A.1) - Figure (A.7): additional historical decompositions.
- Figure (A.8) - Figure (A.11): exchange rate pass-through estimates for disaggregated consumer and producer price indexes.
- Figure (A.12) - Figure (A.17): additional impulse response functions for key macroeconomic and financial variables.

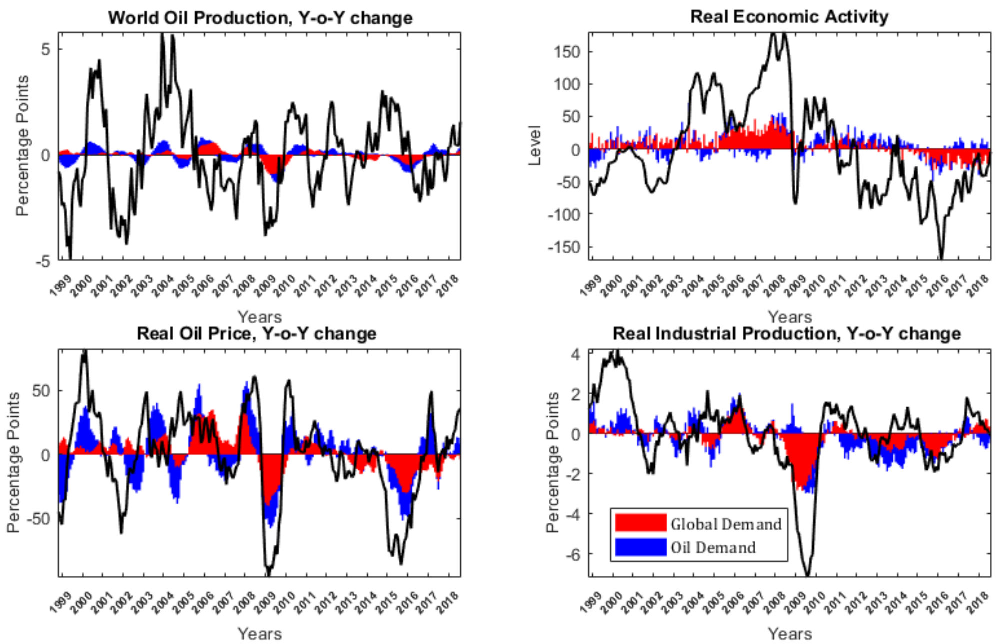

Figure A.1: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed.

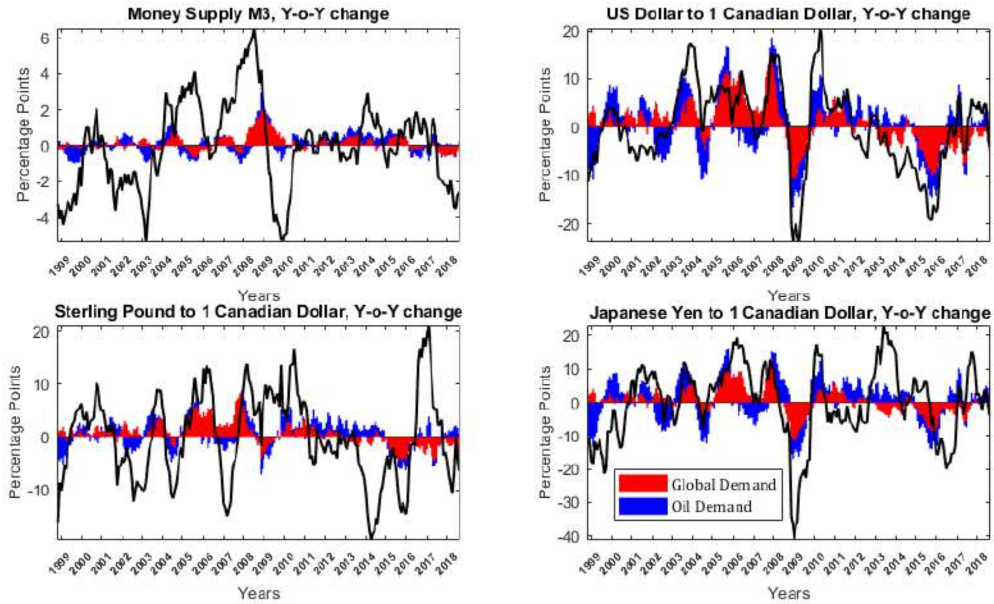

Figure A.2: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed.

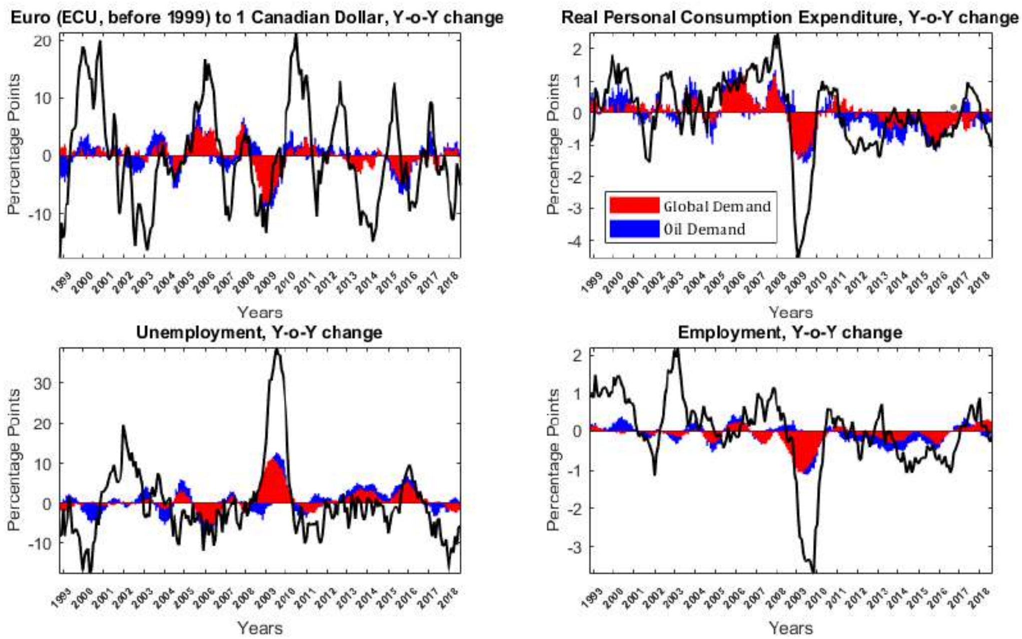

Figure A.3: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed. An increase in nominal bilateral exchange rates denote a nominal appreciation of the Canadian Dollar.

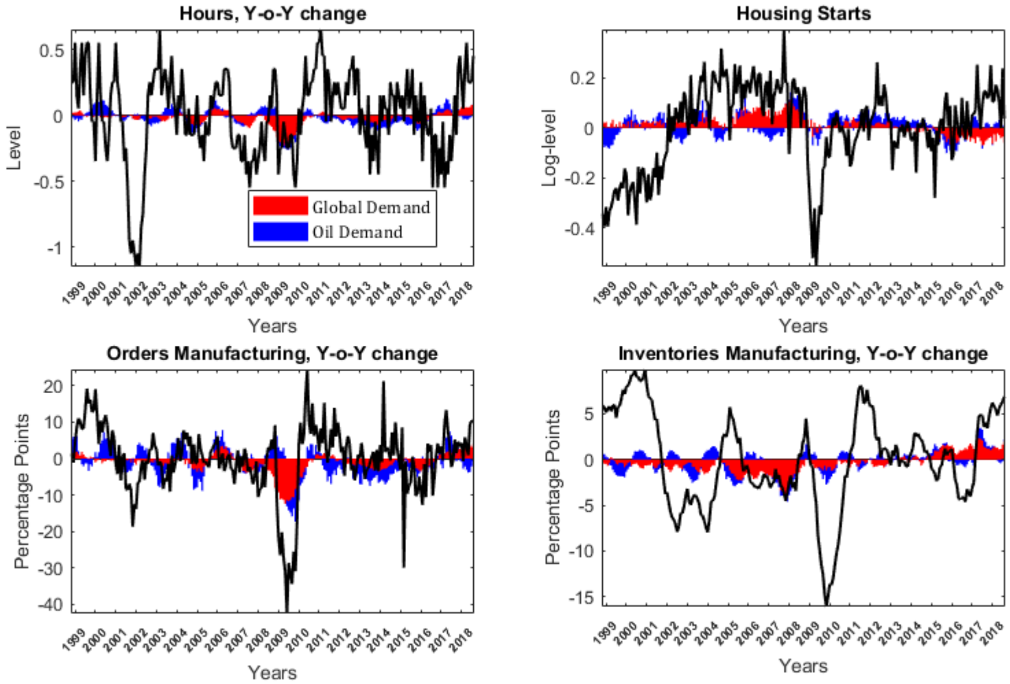

Figure A.4: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed.

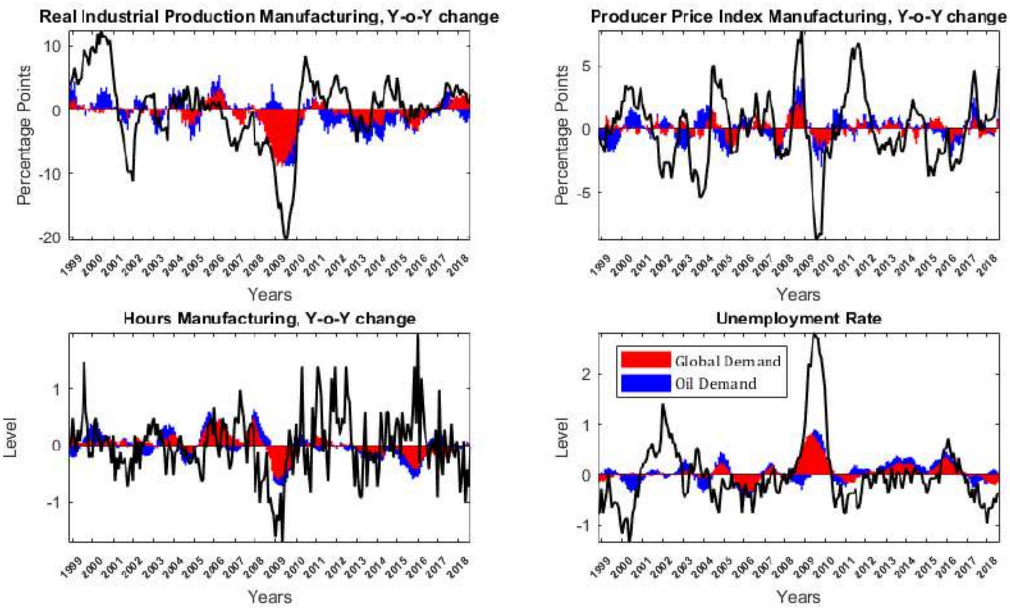

Figure A.5: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed.

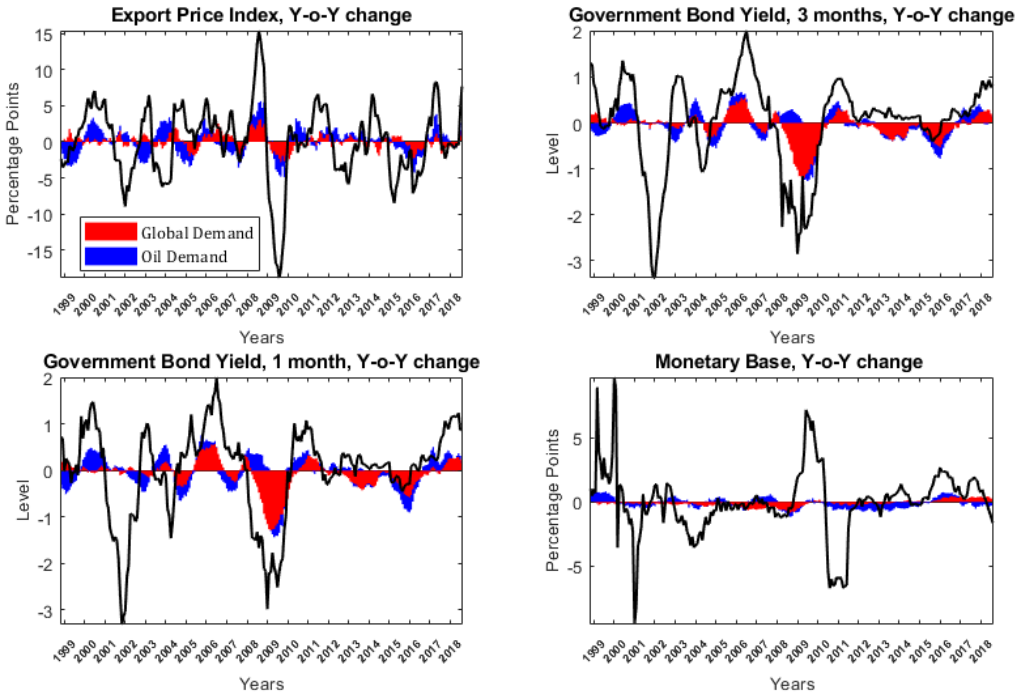

Figure A.6: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed.

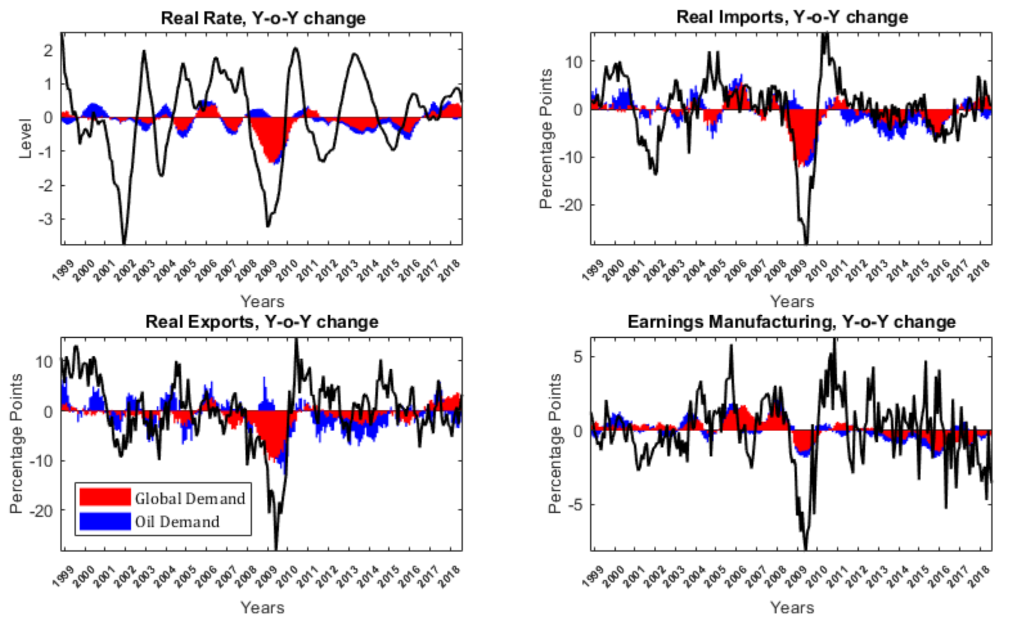

Figure A.7: Black solid line represents historical data (demeaned). Red (blue) area represents the contribution of Global Demand (Oil Demand) shocks to the dynamics of the variables displayed.

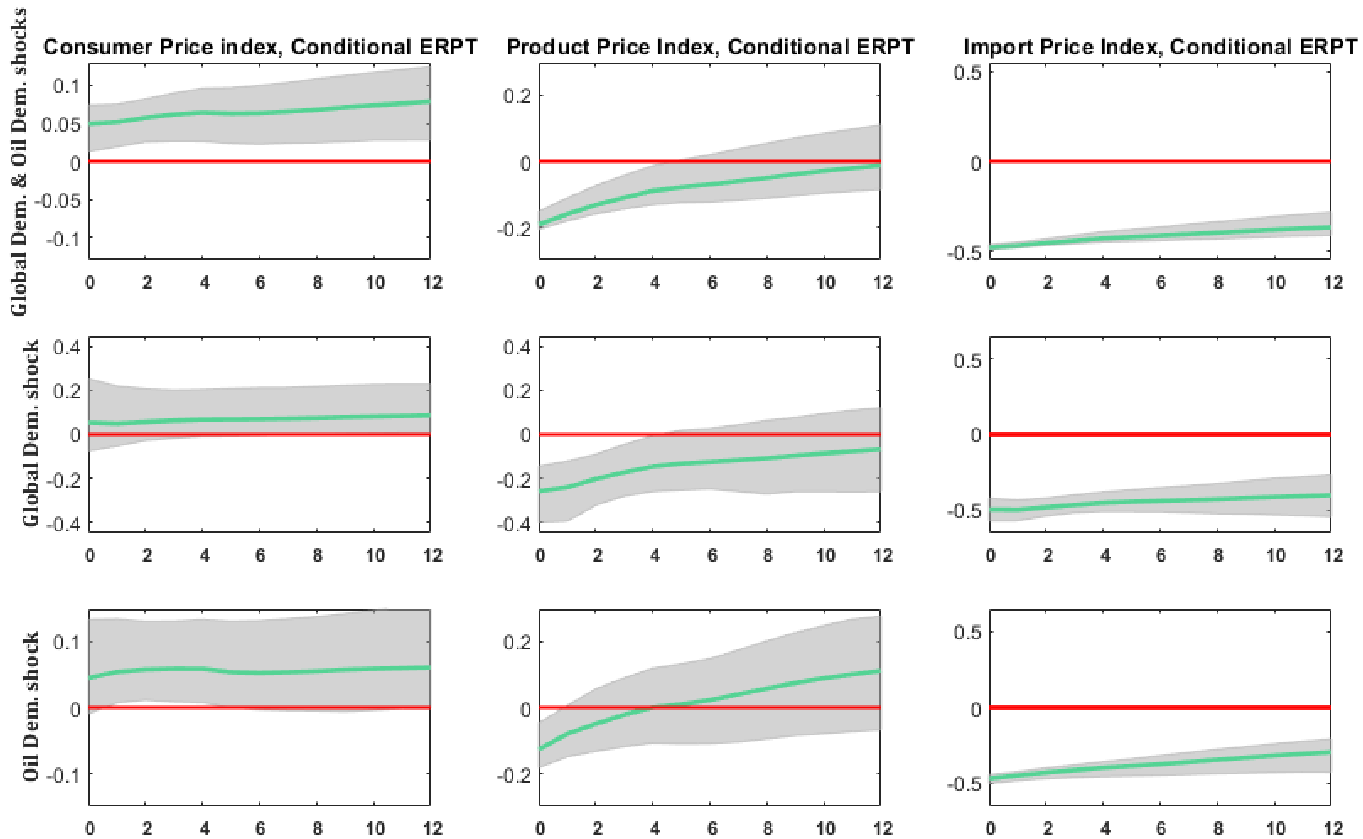

Figure A.8: Green solid lines represent point estimates of conditional exchange rate pass-through (ERPT). Gray shaded areas refer to the 90% confidence intervals. The first row describes the pass-through conditional on positive Global Demand and positive Oil Demand shocks *jointly*. The second and third rows of the panel describe, respectively, pass-through estimates conditional on positive Global Demand and positive Oil Demand shocks *separately*. Unit of measure: percentage points.

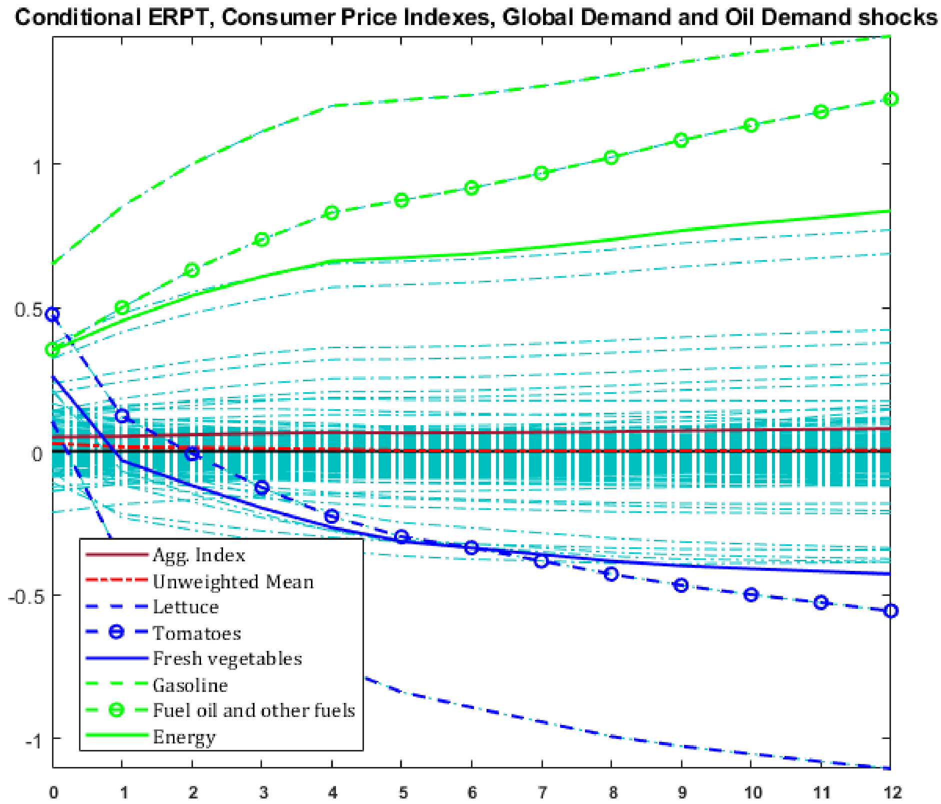

Figure A.9: Conditional exchange rate pass-through (ERPT) estimates for disaggregated consumer price indexes, at different horizons. The pass-through is measured conditional on positive Global Demand and positive Oil Demand shocks jointly. Unit of measure: percentage points.

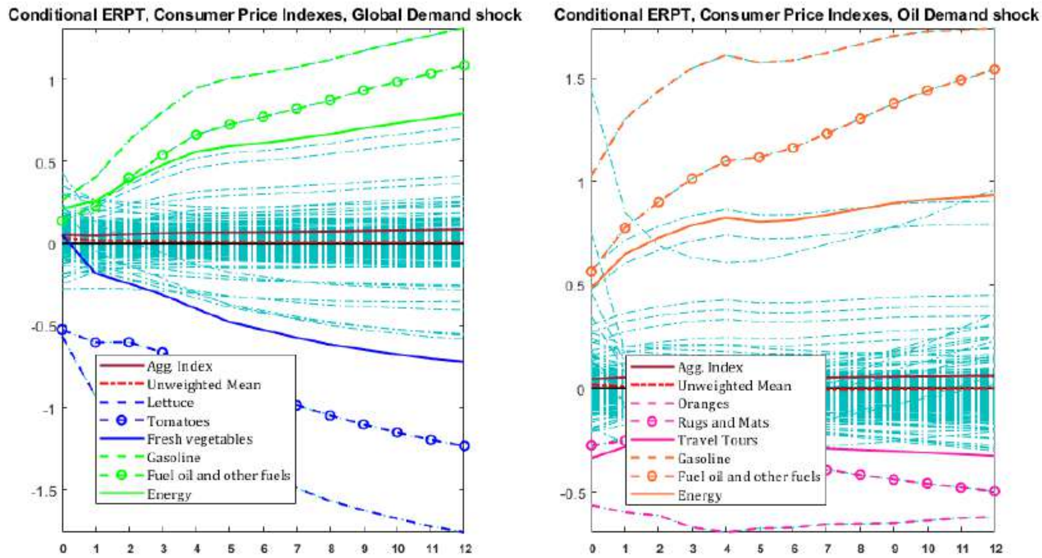

Figure A.10: Conditional exchange rate pass-through (ERPT) estimates for disaggregated consumer price indexes, at different horizons. Left-hand panel describes the pass-through conditional on positive Global Demand shock. The right-hand panel describes pass-through estimates conditional on positive Oil Demand shock. Unit of measure: percentage points.

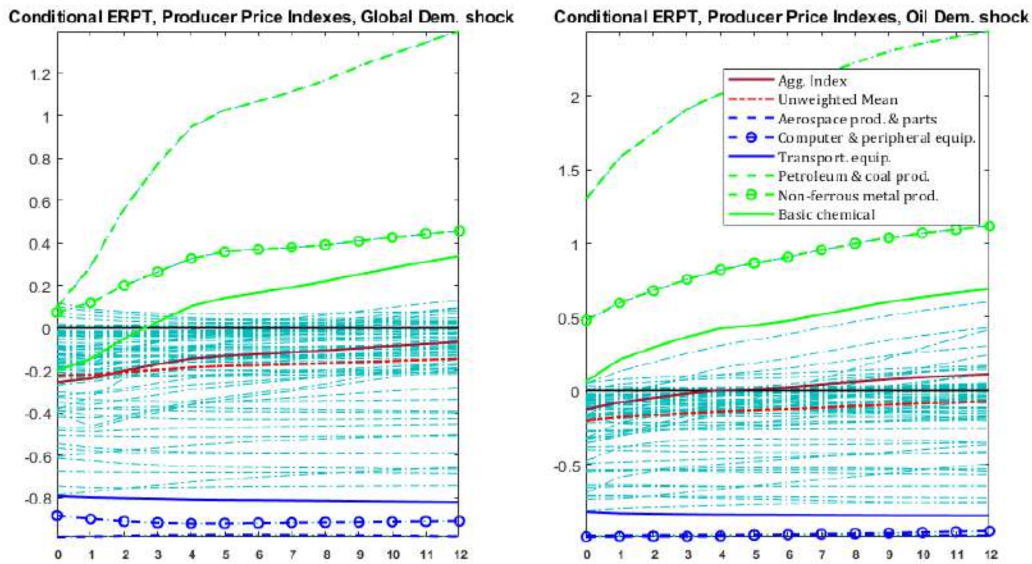

Figure A.11: Conditional exchange rate pass-through (ERPT) estimates for disaggregated manufacturing producer price indexes, at different horizons. Left-hand panel describes the pass-through conditional on positive Global Demand shock. The right-hand panel describes pass-through estimates conditional on positive Oil Demand shock. Unit of measure: percentage points.

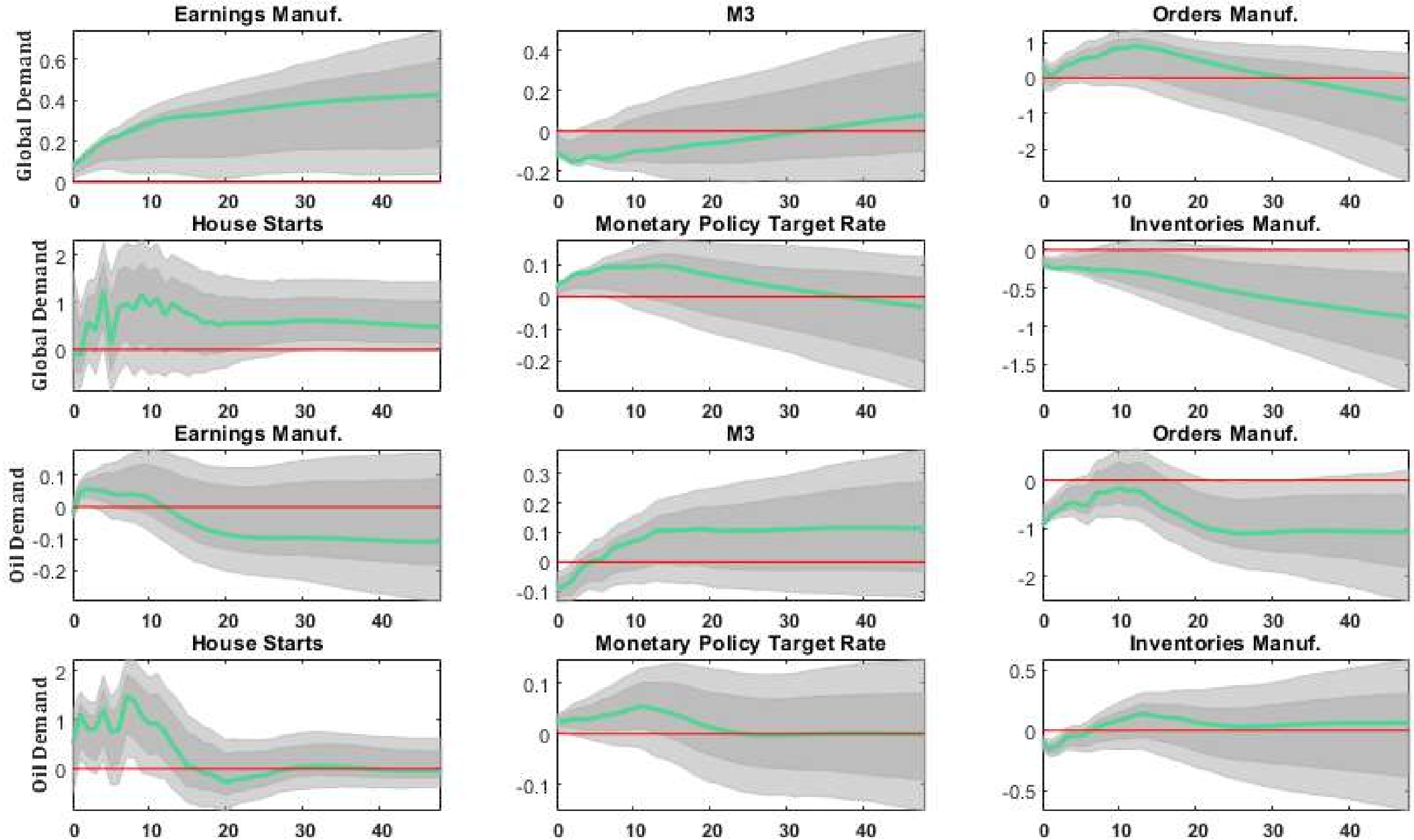

Figure A.12: Impulse response functions to, respectively, a positive Global Demand and positive Oil Demand shocks. The size of the shocks is 1 standard deviation. Point estimates (green solid line) together with 68% confidence intervals (dark gray shaded area), and 90% confidence intervals (light gray shaded area). The confidence intervals are constructed with bootstraap techniques. Unit of measure: percentage points.

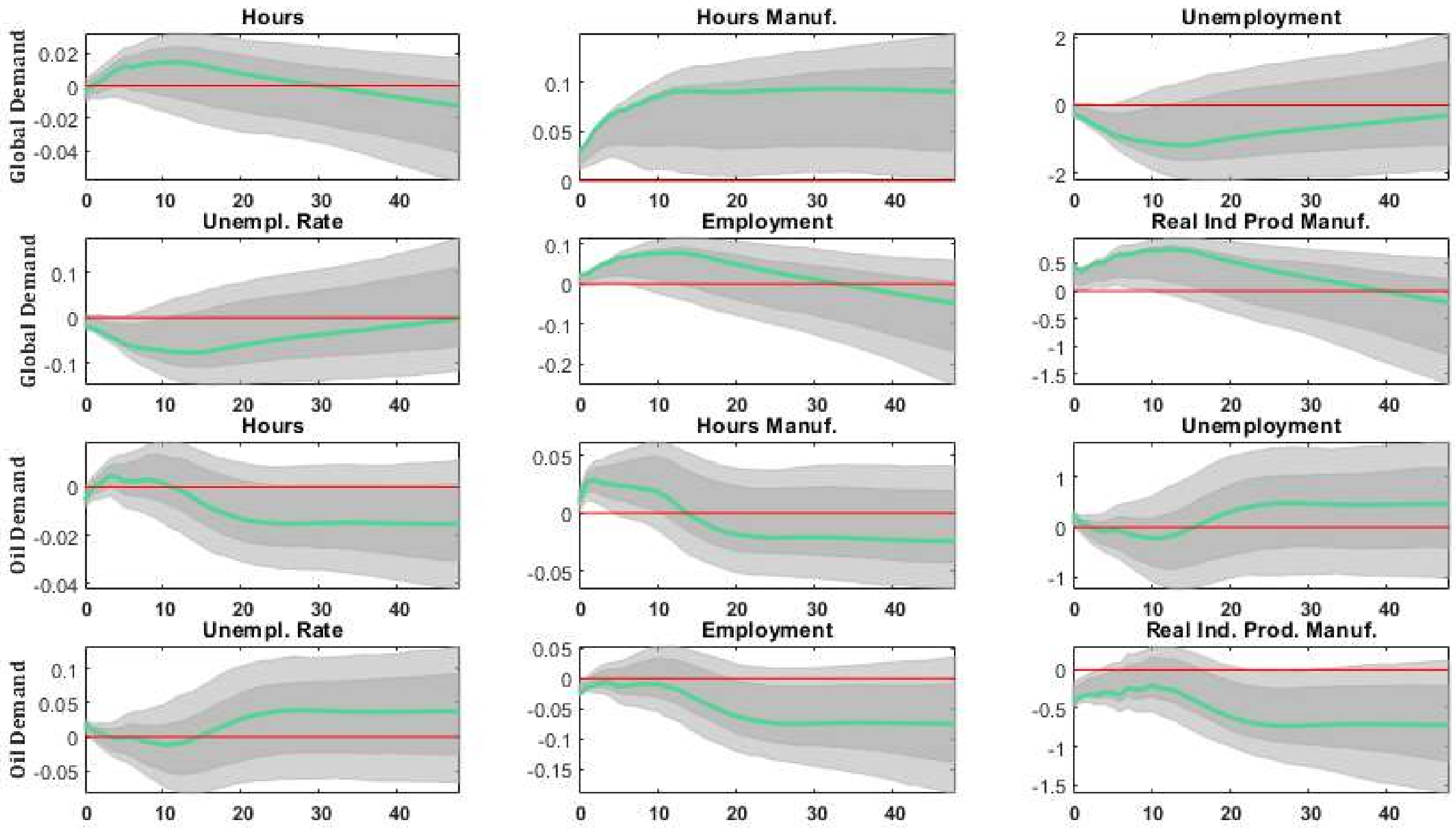

Figure A.13: Impulse response functions to, respectively, a positive Global Demand and positive Oil Demand shocks. The size of the shocks is 1 standard deviation. Point estimates (green solid line) together with 68% confidence intervals (dark gray shaded area), and 90% confidence intervals (light gray shaded area).The confidence intervals are constructed with bootstraap techniques. Units of measure: percentage points (for unemployment rate, employment, unemployment and (real) industrial manufacturing production), and units (for total hours and manufacturing hours).

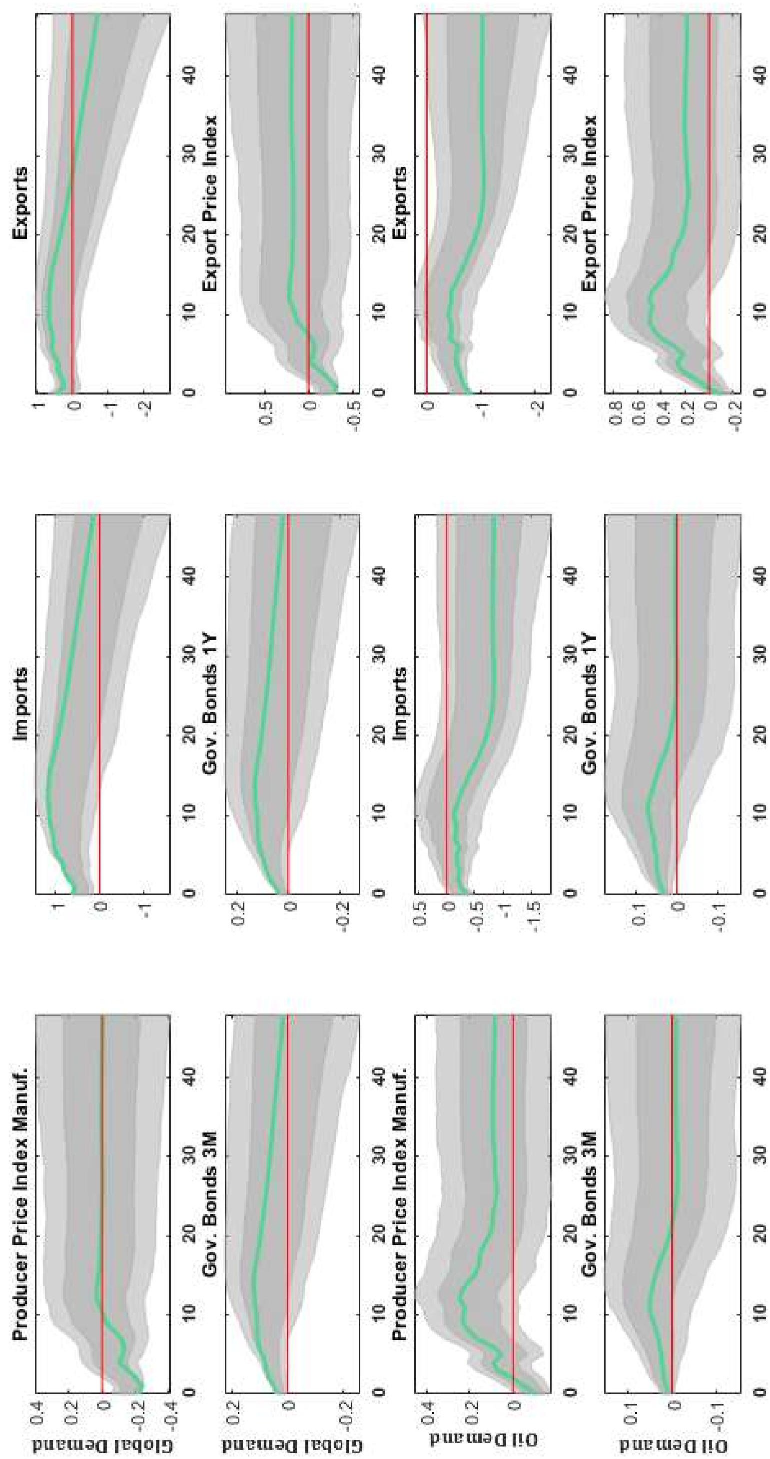

Figure A.14: Impulse response functions to, respectively, a positive Global Demand and positive Oil Demand shocks. The size of the shocks is 1 standard deviation. Point estimates (green solid line) together with 68% confidence intervals (dark gray shaded area), and 90% confidence intervals (light gray shaded area). The confidence intervals are constructed with bootstraap techniques. Unit of measure: percentage points.

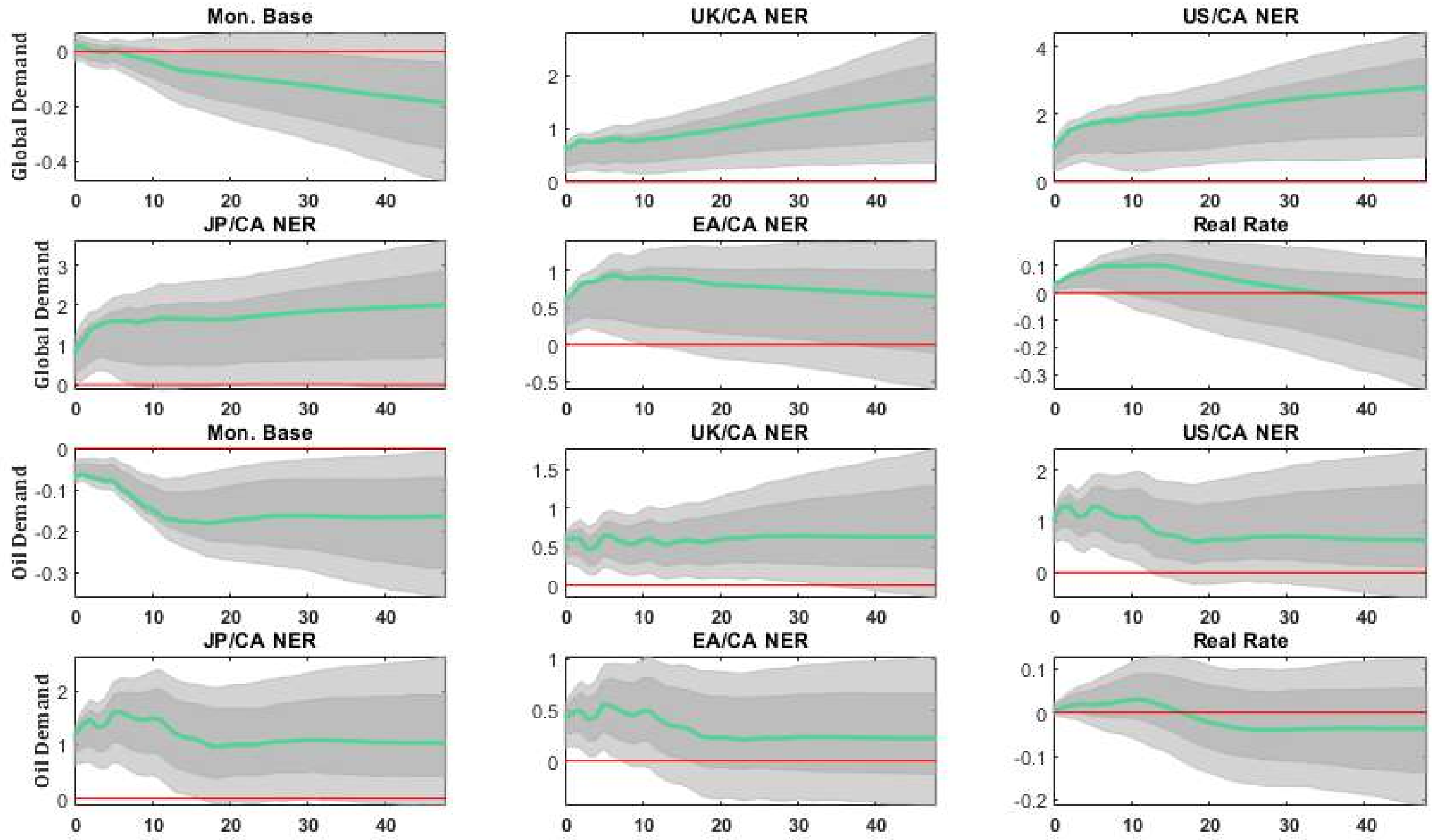

Figure A.15: Impulse response functions to, respectively, a positive Global Demand and positive Oil Demand shocks. The size of the shocks is 1 standard deviation. An increase in nominal bilateral exchange rates (NER) denote a nominal appreciation of the Canadian Dollar. Point estimates (green solid line) together with 68% confidence intervals (dark gray shaded area), and 90% confidence intervals (light gray shaded area). The confidence intervals are constructed with bootstraap techniques. Unit of measure: percentage points.

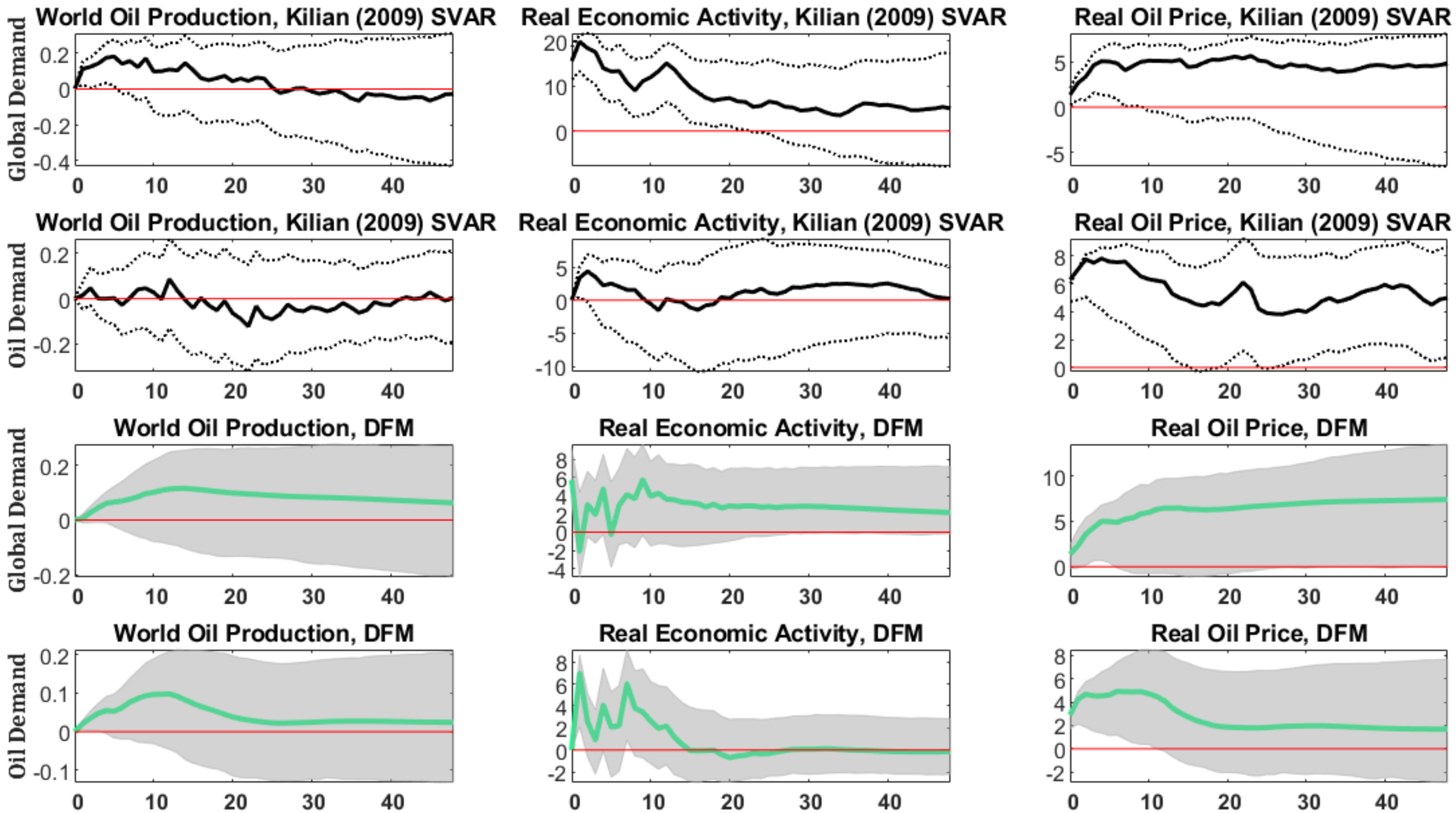

Figure A.16: Comparison of impulse response functions of key commodity variables to positive Global Demand and positive Oil Demand shocks, as in Kilian (2009) SVAR analysis (upper two panels) and our Dynamic Factor Model (lower two panels). Point estimates (solid line) together with 95% confidence intervals (DFM: grey shaded area; SVAR: dotted lines). The SVAR estimations are implemented according to Kilian (2009), for the period 1997 : 1 – 2018 : 7. The confidence intervals are constructed with bootstraap techniques. The size of the shocks is 1 standard deviation. Units of measure: percentage points (for world oil production and real oil price), and units (for real economic activity).

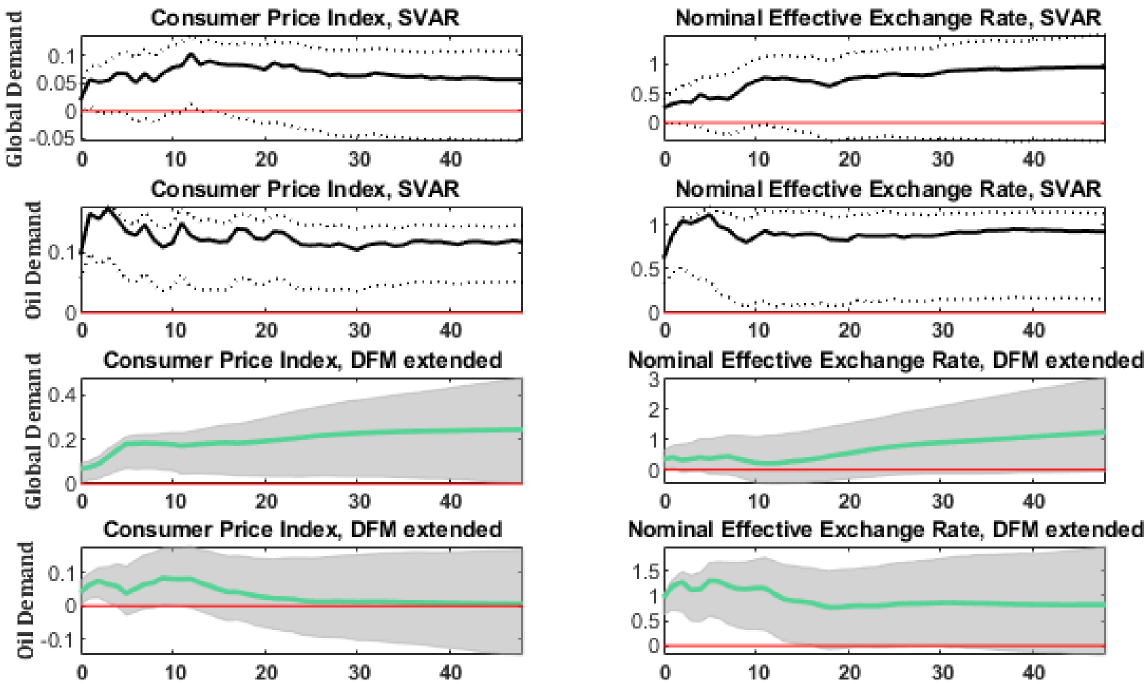

Figure A.17: Comparison of impulse response functions of consumer price index (CPI) and nominal effective exchange rate (NEER) to positive Global Demand and positive Oil Demand shocks, as in a standard SVAR analysis (upper two panels) and Dynamic Factor Model (lower two panels). Point estimates (solid line) together with 90% confidence intervals (DFM: grey shaded area; SVAR: dotted lines). The SVAR estimations are implemented for the period 1997 : 1 – 2018 : 7. The confidence intervals are constructed with bootstraap techniques. The size of the shocks is 1 standard deviation. Units of measure: percentage points.

Chapter 1

Online Appendix for: Exchange Rate Pass-Through in Small, Open, Commodity-exporter Economies: Lessons from Canada

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November 2021

*Bocconi University (PhD Candidate) and Bank of Italy.

A Data Description for Dynamic Factor Model

A.1 Industrial production

Table format: series number, series code (NAICS[1] code, when available), transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm. This dataset refers to Canadian monthly gross domestic product by industry. Data are seasonally adjusted, annual rate, constant 2007 prices.

Canadian monthly gross domestic product by industry

Num	Code	T	Description
1	T001/11-91	5	All industries
2	3A/31-33	5	Manufacturing
3	T012/321,327-339	5	Durable Manufacturing Industries
4	T002/11-33	5	Goods Producing Industries
5	T001/311-316, 322-326	5	Non-durable manufacturing Industries
6	T005	5	Business Sector - Goods
7	T006	5	Business Sector - Services
8	T004	5	Business Sector
9	T010/21-22, 31-33, 562	5	Industrial Production
10	3332	5	Industrial machinery manufacturing
11	112	5	Animal Production
12	111	5	Crop Production
13	$11A/111-112$	5	Crop and Animal Production
14	3313	5	Alumina & Aluminum Production and Processing
15	23	5	Construction
16	22	5	Utilities
17	61	5	Educational Services
18	91	5	Public Administration
20	4A/44-45	5	Retail Trade
21	41	5	Wholesale Trade
22	52	5	Finance & Insurance
23	4B/48-49	5	Transportation & Warehousing
24	23A	5	Residential Building & Construction
25	3364	5	Aerospace product & Parts Manufacturing

Table A.1: Sample period: $1997:1-2018:7$. Source: CANSIM.

[1] The categories for industrial production are based on the North American Industry Classification System (NAICS).

Num	Code	T	Description
26	324	5	Petroleum & Coal Product Manufacturing
27	326	5	Plastics & Rubber Products Manufacturing
28	72	5	Accomodation & Food Services
29	71	5	Arts, Entertainment and Recreation
30	51	5	Information & Cultural Industries
31	721	5	Accomodation Services
32	481	5	Air Transportation
33	31212	5	Breweries
34	325	5	Chemical Manufacturing
35	2121	5	Coal Mining
36	492	5	Couriers and Messangers
37	9111	5	Defence Services
38	T016/211,2121,21229,21311A,211,2212,32411,486	5	Energy Sector
39	311	5	Food Manufacturing
40	113	5	Forestry & Logging
41	3321	5	Forging and Stamping
42	3315	5	Foundries
43	7132	5	Gambling Industries
44	3325	5	Hardware Manufacturing
45	622	5	Hospitals
46	333	5	Machinery Manufacturing
47	339	5	Miscellaneous Manufacturing
48	322	5	Paper Manufacturing
49	491	5	Postal Services
50	212396	5	Potash Mining
51	81	5	Other services (except public administration)
52	482	5	Rail Transportation
53	881	5	Repair and Maintenance
54	484	5	Truck Transportation
55	6113	5	Universities
56	483	5	Water Transportation
57	561	5	Administrative & Support Services
58	5418	5	Advertising, public relations, and related services
59	713A	5	Amusement and recreation industries
60	3111	5	Animal Food Manufacturing
61	3118	5	Bakeries and Tortilla Manufacturing
62	3251	5	Basic Chemical Manufacturing
63	3222	5	Converted Paper Product Manufacturing
64	3115	5	Dairy Product Manufacturing
65	332	5	Fabricated metal product manufacturing
66	911	5	Federal Government Public Administration
67	114	5	Fishing, Hunting and Trapping

Table A.2: Sample period: $1997:1 - 2018:7$. Source: CANSIM.

Num	Code	T	Description
68	113	5	Forestry and Logging
69	3112	5	Grain and oilseed milling
70	21221	5	Iron Ore Mining
71	5311	5	Lessors of Real Estate
72	52213	5	Local Credit Unions
73	3116	5	Meat Product Manufacturing
74	2122	5	Metal Ore Mining
75	3335	5	Metalworking Machinery Manufacturing
76	2212	5	Natural Gas Distribution
77	211	5	Oil and Gas Extraction
78	3259	5	Other Chemical Product Manufacturing
79	3119	5	Other Food Manufacturing
80	21229	5	Other Metal Ore Mining
81	3399	5	Other Miscellaneous Manufacturing
82	3369	5	Other Transportation Equipment Manufacturing
83	3219	5	Other Wood Product Manufacturing
84	331	5	Primary Metal Manufacturing
85	3365	5	Railroad Rolling Stock Manufacturing
86	3211	5	Sawmills and wood preservation
87	T003/41-91	5	Service-producing Industries
88	3366	5	Ship and boat building
89	21231	5	Stone Mining and Quarrying
90	336	5	Transportation Equipment Manufacturing
91	4851	5	Urban Transit Systems
92	321	5	Wood Product Manufacturing
93	713	5	Amusement, Gambling and Recreation Industries
94	3323	5	Architectural and Structural Metals Manufacturing
95	5413	5	Architectural, Engineering and Related Services
96	5321	5	Automotive Equipment Rental and Leasing
97	312	5	Beverage and tobacco product manufacturing
98	3273	5	Cement and Concrete Product Manufacturing
99	334	5	Computer and Electronic Product Manufacturing
100	3341	5	Computer and Peripheral Equipment Manufacturing
101	52X/521-522	5	Credit Intermediation and Monetary Authorities
102	722	5	Food Services and Drinking places
103	337	5	Furniture and Related Product Manufacturing
104	21222	5	Gold and silver ore mining
105	524	5	Insurance Carriers and Related Activities
106	541A	5	Legal, accounting and related services
107	3391	5	Medical equipment and supplies manufacturing
108	3372	5	Office furniture (including fixtures) manufacturing
109	3379	5	Other furniture-related product manufacturing
110	3339	5	Other general-purpose machinery manufacturing

Table A.3: Sample period: $1997:1-2018:7$. Source: CANSIM.

Num	Code	T	Description
111	3255	5	Paint, coating and adhesive manufacturing
112	4862	5	Pipeline transportation of natural gas
113	49A	5	Postal service and couriers and messengers
114	323	5	Printing and related support activities
115	912	5	Provincial and territorial public administration
116	3221	5	Pulp, paper and paperboard mills
117	3117	5	Seafood product preparation and packaging
118	31211	5	Soft drink and ice manufacturing
119	3326	5	Spring and wire product manufacturing
120	3113	5	Sugar and confectionery product manufacturing
121	562	5	Waste management and remediation services
122	2213	5	Water, sewage and other systems
123	5242	5	Agencies, brokerages and other insurance related activities
124	3324	5	Boiler, tank and shipping container manufacturing
125	3328	5	Coating, engraving, heat treating and allied activities
126	3333	5	Commercial and service industry machinery manufacturing
127	21223	5	Copper, nickel, lead and zinc ore mining
128	486A/4861,4869	5	Crude oil and other pipeline transportation
129	2211	5	Electric power generation, transmission and distribution
130	335	5	Electrical equipment, appliance and component manufacturing
131	3336	5	Engine, turbine and power transmission equipment manufacturing
132	3114	5	Fruit and vegetable preserving and specialty food manufacturing
133	3371	5	Household and institutional furniture and kitchen cabinet manufacturing
134	3311	5	Iron and steel mills and ferro-alloy manufacturing
134	913	5	Local, municipal and regional public administration
135	512	5	Motion picture and sound recording industries
136	3362	5	Motor vehicle body and trailer manufacturing
137	71A/711-712	5	Performing arts, spectator sports and related industries, and heritage institutions
138	3253	5	Pesticide, fertilizer and other agricultural chemical manufacturing
139	3344	5	Semiconductor and other electronic component manufacturing
140	3256	5	Soap, cleaning compound and toilet preparation manufacturing
141	3312	5	Steel product manufacturing from purchased steel
142	115	5	Support activities for agriculture and forestry
143	3212	5	Veneer, plywood and engineered wood product manufacturing
144	11	5	Agriculture, forestry, fishing and hunting
145	62	5	Health care and social assistance
146	54	5	Professional, scientific and technical services
147	53	5	Real estate and rental and leasing
148	813	5	Religious, grant-making, civic, and professional and similar organizations
149	3252	5	Resin, synthetic rubber, and artificial and synthetic fibres and filaments manuf.
150	21232	5	Sand, gravel, clay, and ceramic and refractory minerals mining and quarrying

Table A.4: Sample period: $1997:1-2018:7$. Source: CANSIM.

Num	Code	T	Description
151	213	5	Support activities for mining and oil and gas extraction
152	3334	5	Ventilation, heating, air conditioning and commercial refrigeration equipment manuf.
153	3327	5	Machine shops, turned product, and screw, nut and bolt manufacturing
154	531A/5312-5313	5	Offices of real estate agents and brokers and activities related to real estate
155	56	5	Administrative and support, waste management and remediation services
156	5419	5	Other professional, scientific and technical services
157	23B	5	Non-residential building construction
158	522A/5222-5223	5	Non-depository credit intermediation and activities related to credit intermediation
159	T007	5	Non-business sector
160	T008	5	Non-business sector, goods
161	T009	5	Non-business sector, services
162	3314	5	Non-ferrous metal (except aluminum) production and processing
163	2123	5	Non-metallic mineral mining and quarrying
164	327	5	Non-metallic mineral product manufacturing
165	911	5	Federal government public administration
166	21239	5	Other non-metallic mineral mining and quarrying
167	486	5	Pipeline transportation
168	5241	5	Insurance carriers
169	531	5	Real estate
170	3122	5	Tobacco manufacturing
171	493	5	Warehousing and storage
172	3342	5	Communications equipment manufacturing
173	3353	5	Electrical equipment manufacturing
174	334B/334 (-3341)	5	Electronic product manufacturing
175	3352	5	Household appliance manufacturing
176	336Y	5	Motor vehicles and parts manufacturing
177	5311A	5	Owner-occupied dwellings
178	3261	5	Plastic product manufacturing
179	3262	5	Rubber product manufacturing
180	3351	5	Electric lighting equipment manufacturing
181	3363	5	Motor vehicle parts manufacturing
182	3254	5	Pharmaceutical and medicine manufacturing
183	5151	5	Radio and television broadcasting
184	31A	5	Textile and textile product mills
185	5415	5	Computer systems design and related services
186	3359	5	Other electrical equipment and component manufacturing
187	212	5	Mining and quarrying (except oil and gas)
188	511	5	Publishing industries (except Internet)

Table A.5: Sample period: $1997:1 - 2018:7$. Source: CANSIM.

A.2 Employment, hours and earnings

Table format: series number, series code (NAICS code, when available), transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm. This dataset refers to Canadian monthly employment, hours and earnings. Data are seasonally adjusted.

Employment, hours and earnings

Num	Code	T	Description
1	*No Naics*	2	Unemployment Rate (15 YRS & Over)
2	*No Naics*	2	Participation Rate - (15 YRS & Over)
3	11-91	5	Employment (15 YRS & Over) (Thous.)
4	*No Naics*	5	Unemployment (15 YRS & Over) (Thous.)
5	*No Naics*	1	Employment Rate - (15 YRS & Over)
6	*No Naics*	5	Employment: Private Sector Employees (Thous.)
7	T018/61-62, 91	5	Employment: Public Sector Employees (Thous.)
8	*No Naics*	5	Employment: Self-Employed (Thous.)
9	11	5	Employment: Agriculture (Thous.)
10	*No Naics*	5	Employment: By Industries (Thous.)
11	23	5	Employment: Construction (Thous.)
12	61	5	Employment: Educational Services (Thous.)
13	3A1-33	5	Employment: Manufacturing (Thous.)
14	T002/11-33	5	Employment: Goods Producing (Thous.)
15	81	5	Employment: Other Services (Thous.)
16	91	5	Employment: Public Administration(Thous.)
17	T002/41-91	5	Employment: Service-Producing Industries (Thous.)
18	41, 44-45	5	Employment: Trade (Thous.)
19	4B, 48-49	5	Employment: Transportation & Warehousing (Thous.)
20	22	5	Employment: Utilities (Thous.)
21	72	5	Employment: Accomodation & Food Service (Thous.)
22	51	5	Employment: Information, culture and recreation (Thous.)
23	52- 53	5	Employment: Finance, Insurance, Real Estate, Rental and Leasing (Thous.)
24	62	5	Employment: Health Care and Social Assistance (Thous.)
25	55	5	Employment: Business, building and other support services (Thous.)

Table A.6: Sample period: $1997:1-2018:7$. Source: CANSIM.

Num	Code	T	Description
26	54	5	Employment: Professional, Scientific and Technical Services (Thous.)
27	*No Naics*	2	Partecipation Rate: 25 Years and Over: Females
28	*No Naics*	2	Partecipation Rate: 25 Years and Over: Males
29	21	5	Employment: Forestry, Mining, Oil and Gas (Thous.)
30	*No Naics*	1	Avg. Duration of Unemployment (Weeks)
31	11-91	2	Avg. Weekly Hours: Industrial Aggregate (Units)
32	23	1	Avg. Weekly Hours: Construction (Units)
33	*No Naics*	2	Employment: Actual Hours Worked (Units.)
34	11-33	2	Avg. Weekly Hours: Durable Goods(Units)
35	61	2	Avg. Weekly Hours: Educational Services (Units)
36	52	1	Avg. Weekly Hours: Finance and Insurance (Units)
37	31-33	2	Avg. Weekly Hours: Manufacturing (Units)
38	44-45	1	Avg. Weekly Hours: Retail Trade (Units)
39	41, 44 -45	1	Avg. Weekly Hours: Trade (Units)
40	41	1	Avg. Weekly Hours: Wholesale Trade (Units)
41	72	1	Avg. Weekly Hours: Accomodation and Food Services (Units)
42	56	1	Avg. Weekly Hours: Administrative Support, etc. (Units)
43	71	1	Avg. Weekly Hours: Arts, Entertainment and recreation (Units)
44	113, 1153	1	Avg. Weekly Hours: Forestry, Logging and Support (Units)
45	113, 1153, 21-23, 31-33	2	Avg. Weekly Hours: Goods Producing Industries (Units)
46	62	2	Avg. Weekly Hours: Health Care and Social Assistance (Units.)
47	51	1	Avg. Weekly Hours: Information and cultural industries (Units)
48	55	1	Avg. Weekly Hours: Management of companies and enterprises (Units)
49	21	1	Avg. Weekly Hours: Mining, quarrying, and oil and gas extraction (Units.)
50	54	1	Avg. Weekly Hours: Professional, Scientific and Technical Services (Units)
51	53	1	Avg. Weekly Hours: Real Estate, Rental and Leasing (Units)
52	41-91	1	Avg. Weekly Hours: Service-producing Industries (Units)
53	48-49	1	Avg. Weekly Hours: Transportation and Warehousing (Units)
54	*No Naics*	1	Average Weekly Hours: Employed, Both Sexes: 15 Years & Over Units)
55	23	5	Avg. Weekly Earnings: Constructions (Thous.)
56	31-33	5	Avg. Weekly Earnings: Manufacturing (Units)
57	*No Naics*	2	Participation Rate: 15-24 years old

Table A.7: Sample period: $1997:1-2018:7$. Source: CANSIM.

A.3 Global oil market data

Table format: series number, transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm. This dataset refers to global oil market data.

Global oil market data

Num	T	Description
1	1	Real Economic Activity (Source: Kilian, 2009)
2	5	Brent Real Oil Price (Source: South African Reserve Bank) (SA) (Deflated by US PCE (LFE))
3	5	U.S. Crude Oil Real Import Price (Source: EIA) (SA) (Deflated by US PCE (LFE))
4	5	US Crude Oil Real Price (Source: EIA) (SA) (Deflated by US PCE (LFE))
5	5	WTI Real Oil Price (Source: FRED) (SA) (Deflated by US PCE (LFE))
6	5	World Oil Production (Source: EIA) (SA)

Table A.8: Sample is 1997:1-2018:7.

A.4 Gross domestic product by income and by expenditure accounts

Table format: series number, transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm. This dataset refers to Canadian gross domestic product by income and by expenditure accounts. Data are seasonally adjusted.

National gross domestic product by income and by expenditure accounts

Num	T	Description
1	5	Real Gross Domestic Product, expenditure based, AR
2	5	Real Gross Domestic Product, expenditure based
3	5	Real Gross Domestic Product, income based, AR
4	5	Real Gross Domestic Product, income based

Table A.9: Sample is 1997:1-2018:7. Source: CANSIM.

A.5 Nominal and real interest rates, inflation expectations, and real money balances

Table format: series number, transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm.
This dataset refers to Canadian nominal and real interest rates, inflation expectations, and real money balances.

Nominal and real interest rates, inflation expectations, and real money balances

Num	T	Description
1	2	Monetary Policy Target Rate (Not SA) (Source CANSIM)
2	2	Overnight Money Market Financing Rate (Not SA)(Source CANSIM)
3	1	CPI Inflation Expectations (Author's computation)
4	2	Real Interest Rate (3 Months Interbank Rate minus CPI Inflation Expectations) (Author's computation)
5	2	Interbank Rate: 1 Month (Not SA) (converted from daily frequency) (Source CIBC World Market)
6	2	Interbank Rate: 2 Months (Not SA) (converted from daily frequency) (Source CIBC World Market)
7	2	Interbank Rate: 3 Months (Not SA) (converted from daily frequency) (Source CIBC World Market)
8	2	Interbank Rate: 6 Months (Not SA) (converted from daily frequency) (Source CIBC World Market)
9	2	Interbank Rate: 1 Year (Not SA) (converted from daily frequency) (Source CIBC World Market)
10	2	Treasury Bills Rate: 3 Months (Not SA) (Source CANSIM)
11	1	Non-Chequable Saving Deposit Rate (Not SA) (Source CANSIM)
12	2	Government Bond Yield: 1 Month (Not SA) (Source CANSIM)
13	2	Government Bond Yield: 1 Year (Not SA) (Source CANSIM)
14	2	Government Bond Yield: 10 Years (Not SA) (Source CANSIM)
15	2	Government Bond Yield: 2 Years (Not SA) (Source CANSIM)
16	2	Government Bond Yield: 5 Years (Not SA) (Source CANSIM)
17	2	Government Bond Yield: Over 10 Years, Average Yield (Not SA) (Source CANSIM)
18	2	Prime Corporate Paper Rate: 3 Months (Not SA) (Source CANSIM)
19	2	Prime Corporate Paper Rate: 1 Months (Not SA) (Source CANSIM)
20	2	Prime Corporate Paper Rate: 2 Months (Not SA) (Source CANSIM)
21	5	Real Money Supply: M3 (SA), deflated by CPI (LFE) (Source CANSIM)
22	5	Real Money Supply: M1 (SA), deflated by CPI (LFE) (Source BoC)
23	5	Real Money Supply: M2 (SA), deflated by CPI (LFE) (Source CANSIM)
24	5	Real Money Supply: Monetary Base (SA), deflated by CPI (LFE) (Source CANSIM)
25	5	Real Official International Reserves (SA), deflated by CPI (LFE) (Source: Dep. Finance Canada)

Table A.10: Sample is 1997:1-2018:7.

A.6 Stock market prices and exchange rates

Table format: series number, transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm. This dataset refers to Canadian stock market prices and exchange rates.

Stock market prices and exchange rates

	T	Description
1	5	Toronto Stock Exchange: Composite Share Price (Not SA)
2	5	S&P/TSX: Composite Price Index (Not SA) (converted from daily frequency)
3	5	S&P/TSX: Composite CAP GDS Price Index (Not SA) (converted from daily frequency)
4	5	S&P/TSX: Composite Industrial Price Index (Not SA) (converted from daily frequency)
5	5	S&P/TSX: Composite Utilities Price Index (Not SA) (converted from daily frequency)
6	5	S&P/TSX: 60 Price Index (Not SA) (converted from daily frequency)
7	5	S&P/TSX: Composite Energy Price Index (Not SA) (converted from daily frequency)
8	5	S&P/TSX: Composite Banks Price Index (Not SA) (converted from daily frequency)
9	5	S&P/TSX: Composite Real Estate Price Index (Not SA) (converted from daily frequency)
10	5	Real Effective Exchange Rate (Not SA)
11	5	Nominal Effective Exchange Rate (Not SA)
12	5	Foreign Exchange Rate: US (US Dollar to 1 Canadian Dollar) (Not SA)
13	5	Foreign Exchange Rate: Japan (Japanese Yen to 1 Canadian Dollar) (Not SA)
14	5	Foreign Exchange Rate: UK (UK Sterling to 1 Canadian Dollar) (Not SA)
15	5	Foreign Exchange Rate: SDR (Special Drawing Right to 1 Canadian Dollar) (Not SA)
16	5	Foreign Exchange Rate: Euro Area (Euro/ECU to 1 Canadian Dollar) (Not SA)

Table A.11: Sample is 1997:1-2018:7. Source: Datastream.

A.7 Balance of payment statistics, quantity indexes

Table format: series number, series code (NAPCS[2] for merchandise imports and exports, when available) transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm.
This dataset refers to Canadian balance of payment statistics, real imports and exports. Data are seasonally adjusted, 2012 chained prices.

[2]The categories for merchandise imports and exports are largely based on a variant of the North American Product Classification System (NAPCS).

Balance of payment statistics, real imports and exports

Num	Code	T	Description
1	*No Napcs*	1	Trade Balance (goods, all type), % GDP
2	C11 - C24	5	Imports: Total of all Merchandise
3	C12	5	Imports: Energy Product
4	C22	5	Imports: Consumer Goods
5	C18	5	Imports: Electronic, Electrical Equipment and Parts
6	C11	5	Imports: Farm, Fishing and Intermediate Food Products
7	C17	5	Imports: Industrial Machinery Equipment and Parts
8	C19	5	Imports: Motor Vehicles and Parts
9	C24	5	Imports: Other Balance of Payments Adjustments
10	C23	5	Imports: Special Transactions Trade
11	C21	5	Imports: Aircraft and Other Transportation Equipment
12	C15	5	Imports: Basic and Industrial Chemicals, Plastic and Rubber
13	C16	5	Imports: Forestry Product and Building and Packaging
14	C14	5	Imports: Metal and Non-Metallic Mineral Products
15	C13	5	Imports: Metal Ores and Non-Metallic Minerals
16	C11 - C24	5	Exports: Total of all Merchandise
17	C12	5	Exports: Energy Product
18	C22	5	Exports: Consumer Goods
19	C18	5	Exports: Electronic, Electrical Equipment and Parts
20	C11	5	Exports: Farm, Fishing and Intermediate Food Products
21	C17	5	Exports: Industrial Machinery Equipment and Parts
22	C19	5	Exports: Motor Vehicles and Parts
23	C24	5	Exports: Other Balance of Payments Adjustments
24	C23	5	Exports: Special Transactions Trade
25	C21	5	Exports: Aircraft and Other Transportation Equipment
26	C15	5	Exports: Basic and Industrial Chemicals, Plastic and Rubber
27	C16	5	Exports: Forestry Product and Building and Packaging
28	C14	5	Exports: Metal and Non-Metallic Mineral Products
29	C13	5	Exports: Metal Ores and Non-Metallic Minerals

Table A.12: Sample is 1997:1-2018:7. Source: CANSIM.

A.8 Balance of payment statistics, price indexes

Table format: series number, series code (NAPCS for merchandise imports and exports, when available) transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm. This dataset refers to Canadian balance of payment statistics, price indexes. Data are seasonally adjusted, Laspeyres fixed weighting (with 2012 = 100).

Import and export price indexes

Num	Code	T	Description
1	*No Napcs*	5	Term of Trade
2	C11 - C24	5	IPI - Total of all merchandise
3	C11	5	IPI - Farm, fishing and intermediate food products
4	C12	5	IPI - Energy products
5	C14	5	IPI - Metal ores and non-metallic minerals
6	C13	5	IPI - Metal and non-metallic mineral products
7	C15	5	IPI - Basic and industrial chemical, plastic and rubber products
8	C16	5	IPI - Forestry products and building and packaging materials
9	C17	5	IPI - Industrial machinery, equipment and parts
10	C18	5	IPI - Electronic and electrical equipment and parts
11	C19	5	IPI - Motor vehicles and parts
12	C21	5	IPI - Aircraft and other transportation equipment and parts
13	C22	5	IPI - Consumer goods
14	C23	5	IPI - Special transactions trade
15	C24	5	IPI - Other balance of payments adjustments
16	C11 - C24	5	EPI- Total of all merchandise
17	C11	5	EPI - Farm, fishing and intermediate food products
18	C12	5	EPI - Energy products
19	C13	5	EPI - Metal ores and non-metallic minerals
20	C14	5	EPI - Metal and non-metallic mineral products
21	C15	5	EPI - Basic and industrial chemical, plastic and rubber products
22	C16	5	EPI - Forestry products and building and packaging materials
23	C17	5	EPI - Industrial machinery, equipment and parts
24	C18	5	EPI - Electronic and electrical equipment and parts
25	C19	5	EPI - Motor vehicles and parts
26	C21	5	EPI - Aircraft and other transportation equipment and parts
27	C22	5	EPI - Consumer goods
28	C23	5	EPI - Special transactions trade
29	C24	5	EPI - Other balance of payments adjustments

Table A.13: Sample is 1997:1-2018:7. Source: CANSIM.

A.9 Housing starts, inventories and orders

Table format: series number, transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm.
This dataset refers to housing starts, inventories and orders. Data are seasonally adjusted, annual rates.

Housing starts, inventories and orders

Num	T	Description
1	4	Housing Starts: Canada (Units) (Source: CMHC)
2	5	Housing Starts: Quebec - Apartments (Units) (Source: CMHC)
3	5	Housing Starts: British Columbia - Apartments (Units) (Source: CMHC)
4	4	Housing Starts: Ontario - Apartment (Units) (Source: CMHC)
5	5	New Orders: All Manufacturing Industries, Deflated by CPI (LFE) (Units)
6	5	Inventory Owned: All Manufacturing Industries, Deflated by CPI (LFE) (Units)
7	5	New Orders: Durable Goods Industries, Deflated by CPI (LFE) (Units)
8	5	Unfilled Orders: All Manufacturing Industries, Deflated by CPI (LFE) (Units)

Table A.14: Sample is 1997:1-2018:7.

A.10 Real personal consumption expenditure

Table format: series number, series code (COICOP[3], when available) transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm.
This dataset refers to personal consumption expenditure. Data are seasonally adjusted, chained (2007) prices. Note that personal consumption expenditure variables are available only at the quarterly level. Interpolation techniques are implemented in order to transform them to monthly frequencies.

[3] The categories of household final consumption expenditure are based largely on the Classification of Individual Consumption According to Purpose (COICOP).

Personal consumption expenditure

Num	Code	T	Description
1	C131		PCE: Clothing
2	C13		PCE: Clothing and Footwear
3	C18		PCE: Communications
4	C21		PCE: Education
5	C145		PCE: Electricity, Gas and Other Fuels
6	C252		PCE: Expenditure by non Residents
7	C232		PCE: Financial Services indirectly measured
8	C111		PCE: Food
9	C22		PCE: Food Beverage and Accommodation Services
10	C221		PCE: Food and Beverage Services
11	C11		PCE: Food and non-Alcoholic Beverages
12	C132		PCE: Footwear
13	C16		PCE: Health
14	C163		PCE: Hospital Services
15	C153		PCE: Household Appliances
16	C152		PCE: Household Textiles
17	C142		PCE: Imputed Rental Fees for Housing
18	C231		PCE: Insurance
19	C23		PCE: Insurance and Financial services
20	C143		PCE: Maintenance and Repair of the Dwelling
21	C161		PCE: Medical Products Appliance and Equipment
22	C24		PCE: Miscellaneous Goods and Services
23	C195		PCE: Newspapers, Books and Stationery
24	C112		PCE: Non-Alcoholic Beverages
25	C172		PCE: Operation of Transport Equipment

Table A.15: Sample is 1997:1-2018:7. Source: CANSIM.

Num	Code	T	Description
26	C233		PCE: Other Financial Services
27	C244		PCE: Other Services
28	C162		PCE: Out-Patient Services
29	C141		PCE: Paid Rental Fees for Housing
30	C241		PCE: Personal Care
31	C242		PCE: Personal Effects
32	C171		PCE: Purchase of Vehicles
33	C19		PCE: Recreation and Culture
34	C194		PCE: Recreational and Cultural Services
35	C243		PCE: Social Services
36	C122		PCE: Tobacco
37	C154		PCE: Tools and Equipment for House and Garden
38	C17		PCE: Transport
39	C173		PCE: Transport Services
40	C144		PCE: Water Supply and Sanitation Services
41	CD		PCE: Durable Goods
42	CG		PCE: Goods
43	CSD		PCE: Semi-durable Goods
44	CS		PCE: Services
45	C151		PCE: Furniture, Furnishing Carpets and Floor Covering
46	C14		PCE: Housing Water Electricity, Gas and Other Fuels
47	C192		PCE: Other Major Durables for Recreation and Culture
48	C193		PCE: Recreational Items, Equipment for Garden Products, Pets
49	C		PCE: Household Final Consumption Expenditure

Table A.16: Sample is 1997:1-2018:7. Source: CANSIM.

A.11 Consumer price index

Table format: series number, transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm.
This dataset refers to consumer price indexes. Data are seasonally adjusted (2002 = 100). Note no category code is displayed. This is due to the fact that consumer price indexes are organized according to a, simple, indenting hierarchical structure by Canadian Socio-Economic Information Management System (CANSIM).

Consumer price index

Num	T	Description
1	5	Air Transportation
2	5	Beverages, Tobacco Products and Recreational Cannabis
3	5	Alcoholic Beverages
4	5	Apples
5	5	Athletic Footwear
6	5	Audio Equipment
7	5	Bakery Products
8	5	Bananas
9	5	Footwear
10	5	Books and Reading Material (Excluding Textbooks)
11	5	Butter
12	5	Cheese
13	5	Child Care Services
14	5	Children's Clothing
15	5	Children's Footwear (Excluding Athletic)
16	5	Cigarettes
17	5	Clothing and Footwear
18	5	Coffee and Tea
19	5	Coffee
20	5	Communications
21	5	Confectionery
22	5	Cooking Appliances
23	5	Dairy Products
24	5	Dental Care Services
25	5	Detergents and Soaps (Other than Personal Care)

Table A.17: Sample is 1997:1-2018:7. Source: CANSIM.

Num	T	Description
26	5	Housekeeping Services
27	5	Drivers' Licences
28	5	Dry Cleaning Services
29	5	Durable Goods
30	5	Education
31	5	Energy
32	5	All-items Excluding Food and Energy
33	5	Services Excluding Shelter Services
34	5	Food
35	5	Gasoline
36	5	Goods
37	5	Health and Personal Care
38	5	Household Operations, Furnishings and Equipment
39	5	Non-Electric Kitchen Utensils, Tableware and Cookware
40	5	Men's Footwear (Excluding Athletic)
41	5	Non-Alcoholic Beverages
42	5	Reading Material (Excluding Textbooks)
43	5	Rail, highway bus and other inter-city transportation
44	5	Services
45	5	Shelter
46	5	Spectator Entertainment (Excluding Video and Audio Subscription Services)
47	5	Transportation
48	5	Women's Footwear (Excluding Athletic)
49	5	All-items
50	5	All-items, Less 8 Volatile Component
51	5	Education and Reading
52	5	Eggs
53	5	Electricity
54	5	Eye Care Goods
55	5	Edible Fats and Oils
56	5	Fish
57	5	Food and Energy
58	5	Fresh Fruit
59	5	Fresh Milk
60	5	Fresh Vegetables
61	5	Fruit Juices
62	5	Furniture
63	5	Ham and Bacon
64	5	Health Care
65	5	Homeowners' Home and Mortgage Insurance
66	5	Household Appliances
67	5	Household Equipment
68	5	Household Furnishings and Equipment

Table A.18: Sample is 1997:1-2018:7. Source: CANSIM.

Num	T	Description
69	5	Household Operations
70	5	Household Textiles
71	5	Household Cleaning Products
72	5	Housing (1986 Definition) (Terminated)
73	5	Inter-city Transportation
74	5	Jewellery
75	5	Laundry Services
76	5	Leather Clothing Accessories
77	5	Lettuce
78	5	Magazines and Periodicals
79	5	Margarine
80	5	Meat
81	5	Men's Clothing
82	5	Mortgage Interest Cost
83	5	Natural Gas
84	5	Newspapers
85	5	Nuts and Seeds
86	5	Oral-hygiene Products
87	5	Oranges
88	5	Other Clothing Accessories
89	5	Other Bakery Products
90	5	Other Clothing Services
91	5	Other Dairy Products
92	5	Other Food Preparations
93	5	Other Food Products and Non-Alcoholic Beverages
94	5	Other Fresh Vegetables
95	5	Property taxes and other special charges
96	5	Other Furniture
97	5	Other Horticultural Goods
98	5	Alcoholic Beverages Purchased from Stores
99	5	All Other Food Preparations
100	5	All Other Passenger Vehicle Operating Expenses
101	5	Area Rugs and Mats (Terminated)
102	5	Passenger Vehicle Insurance Premiums
103	5	Passenger Vehicle Maintenance and Repair Services
104	5	Passenger Vehicle Registration Fees
105	5	Passenger Vehicle Parts, Accessories and Supplies
106	5	Bakery and Cereal Products (Excluding Baby Food)
107	5	Bedding and Other Household Textiles
108	5	Beer Purchased from Stores
109	5	Bread, Rolls and Buns
110	5	Breakfast Cereal and Other Cereal Products (Excluding Baby Food)

Table A.19: Sample is 1997:1-2018:7. Source: CANSIM.

Num	T	Description
111	5	Video and Audio Subscription Services
112	5	Canned and Other Preserved Fish
113	5	Canned Vegetables and Other Vegetable Preparations
114	5	Child Care and Housekeeping Services
115	5	City Bus and Subway Transportation
116	5	Clothing Accessories, Watches and Jewellery
117	5	Clothing Material, Notions and Services
118	5	Clothing Material and Notions
119	5	Digital Computing Equipment and Devices
120	5	Condiments, Spices and Vinegars
121	5	Dairy Products and Eggs
122	5	Fish, Seafood and other Marine Products
123	5	Flour and Flour Based Mixes
124	5	Food Purchased from Restaurants
125	5	Food Purchased from Stores
126	5	Food Purchased from Tableservice Restaurants
127	5	Fresh fruit and vegetables
128	5	Fresh or frozen beef
129	5	Fresh or frozen chicken
130	5	Fresh or frozen pork
131	5	Fresh or frozen poultry
132	5	Frozen and dried vegetables
133	5	Fruit, fruit preparations and nuts
134	5	Fuel oil and other fuels
135	5	Furniture and household textiles
136	5	Home entertainment equipment, parts and services
137	5	Homeowners' maintenance and repairs
138	5	Tools and other household equipment
139	5	Ice cream and related products
140	5	Baby foods
141	5	Laundry and dishwashing appliances
142	5	Liquor purchased from stores
143	5	Local and commuter transportation
144	5	Medicinal and pharmaceutical products
145	5	Operation of passenger vehicles
146	5	Operation of recreational vehicles
147	5	Other passenger vehicle operating expenses
148	5	Cereal products (excluding baby food)
149	5	Other edible fats and oils
150	5	Other fresh or frozen poultry

Table A.20: Sample is 1997:1-2018:7. Source: CANSIM.

Num	T	Description
151	5	Other household appliances
152	5	Other household equipment
153	5	Other household services0
154	5	Other household supplies0
155	5	Other processed meat
156	5	Seafood and other marine products
157	5	Paper supplies
158	5	Parking fees
159	5	Pasta products
160	5	Personal care
161	5	Personal care services
162	5	Potatoes
163	5	Medicines (excluding medicinal cannabis)
164	5	Private transportation
165	5	Processed meat
166	5	Public transportation
167	5	Recreation
168	6	Rent
169	5	Homeowners' replacement cost
170	5	Rice and rice based mixes
171	5	Semi-durable goods
172	5	Alcoholic beverages served in licensed establishment
173	5	Beer served in licensed establishments
174	5	Liquor served in licensed establishments
175	5	Wine served in licensed establishments
176	5	Soup
177	5	Sugar and confectionery
178	5	Sugar and syrup
179	5	Tea
180	5	Telephone services
181	5	Tenants' insurance premiums
182	5	Tomatoes
183	5	Travel services
184	5	Travel tours
185	5	Traveller accommodation
186	5	Tuition fees
187	5	Upholstered furniture
188	5	Video equipment
189	5	Watches
190	5	Water
191	5	Window coverings
192	5	Women's clothing

Table A.21: Sample is 1997:1-2018:7. Source: CANSIM.

Num	T	Description
193	5	Wooden furniture
194	5	Food purchased from fast food and take-out restaurants
195	5	Food purchased from cafeterias and other restaurants
196	5	Fresh or frozen fish (including portions and fish sticks)
197	5	Fresh or frozen meat (excluding poultry)
198	5	Fuel, parts and accessories for recreational vehicles
199	5	Health care goods
200	5	Health care services
201	5	Insurance, licences and other services for recreational vehicles
202	5	Non-prescribed medicines
203	5	Non-durable goods
204	5	Other fresh or frozen meat (excluding poultry)
205	5	Other health care services
206	5	Other health care goods
207	5	Other household cleaning products
208	5	Other household goods and services
209	5	Other lessons, courses and education services
210	5	Other owned accommodation expenses
211	5	Other personal care supplies and equipment
212	5	Other preserved fruit and fruit preparations
213	5	Other recreational equipment
214	5	Other cultural and recreational services
215	5	Other tobacco products and smokers' supplies
216	5	Owned accommodation
217	5	Paper, plastic and aluminum foil supplies
218	5	Personal care supplies and equipment
219	5	Pet food and supplies
220	5	Postal and other communications services
221	5	Frozen food preparations
222	5	Preserved fruit and fruit preparations
223	5	Preserved vegetables and vegetable preparations
224	5	Purchase and operation of recreational vehicles
225	5	Purchase and leasing of passenger vehicles

Table A.22: Sample is 1997:1-2018:7. Source: CANSIM.

Num	T	Description
226	5	Purchase of passenger vehicles
227	5	Purchase of recreational vehicles and outboard motors
228	5	Refrigerators and freezers
229	5	Rental of passenger vehicles
230	5	Rented accommodation
231	5	School textbooks and supplies
232	5	Seeds, plants and cut flowers
233	5	Services related to household furnishings and equipment
234	5	Sporting and exercise equipment
235	5	Taxi and other local and commuter transportation services
236	5	Tenants' maintenance, repairs and other expenses,
237	5	Tobacco products and smokers' supplies
238	5	Toiletry items and cosmetics
239	5	Household tools (including lawn, garden and snow removal equipment)
240	5	Toys, games (excluding video games) and hobby supplies
241	5	Use of recreational facilities and services
242	5	Vegetables and vegetable preparations
243	5	Water, fuel and electricity
244	5	Wine purchased from stores
245	5	Personal Soap

Table A.23: Sample is 1997:1-2018:7. Source: CANSIM.

A.12 Raw material price index

Table format: series number, series code (NAPCS, when available) transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm. This dataset refers to raw material price index. Data are seasonally adjusted.

Raw material price index

Num	Code	T	Description
1	M51	5	Crude energy products
2	M31	5	Non-metallic minerals
3	RMPI	5	Raw materials price indexes

Table A.24: Sample is 1997:1-2018:7. Source: CANSIM.

A.13 Product price index

Table format: series number, series code (NAPCS/NAICS, when available), transformation code and series description. The transformation codes are as in Stock and Watson (2016): 1 - no transformation; 2 - first difference; 4 - logarithm; 5 - first difference of logarithm; 6 - second difference of logarithm. This dataset refers to product price index. In particular, producer price data are collect at the product level (NAPCS codes) or establishment level (NAICS code). The latter are interpreted as the price index of the producers whose establishments are located in Canada. Data are seasonally adjusted (2010 = 100).

Product price index

Num	Code: NAPCS	T	Description
1	P7491	5	Furniture and Fixiture
2	211	5	Alcoholic beverages
3	*No Napcs*	5	Beverages Industries
4	312	5	Beverage and tobacco product manufacturing
5	P81	5	Cement, glass, and other nonmetallic mineral products
6	P31	5	Chemicals and chemical products
7	P22/231	5	Clothing, footwear and accessories
8	191	5	Coffee and tea
9	P73	5	Electrical, electronic, audiovisual and telecommunication products
10	P51	5	Energy and petroleum products
11	P63	5	Fabricated metal products and construction materials
12	472	5	Fabricated metal products
13	26133	5	Heavy fuel oils
14	26131	5	Jet fuel
15	47553	5	Jewellery, cut gems, jewellery findings, and precious metal hollowware and flatware
16	26132	5	Light fuel oils
17	P41	5	Lumber and other wood products
18	P72	5	Machinery and equipment
19	P11	5	Meat, fish, and dairy products
20	172	5	Meat products
21	26121	5	Motor gasoline
22	P71	5	Motorized and recreational vehicles
23	25121	5	Newsprint
24	291	5	Non-metallic mineral products
25	41111	5	Passenger cars
26	273	5	Pharmaceutical and medicinal products
27	3254	5	Pharmaceutical and medicine manufacturing

Table A.25: Sample is 1997:1-2018:7. Source: CANSIM.

	Code: NAPCS	T	Description
28	P32	5	Plastic and rubber products
29	P42	5	Pulp and paper products
30	24112	5	Softwood lumber (except tongue and groove and other edge worked lumber)
31	47531	5	Sporting and athletic goods
32	P21	5	Textile and leather products
33	P14	5	Tobacco product
34	IPPI	5	Total, Industrial product price index
35	322	5	Unwrought copper and copper alloys
36	321	5	Unwrought aluminum and aluminum alloys
37	P21	5	Fruit, vegetables, feed and other food products

Table A.26: Sample is 1997:1-2018:7. Source: CANSIM.

Num	Code: NAICS	T	Description
1	$3A/31$-33	5	Manufacturing
2	3332	5	Industrial machinery manufacturing
3	3313	5	Alumina & Aluminum Production and Processing
4	3364	5	Aerospace product & Parts Manufacturing
5	324	5	Petroleum & Coal Product Manufacturing
6	31212	5	Breweries
7	325	5	Chemical Manufacturing
8	311	5	Food Manufacturing
9	3321	5	Forging and Stamping
10	3315	5	Foundries
11	3325	5	Hardware Manufacturing
12	333	5	Machinery Manufacturing
13	339	5	Miscellaneous Manufacturing
14	322	5	Paper Manufacturing
15	3111	5	Animal Food Manufacturing
16	3118	5	Bakeries and Tortilla Manufacturing
17	3251	5	Basic Chemical Manufacturing
18	3222	5	Converted Paper Product Manufacturing
19	3115	5	Dairy Product Manufacturing
20	332	5	Fabricated metal product manufacturing

Table A.27: Sample is 1997:1-2018:7. Source: CANSIM.

Num	Code: NAICS	T	Description
21	3112	5	Grain and oilseed milling
22	3116	5	Meat Product Manufacturing
23	3335	5	Metalworking Machinery Manufacturing
24	3259	5	Other Chemical Product Manufacturing
25	3119	5	Other Food Manufacturing
26	3399	5	Other Miscellaneous Manufacturing
27	3369	5	Other Transportation Equipment Manufacturing
28	3219	5	Other Wood Product Manufacturing
29	331	5	Primary Metal Manufacturing
30	3365	5	Railroad Rolling Stock Manufacturing
31	3211	5	Sawmills and wood preservation
32	3366	5	Ship and boat building
33	336	5	Transportation Equipment Manufacturing
34	321	5	Wood Product Manufacturing
94	3323	5	Architectural and Structural Metals Manufacturing
35	312	5	Beverage and tobacco product manufacturing
36	3273	5	Cement and Concrete Product Manufacturing
37	334	5	Computer and Electronic Product Manufacturing
38	3341	5	Computer and Peripheral Equipment Manufacturing
39	337	5	Furniture and Related Product Manufacturing
40	3391	5	Medical equipment and supplies manufacturing
41	3372	5	Office furniture (including fixtures) manufacturing
42	3379	5	Other furniture-related product manufacturing
43	3339	5	Other general-purpose machinery manufacturing
44	3255	5	Paint, coating and adhesive manufacturing
45	323	5	Printing and related support activities
46	3221	5	Pulp, paper and paperboard mills
47	3117	5	Seafood product preparation and packaging
48	31211	5	Soft drink and ice manufacturing
49	3326	5	Spring and wire product manufacturing
50	3113	5	Sugar and confectionery product manufacturing

Table A.28: Sample is 1997:1-2018:7. Source: CANSIM.

Num	Code	T	Description
51	3324	5	Boiler, tank and shipping container manufacturing
52	3328	5	Coating, engraving, heat treating and allied activities
53	3333	5	Commercial and service industry machinery manufacturing
54	335	5	Electrical equipment, appliance and component manufacturing
55	3336	5	Engine, turbine and power transmission equipment manufacturing
56	3114	5	Fruit and vegetable preserving and specialty food manufacturing
57	3371	5	Household and institutional furniture and kitchen cabinet manufacturing
58	3311	5	Iron and steel mills and ferro-alloy manufacturing
59	3362	5	Motor vehicle body and trailer manufacturing
60	3253	5	Pesticide, fertilizer and other agricultural chemical manufacturing
61	3344	5	Semiconductor and other electronic component manufacturing
62	3256	5	Soap, cleaning compound and toilet preparation manufacturing
63	3312	5	Steel product manufacturing from purchased steel
64	3212	5	Veneer, plywood and engineered wood product manufacturing
65	3252	5	Resin, synthetic rubber, and artificial and synthetic fibres and filaments manuf.
66	3334	5	Ventilation, heating, air conditioning and commercial refrigeration equipment manuf.
67	3327	5	Machine shops, turned product, and screw, nut and bolt manufacturing
68	3314	5	Non-ferrous metal (except aluminum) production and processing
69	327	5	Non-metallic mineral product manufacturing
70	3122	5	Tobacco manufacturing
71	3342	5	Communications equipment manufacturing
72	3353	5	Electrical equipment manufacturing
73	3352	5	Household appliance manufacturing
74	336Y	5	Motor vehicles and parts manufacturing
75	3262	5	Rubber product manufacturing
76	3351	5	Electric lighting equipment manufacturing
77	3363	5	Motor vehicle parts manufacturing
78	3254	5	Pharmaceutical and medicine manufacturing
79	3359	5	Other electrical equipment and component manufacturing

Table A.29: Sample is 1997:1-2018:7. Source: CANSIM.

B Data Description for Regression Analysis

- *Profit Margin*: Average (percentage) profit margin for Canadian firms (i.e. firms established in Canada), whose revenues range from 30 thousands and 5 million Canadian Dollars. Period: 2013-2014-2015. Source: Canadian Government, Financial Performance Data.

- *Import Penetration*: Average import penetration at the industry level, which is defined, for industry j and time t, as:

$$Penetration_{j,t} = \frac{Imports_{j,t}}{Imports_{j,t} + Production_{j,t} - Exports_{j,t}}.$$

Period: $2013 - 2014 - 2015$. Source: Supply and Use table for Canada, as provided by CANSIM.

Chapter 2
Foreign Monetary Policy and Domestic Inflation in Emerging Markets*

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Abstract

We estimate the response of domestic inflation to a US interest rate shock in a sample of 24 emerging economies, using local projection methods. Our results point out that the sign of the inflation response crucially depends on the monetary policy framework: after a US monetary policy tightening, inflation decreases in peggers; inflation increases in floaters that do not target inflation; the inflation response is not statistically different from zero in floaters that are committed to an inflation target. We rationalize this outcome using a standard DSGE model. We show that targeting inflation yields larger welfare gains compared to the other two monetary policy frameworks, even assuming dominant currency pricing.

Keywords: Inflation Stabilization, Inflation Targeting, Monetary Policy, Open Economy Macroeconomics.
JEL Codes: E31, E52, F41.

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1 Introduction

Policy makers in emerging markets are typically concerned about both stages of US monetary cycles. When the US conducts a loose monetary stance, other countries are worried about the appreciation of the domestic currency and the resulting lower competitiveness. When the Fed tightens monetary policy, policy makers in other economies are concerned about a recessionary sudden stop in capital inflows. One of the critical issues for central banks in emerging markets is indeed how to respond to US interest rate shocks.

The macroeconomic literature has deeply investigated the international spillover effects of monetary policy shocks in center countries. In particular, the literature has focused on the spillover effect on exchange rates, real activity, and capital flows. Policy makers are also concerned about the response of domestic prices to foreign monetary policy shocks. The workhorse macroeconomic models for small open economies, whose variants are widely adopted by central banks, underline that inflation is costly and optimal policy requires some degree of inflation targeting.[1] However, the response of inflation to foreign interest rate shocks has been partially overlooked by the empirical literature. Few papers include inflation among the endogenous variables of the empirical model and the sign of the inflation response does not seem robust across these studies (Canova, 2005; and Maćkowiak, 2007, find that inflation increases in emerging markets; Degasperi et al., 2020, find that inflation decreases).

Motivated by these observations, we ask the following questions. Does the response of inflation to foreign monetary policy shocks depend on the exchange rate regime and on whether the country is an inflation targeter? Which monetary policy framework should be preferred by policy makers in economies hit by foreign interest rate shocks?

To answer these questions, we use both an empirical and a theoretical approach. First, we estimate a local projection model fed with US monetary policy shocks, using data for a set of emerging economies (henceforth EME). We leverage the flexibility of the local projection framework (Jordà, 2005) to estimate state-dependent responses, where the states refer to the monetary policy framework in place when the shock hits. We rely on the instrument proposed by Miranda-Agrippino and Ricco (2021) to identify US monetary policy shocks. We distinguish between three monetary policy frameworks, using the classifications of Ilzetzki et al. (2019): i) a fixed exchange rate regime; ii) a flexible exchange rate regime with no commitment to inflation targeting; iii) a flexible exchange rate regime with an explicit commitment to an inflation targeting. Among peggers, we

[1] In some cases, a strict inflation targeting is the optimal policy, as in Gali and Monacelli (2005). In other cases, the social planner trades off the volatility of inflation with the volatility of other variables (Monacelli, 2013; Corsetti et al., 2020).

also differentiate countries by the stock of FX reserves and the degree of capital controls, following the insights of the IMF Integrated Policy Framework (Basu et al., 2020, Adrian et al., 2020).

Second, we set up a DSGE model for a small-open economy to interpret our empirical results. The model features incomplete markets, nominal rigidities (price adjustment costs), and dominant currency pricing, which better captures the trade invoicing of EME compared to alternative pricing assumptions (Burstein and Gopinath, 2014; Gopinath, 2015). We carry out four exercises. First, we calibrate three different Taylor rules that capture the basic features of each monetary policy framework, to provide a qualitative description of the main channels: we obtain three small-open economy models that are different only in terms of the Taylor rule, which parsimoniously represents the key feature of each policy regime. Second, we estimate the parameters of the Taylor rule for each monetary policy framework by matching the DSGE impulse responses with the empirical responses. Third, we compute numerically the impulse response under the optimal policy and we compare it with the impulse responses obtained in the matching exercises. Fourth, we introduce capital controls and foreign exchange interventions to explore whether our theoretical results change for pegger countries.

On the empirical side, we find that the sign of the inflation response to a US monetary policy tightening crucially depends on the monetary policy framework: it decreases in countries that adopt a fixed exchange rate regime, whereas it increases in floaters that do not explicitly target inflation. In inflation targeters, the response of inflation is not statistically significant. We also find that the fall in inflation in peggers is mainly driven by those countries with a low level of foreign reserves and more open to international capital markets. Consistently with what is expected, a US monetary tightening depreciates the domestic currency in countries adopting a floating exchange rate regime (both inflation targeters and non-targeters), while the effect is not statistically significant in peggers.

On the theoretical side, we show that our model replicates the results of the empirical analysis. First, when we calibrate the three Taylor rules, in peggers inflation falls as a result of the monetary contraction needed to defend the peg; in floaters non-inflation targeters, inflation rises as a result of the nominal depreciation, which increases the costs of imports, and in turn increases the demand for the domestic good; in inflation targeters, the response of inflation is muted by assumption. Second, when we estimate the three Taylor rules by matching the DSGE with the empirical impulse responses, we indeed find that in peggers the central bank aggressively responds to exchange rate fluctuations; in floaters the central bank responds only to inflation fluctuations, and the response to inflation is much stronger in inflation targeters than non-targeters. Third, we find that the optimal policy prescribes to dampen the volatility of producer price inflation (PPI) in domestic markets, as standard in the New Keynesian open economy literature (e.g. Gali and Monacelli, 2005): this result holds even in our model with dominant currency pricing, in line with Egorov and Mukhin (2020). We show that, among the three policy regimes considered, CPI inflation targeting yields higher welfare compared to floaters non-targeters and, in particular, to peggers: by targeting CPI inflation, the central bank is able to dampen also PPI inflation, whose fluctuations are costly. Fourth, when the central bank in pegger countries can manage capital controls and foreign exchange intervention, we find that inflation still falls, but to a lesser extent.

Our paper contributes to two different strands of literature.

First we contribute to the literature on spillover effects of US monetary policy. The debate started in the early 90s with the seminal work of Calvo et al. (1993), who show the linkage between external shocks and capital flows in EME. Recently, Rey (2013) and Miranda-Agrippino and Rey (2020) argue for the existence of a global financial cycle triggered by US monetary policy. As stated above, so far the literature has focused on the responses of economic activity, capital flows, and domestic financial conditions to US monetary policy shocks (Maćkowiak, 2007; Dedola et al., 2017; Miranda-Agrippino and Rey, 2020; Iacoviello and Navarro, 2019; and Degasperi et al., 2020). Few studies include inflation among the endogenous variables of the empirical model and the sign of the inflation response does not seem robust across these papers (Canova, 2005, Maćkowiak, 2007, and Degasperi et al., 2020). Our contribution to this literature is twofold. First, we show that the sign of the inflation response crucially depends on the monetary policy framework. Second, we augment the previous analysis by considering the inflation targeting as a stand-alone case, rather than focusing on the standard dichotomy peggers vs floaters: this further distinction is important, as inflation targeters may respond differently compared to non-targeters, and given that the share of emerging markets explicitly targeting inflation is increasing since the early 2000s (Figure 1).

Second, we contribute to the literature on optimal monetary policy in small open economies. The benchmark contribution by Gali and Monacelli (2005) shows that targeting PPI inflation is optimal in small open economies under producer currency pricing, while pegging the exchange rate yields higher welfare loss. This result has been challenged by several studies, showing that deviations from inflation targeting may be optimal for several reasons: to affect terms of trade externalities (Faia and Monacelli, 2008; De Paoli, 2009; and Monacelli, 2013); to mitigate divergences from the law of one price in models with local currency pricing (Devereux and Engel, 2003; and Monacelli, 2005); to dampen the effects of financial frictions (Davis and Presno, 2016; and Aoki et al., 2016). We contribute to this literature by showing that targeting PPI inflation is optimal even in a model with dominant currency pricing: in a richer framework, our paper extends the closed-form results obtained by Casas et al. (2017) and Egorov and Mukhin (2020), who find that targeting PPI inflation is the optimal policy when export prices are sticky in foreign currency.

The paper is organized as follows: Section 2 describes the data set; Section 3 shows the econometric framework; Section 4 presents the empirical analysis and the results; Section 5 describes the DSGE model; Section 6 shows the impulse response matching and the welfare analysis; Section 7 concludes.

Emerging market economies by monetary policy framework

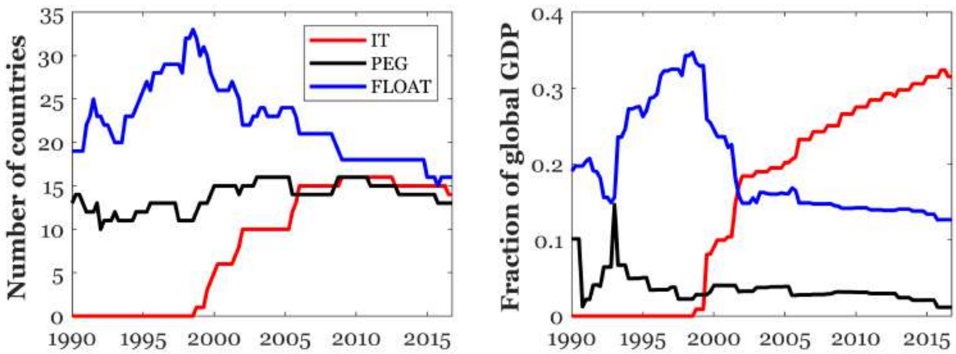

Figure 1: IT denotes floating exchange rate with an inflation target; PEG denotes fixed exchange rate regime; FLOAT denotes floating exchange rate regime, without an explicit commitment to inflation. Source: Ilzetzki et al. (2019) and WEO. The sample includes 51 EME.

2 Data

Our initial dataset covers the time horizon $1991Q1 - 2012Q4$ for 24 EME at the quarterly frequency. We have selected only those countries with a currency anchored to the US dollar in at least one year, according to the de-facto anchor currency classification of Ilzetzki et al. (2019). This ensures that fixed and floating exchange rate regimes are on an equal footing when responses to a US monetary policy shock are compared. We have excluded low-income, oil-exporters, and small countries. The time horizon ends in 2012Q4, as the monetary policy instrument provided by Miranda-Agrippino and Ricco (2021) ends in 2009: given that we estimate local-projection impulse response functions up to three years after the shock, the estimation sample ends three year after the end of the shock's time series. This is not necessarily a limitation, as we are excluding the zero-lower bound period in the US, when the use of unconventional tools may have modified the transmission mechanism of monetary policy.

Our sample includes the following variables, for each EME: Consumer Price Index (CPI), real GDP, nominal effective exchange rates (NEER), and the policy rate. The series, except for the policy rate, are seasonally adjusted using the ARIMA X−13 method, and they are winsorized at both sides at 1% threshold, in order to remove outliers and avoid extreme measurement errors.

We apply a Band-Pass filter to the log first difference of CPI and NEER, in order to extract the cyclical components.[2] The choice of detrending these variables is consistent with the results of a standard Wald test, at the 95% significance.[3]

We rely on the instrument for US monetary policy shocks proposed by Miranda-Agrippino and Ricco (2021) available at monthly frequency. The instrument is constructed as the part of high-frequency market surprises driven by monetary policy announcements that is orthogonal to past market surprises and to the central bank's economic forecasts.[4] Given our focus on quarterly series, we aggregate the instrument by taking the average of its observations within the quarter. While this procedure implies a compensation of shocks of different signs within the same quarter, it permits to estimate the responses of quarterly variables to the "average" shock occurred in the quarter.

We use the classification by Ilzetzki et al. (2019) to distinguish between peg and floating exchange rate regimes. The authors develop a de-facto classification of exchange rate regimes, consisting of 15 ordered categories at the monthly frequency (Table A.1). We convert monthly into quarterly values by considering the value at the end of the quarter. Following Ben Zeev (2019), for each country i and period t, we define a dummy variable I_{it}^{PEG} that is 1 if the category is no larger than 4, and 0 otherwise. Given this classification, we interpret $I_{it}^{PEG} = 1$ as a fixed exchange rate regime. We only use categories $1 - 13$, omitting the extreme cases "Freely Falling" and "Dual market", to avoid extreme crisis periods.[5]

We also follow the de-iure classification of Ilzetzki et al. (2019) to distinguish between inflation targeters and non-targeters. We define a dummy I_{it}^{IT}, which is 1 if the country is an inflation targeter, and zero otherwise.

Finally, we include the following US and global variables in our dataset, the latter being useful to control for potential endogeneity bias between US policy rates and EME

[2]We apply a Band-Pass filter that suppresses all the fluctuations that are shorter than 1.5 years or longer than 8 years; the filter allows the remaining elements of the series to pass through without being affected.

[3]The test suggests the existence of a linear trend for CPI inflation and NEER growth rate for nearly 21%, and 8% of the series, respectively. We can not reject the null hypothesis of no linear trend for all the series of GDP growth.

[4]Miranda-Agrippino and Ricco (2021) measure high-frequency market surprise using the difference between the Fed-Fund future price immediately after and immediately before a FOMC announcement. The instrument leverages on the insights of high-frequency (as in Gertler and Karadi, 2015) and narrative (as in Romer and Romer, 2004) approaches to monetary policy shock identification, and it is robust to predictability and autocorrelation concerns.

[5]Categories 1-4 include relatively strict pegs (*de iure* and *de facto*), currency unions, and currency boards. Categories higher than 4 include floaters, managed floaters, and a large variety of intermediate regimes. In our binary classification, we consider all these categories as floaters, given that in these countries the exchange-rate policy is much less constrained than in countries with category 1-4.

domestic variables (Table A.5): the 1-year government bond yield, as a proxy of US monetary policy;[6] the index of global economic activity (REA) developed by Kilian (2009); real oil price (in logs); the CBOE S&P 100 Volatility Index (VXO).

3 Econometric Setup

We follow Stock and Watson (2018) and use a panel local projection with an instrumental variable (LP-IV, henceforth). Our main goal is to find the impulse response function of domestic inflation to a foreign monetary policy shock, conditional on the monetary policy regime. We also estimate the responses of other relevant variables (GDP, NEER, and policy rate). Our econometric setup consists of two steps. In the first stage of estimation, we regress the 1-year US government bond yield on the instrument proposed by Miranda-Agrippino and Ricco (2021): the fitted dependent variable is the monetary policy shock. In the second stage, we estimate the impulse response function of the endogenous variables to the identified shock, which is scaled in order to determine a 1% impact increase in the 1-year US government bond yield. We estimate standard errors robust to cross-sectional and time-series correlation, following Discroll and Kraay (1980).[7]

3.1 Linear model

We estimate the linear model using a panel LP-IV, in which we do not condition the impulse responses to the monetary policy regime. Let y_{it+h} be the CPI in country i and in the period h. For each horizon h, we estimate the following regression:[8]

$$y_{it+h} - y_{it-1} = \alpha_h + \gamma_{ih} + \beta_h \widehat{\Delta r}_t^{US} + A_h(L)\,\Delta y_{it-1} + B_h(L)\,z_{t-1} + C_h(L)\,X_{t-1} + u_{it+h}. \quad (1)$$

where α_h is the constant term; γ_{ih} denotes country-fixed effects; $\widehat{\Delta r}_t^{US}$ is the monetary policy shock; z_t is the monetary policy instrument provided by Miranda-Agrippino and Ricco (2021): we include its lags in the second stage in order to satisfy the "lead-lag" exogeneity condition, which requires the instrument to be uncorrelated with past and future shocks; X_{t-1} is a vector of global variables including: REA, VXO, and the log difference of real oil price; β_h is the response to US monetary policy shocks at horizon, h,

[6] This choice is standard in the literature studying the transmission of US monetary policy shocks (Gertler and Karadi, 2015 and Miranda-Agrippino and Ricco, 2021, among others).

[7] Discroll and Kraay (1980) represents a suitable econometric tool for panel LP-IV analysis, in which the residuals of the estimation are potentially characterized by cross-sectional correlation across countries, and time-series correlation across time.

[8] The regressions for NEER and GDP are analogous. In the regression for the policy rate, the dependent variable is y_{it+h} (as opposed to $y_{it+h} - y_{it-1}$); in that regression, we control for lagged levels of policy rate, rather than lagged first differences.

in the average EME (i.e. without conditioning on the monetary policy regime); $A_h(L)$, $B_h(L)$, and $C_h(L)$ are lag polinomia of order 1.[9] In order to obtain the monetary policy shock, we estimate a first-stage regression of Δr_t^{US} (the first-difference of the 1-year US government bond yield):

$$\Delta r_t^{US} = \phi + \lambda_i + \omega z_t + D(L)\,\Delta y_{it-1} + E(L)\,z_{t-1} + F(L)\,X_{t-1} + v_t, \tag{2}$$

where the variables are defined as above, and $D(L)$, $E(L)$ and $F(L)$ are lag polynomial of order 1.[10] By plugging the fitted values of the first stage regression (equation 2), in the second-stage specification (equation 1), we disentangle the variation in the US policy rate that is only related to the instrument z_t, and label it $\widehat{\Delta r_t}^{US}$, which is the monetary policy shock.[11] We find that z_t is not a weak instrument, as the $t - statistic$ on z_t is well above 4 in all the specifications (Table 1). This implies an $F - statistic$ higher than 10, which is the threshold for weak instruments proposed by Stock and Yogo (2005).

First-stage regression

	Dependent variable: Δr_t^{US}			
	(1) (CPI)	(2) (GDP)	(3) (Policy rate)	(4) (NEER)
z_t (instrument)	5.95**	5.98**	5.64**	5.94**
	(1.40)	(1.44)	(1.23)	(1.42)
t-statistic	4.22	4.14	4.59	4.16

Table 1: Driscoll-Kraay standard errors are in parenthesis. * (**) denotes significance at 10 (5) percent level. We report only the coefficients related to the instrument, to save space.

3.2 State-dependent model

The linear model in equation (1) can be easily extended to a state-dependent specification by allowing the parameters to vary according to the state of the economy. By interacting the dummies I_{it}^{PEG} and I_{it}^{IT}, we obtain three dummies of relevant monetary

[9]The number of lags strikes a balance between those prescribed by the Akaike Information Criterium for GDP (0), and for CPI (3) when equation 1 is estimated at horizon $h = 0$. The baseline results are robust to the number of lags.

[10]For ease of exposition, we do not specify the horizon h in the first-stage regression.

[11]For a thorough analysis of local projection techniques with instrumental variables see Stock and Watson (2018) and Jordà et al. (2020), among others.

policy regimes. Floating exchange rate with an inflation targeting: $IT_{it} = 1$, if $I_{it}^{PEG} = 0$ and $I_{it}^{IT} = 1$; fixed exchange rate regime with no inflation targeting: $PEG_{it} = 1$, if $I_{it}^{PEG} = 1$ and $I_{it}^{IT} = 0$; floating exchange rate regime with no inflation targeting (NIT): $FLOAT_{it} = 1$, if $I_{it}^{PEG} = I_{it}^{IT} = 0$. In principles, a fourth monetary policy framework can arise for countries that target both the exchange rate and inflation ($I_{it}^{PEG} = I_{it}^{IT} = 1$): not surprisingly, there are no observations for this regime. Let y_{it+h} be the CPI in country i and in period $t+h$. For each horizon h, we estimate the following state-dependent local projection:[12]

$$\begin{aligned} y_{it+h} - y_{it-1} = IT_{it-1} \left[\alpha_h^{IT} + \beta_h^{IT} \widehat{\Delta r}_t^{US} + A_h^{IT}(L)\,\Delta y_{it-1} + B_h^{IT}(L)\,z_{t-1} \right] + \\ PEG_{it-1} \left[\alpha_h^{PEG} + \beta_h^{PEG} \widehat{\Delta r}_t^{US} + A_h^{PEG}(L)\,\Delta y_{it-1} + B_h^{PEG}(L)\,z_{t-1} \right] + \\ FLOAT_{it-1} \left[\alpha_h^{FLOAT} + \beta_h^{FLOAT} \widehat{\Delta r}_t^{US} + A_h^{FLOAT}(L)\,\Delta y_{it-1} + B_h^{FLOAT}(L)\,z_{t-1} \right] + \\ + C_h(L)\,X_{t-1} + \gamma_{ih} + u_{it+h}, \end{aligned} \tag{3}$$

where the variables are defined as above and the coefficients β_h^{IT}, β_h^{PEG} and β_h^{FLOAT} represent the average effect of the US monetary policy shocks at horizon, h, conditional on the monetary policy framework in place in the quarter before the shock occurs. We directly factor in the time variation of the monetary policy framework, which is time-indexed: given that in our sample most countries have experienced at least one change, our empirical analysis improves upon models where the exchange rate regime is constant (e.g. Dedola et al., 2017; and Degasperi et al., 2020).[13] Non-linear projection methods *à la* Jordà (2005) have been recently used to study the state-dependent effect of monetary and fiscal policy shocks (e.g. Tenreyro and Thwaites, 2016, Ramey and Zubairy, 2018, and Alpanda et al., 2019). They offer two remarkable advantages with respect standard vector autoregressive (VAR) models. First, they do not impose dynamic restrictions on the responses of the endogenous variables and, thus, they are less plagued by mispecifications. Second, they are more suitable for implementing a state-dependent analysis because they do not require to take a stand on the transition process across states. In fact, our state-dependent responses take into account the average endogenous transition in the monetary policy framework that takes place after the shock occurs, without requiring any assumption on its process.

[12] The regression for NEER and GDP are analogous. In the regression for the policy rate, the dependent variable is y_{it+h} (as opposed to $y_{it+h} - y_{it-1}$); in that regression, we control for lagged levels of policy rate, rather than lagged first differences.

[13] In the estimation sample there are 25 changes of regime.

3.2.1 Focus on peggers: other policy instruments

EME use a variety of instruments to tackle foreign interest rate shocks, as highlighted also by the Integrated Policy Framework developed by the IMF (Basu et al., 2020 and Adrian et al., 2020). The state-dependent econometric setup is suitable also to investigate the role of other policy instruments, such as FX interventions and capital controls. We test the effect of FX-interventions by introducing a dummy variable I_{it}^{RES}, which is 1 if country i has a FX reserves-GDP ratio higher than the 75 percentile in period t, and 0 otherwise. In a sample of only peggers, we estimate the following equivalent of equation 3:

$$\begin{aligned} y_{it+h} - y_{it-1} \quad = \quad & I_{it-1}^{RES}\left[\alpha_h^H + \beta_h^H \widehat{\Delta r}_t^{US} + A_h^H\left(L\right)\Delta y_{it-1} + B_h^H\left(L\right) z_{t-1}\right] + \\ & + \left(1 - I_{it-1}^{RES}\right)\left[\alpha_h^L + \beta_h^L \widehat{\Delta r}_t^{US} + A_h^L\left(L\right)\Delta y_{it-1} + B_h^L\left(L\right) z_{t-1}\right] + \\ & + C_h\left(L\right) X_{t-1} + \gamma_{ih} + u_{it+h}, \end{aligned} \tag{4}$$

where we condition only the level of reserves (high H vs low L). We also test whether the same line of reasoning holds for capital controls. We build a dummy variable I_{it}^{CC}, which is 1 if country i has capital controls higher than the 75 percentile in period t, and 0 otherwise.[14] In a sample of only peggers, we estimate the equivalent of equation 4, conditional on I_{it-1}^{CC}.

4 Empirical Results

We report the empirical impulse response functions to a US monetary shock that increases the 1-year US government bond yield by 100 basis points, on impact.

In the linear model, the impact of US monetary policy shocks is evaluated on the "average" EME (Figure 2). A US monetary policy shock induces an increase in inflation for the "average" EME after 6-8 quarters, and a nominal depreciation on impact. The central bank responds by immediately increasing the policy rate. The response of GDP is not statistically different from 0, probably because the expansionary effects of the nominal depreciation are offset by the domestic monetary tightening.

In the state-dependent model, we disentangle the response of endogenous variables across the three monetary policy frameworks. We show that the sign of the inflation response crucially depends on the monetary policy framework (Figure 3): CPI decreases in pegger countries, it increases in floaters NIT, it is not statistically different from zero

[14] We use the indicator *kai* provided by Fernandez et al. (2015). The indicator is a measure of controls on capital inflows.

in inflation targeters. These results show that not only the magnitude, but also the sign of the responses changes across monetary policy frameworks. We formally test the hypothesis that the difference between the responses to a US monetary policy shock is zero across states: we show that the null hypothesis of no difference in the CPI response between floaters NIT and peggers is rejected, at the 10% significance level, for the initial four quarters (Figure A.1). Regarding real economic activity, we observe a drop in real GDP some periods after the shock, although not statistically significant (Figure 4, left column).

Are these responses driven by the endogenous response of domestic monetary policy? We find that peggers raise the policy rate immediately, in order to defend the peg (Figure 4): the response of the exchange rate is not statistically different from 0, and this is consistent with our initial hypothesis. In floaters NIT, the response of the policy rate is more gradual and larger, but it is estimated less precisely. Consistently with the conventional wisdom, the domestic currency depreciates in floaters NIT. In inflation targeters, the response of the policy rate is positive and borderline significant only after several quarters, perhaps suggesting that in these countries inflation expectations are well anchored.

We investigate further why the policy rate increases by less in peggers compared to floaters NIT. One explanation could be that peggers rely also on instruments other than the policy rate to defend the peg, notably FX interventions and capital controls.

We estimate equation (4): inflation significantly falls and the policy rate is significantly higher only in peggers with a low level of FX reserves (Figure 5). Crucially, the response of the policy rate is much larger compared to the baseline estimate. If countries with a relatively low stock of reserves are less likely to intervene in order to defend the peg, or simply they are less credible, this evidence supports the narrative that inflation declines in peggers via the domestic monetary tightening.

We also estimate equation (4) by using the capital control dummy: inflation significantly falls and the policy rate is significantly higher only in peggers with low level of capital controls. Again, the policy rate increase is much larger than the baseline estimation (Figure 6). If countries with higher capital controls are more likely to remove them in order to defend the peg when a shock hits, this evidence supports the narrative that inflation declines in peggers via the domestic monetary tightening. Another complementary interpretation is that countries with higher capital controls are more closed to capital inflows and thus are less sensitive to foreign shocks.

Impulse response in the linear model

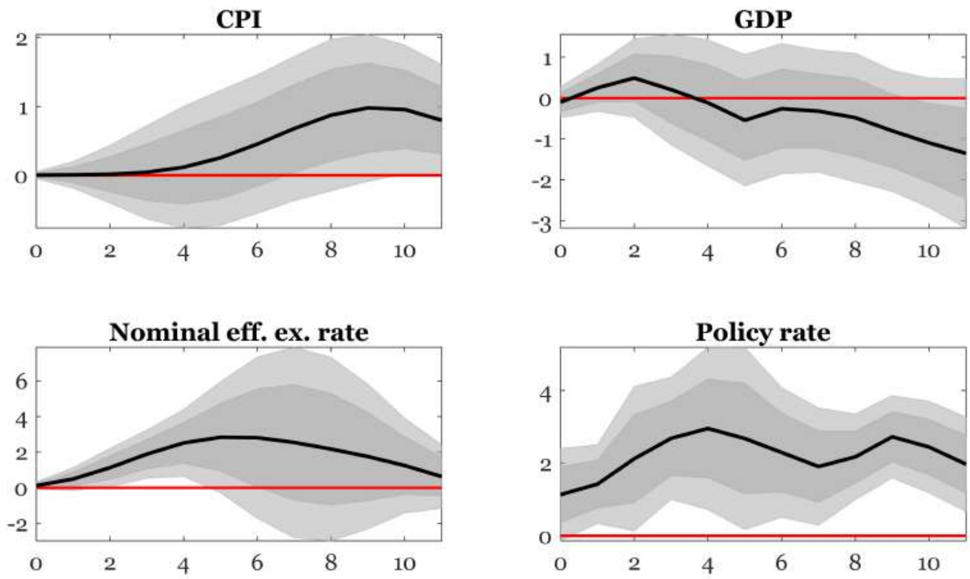

Figure 2: Impulse response functions to a US monetary policy shock that determines a 1% increase in the 1-year US government bond yield, on impact (linear model). Solid dashed lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 90% confidence intervals. Unit of measure: percentage points.

Impulse response in the state-dependent model (1)

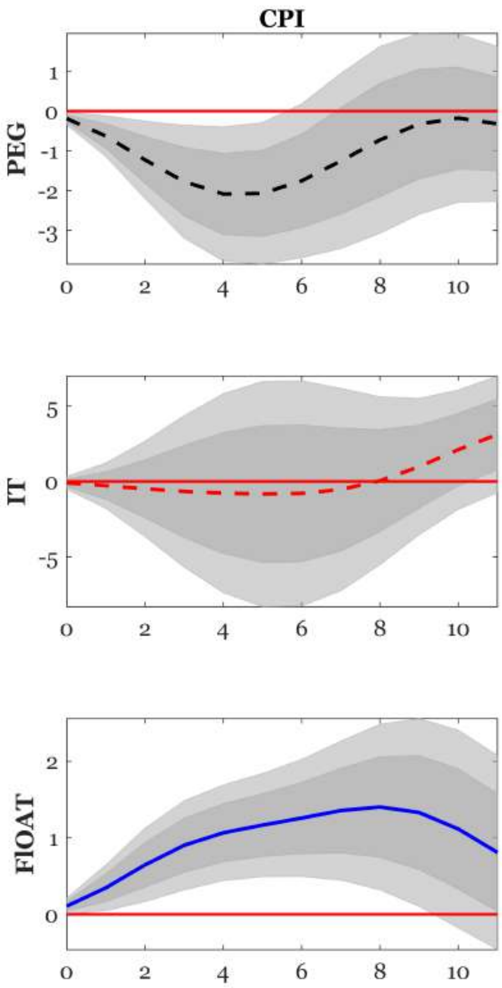

Figure 3: Impulse response functions to a US monetary policy shock that determines a 1% increase in the 1-year US government bond yield, on impact (state-dependent model). Solid and dashed lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 90% confidence intervals. Unit of measure: percentage points.

Impulse response in the state-dependent model (2)

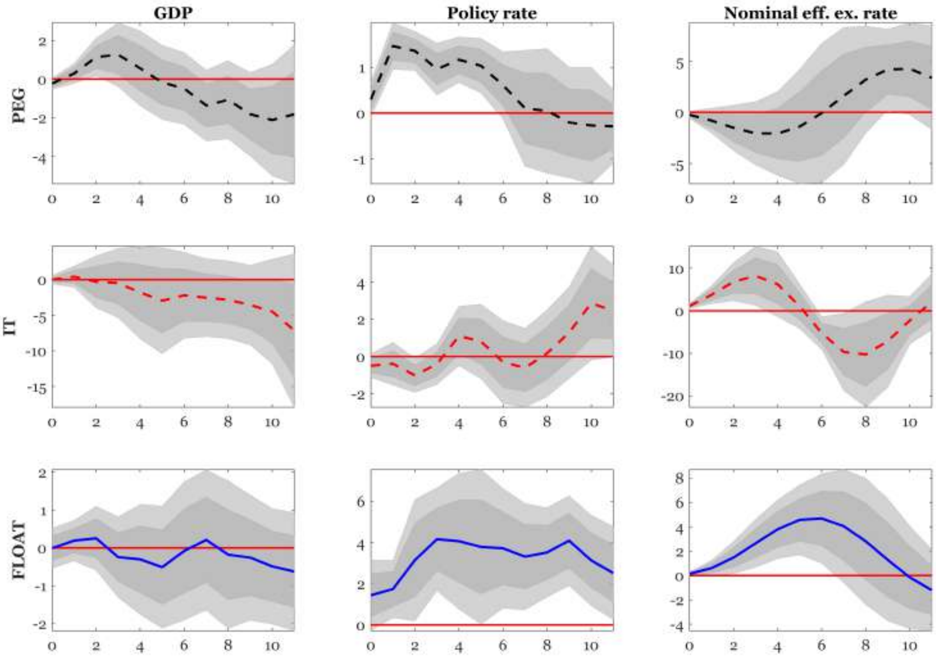

Figure 4: Impulse response functions to a US monetary policy shock that determines a 1% increase in the 1-year US government bond yield, on impact (state-dependent model). Solid and dashed lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 90% confidence intervals. Unit of measure: percentage points. An increase in the NEER refers to a nominal depreciation. Unit of measure: percentage points.

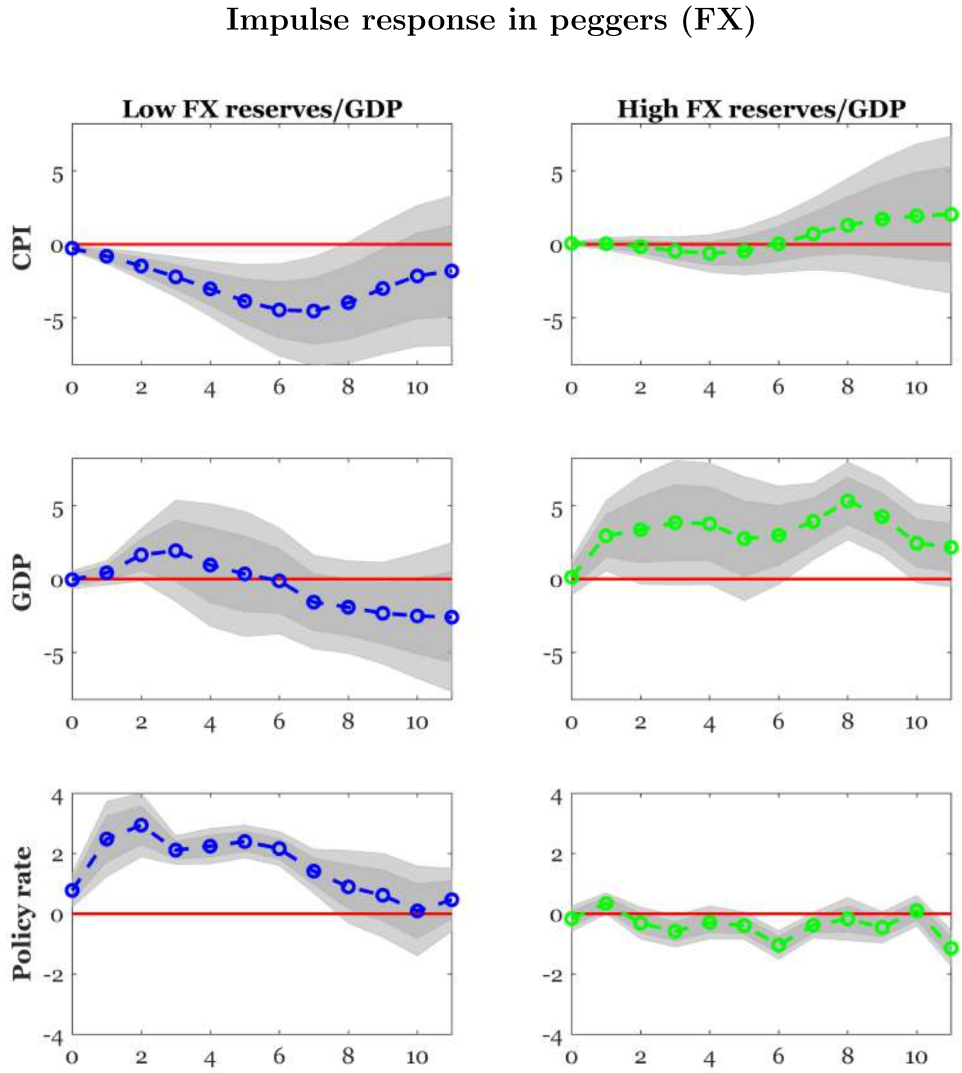

Figure 5: Impulse response functions to a US monetary policy shock that determines a 1% increase in the 1-year US government bond yield, on impact. US monetary policy shocks are identified with the instruments developed by Miranda-Agrippino and Ricco (2021). Circled line: point estimate; dark gray shaded area: 68% confidence intervals; light gray shaded area: 90% confidence intervals. The left panel displays the responses for “low” (L) FX reserve-GDP ratio, and the right panel the responses for “high” (H) FX reserve-GDP ratio. Unit of measure: percentage points.

Impulse response in peggers (capital controls)

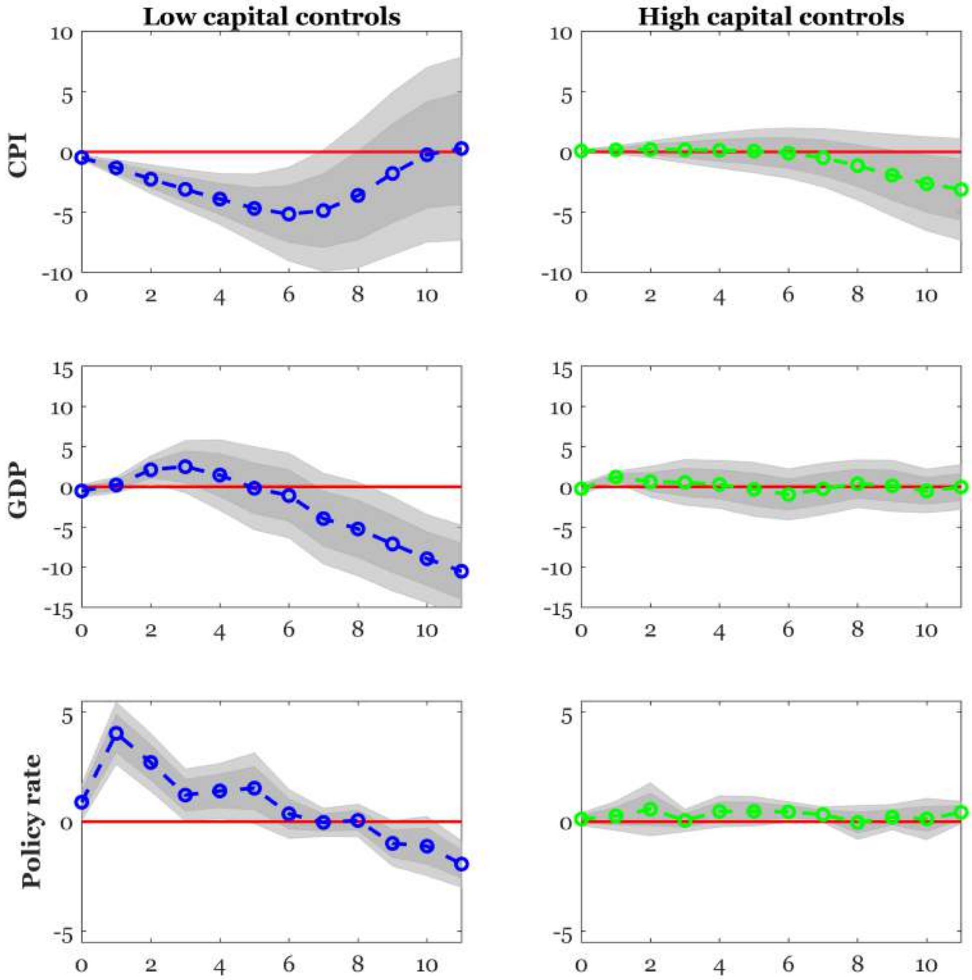

Figure 6: Impulse response functions to a US monetary policy shock that determines a 1% increase in the 1-year US government bond yield, on impact. US monetary policy shocks are identified with the instruments developed by Miranda-Agrippino and Ricco (2021). Circled line: point estimate; dark gray shaded area: 68% confidence intervals; light gray shaded area: 90% confidence intervals. The left panel displays the responses for "low" (L) capital controls, and the right panel the responses for "high" (H) capital controls. Unit of measure: percentage points.

5 A DSGE Model for a Small Open Economy

We rationalize our empirical results using a DSGE model for a small open economy, along the lines of Gali and Monacelli (2005) (Figure 7). Specifically, for each monetary regime we calibrate the parameters of the Taylor rule to match the empirical impulse response functions: we get three models that differ only for the monetary rule. With these models in hand, we compare the positive and normative implications of each model with the optimal monetary policy designed by a Ramsey social planner.

In our model, households maximize utility by choosing consumption of final domestic and foreign goods, labor in domestic intermediate firms, investment in capital, investment in domestic and in foreign bonds (international financial markets are incomplete). The representative final-good firm produces the final good using intermediate differentiated goods produced by domestic intermediate firms. Domestic intermediate firms operate in monopolistic competition and produce differentiated goods. We adopt the dominant currency paradigm, to capture the empirical fact that import and export prices are denominated in US dollar, as documented by Burstein and Gopinath (2014): in the model, we assume that export and import prices are sticky in foreign currency, as in Gopinath et al. (2020);[15] in domestic markets, prices of domestic goods are sticky in domestic currency. The central bank sets the nominal interest rate using a Taylor rule. We describe the details of the models in what follows, leaving the full list of equations in Appendix B. The steady state of the model is computed in Appendix C. Parameters are defined and calibrated in Table 2.

The structure of the model

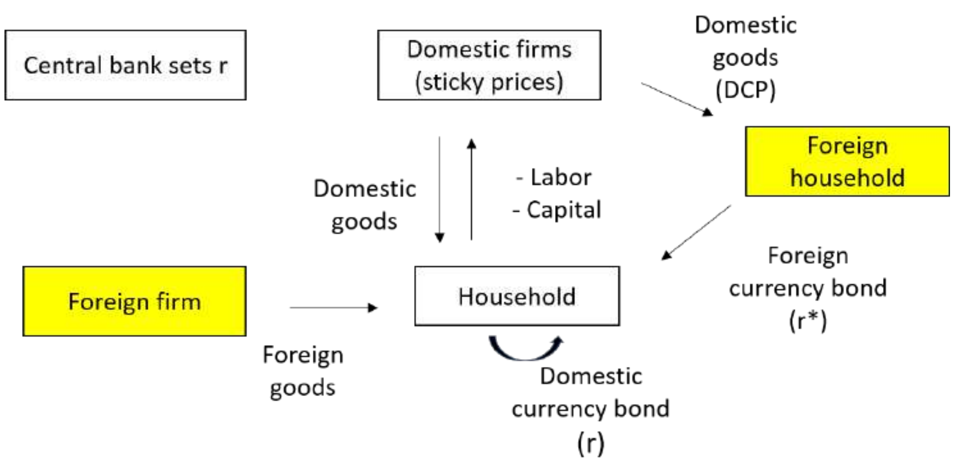

Figure 7: A model for a small-open economy.

[15]We actually assume that import prices are constant in foreign currency, given that they depend on exogenous developments in the rest of the world, which are assumed to be constant.

5.1 Households

5.1.1 Intratemporal problem

The consumption bundle is defined as follows:

$$c_t = \left[(1-\gamma)^{\frac{1}{\eta}} c_{Ht}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} c_{Ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{5}$$

where c_{Ht} and c_{Ft} denote consumption of domestic and foreign final good respectively. The investment bundle is defined analogously. The representative household decides how to allocate her consumption expenditure between domestic and foreign goods. The resulting demand functions read:[16]

$$c_{Ht} = (1-\gamma) \left(\frac{P_{Ht}}{P_t} \right)^{-\eta} c_t \tag{6}$$

$$c_{Ft} = \gamma \left(\frac{P_{Ft}}{P_t} \right)^{-\eta} c_t, \tag{7}$$

where P_{Ht} (P_{Ft}) is the price of the domestic (foreign) good expressed in domestic currency, and P_t is the domestic CPI:

$$P_t = \left[(1-\gamma) P_{Ht}^{1-\eta} + \gamma P_{Ft}^{1-\eta} \right]^{\frac{1}{1-\eta}}. \tag{8}$$

Given that the domestic economy is sufficiently small with respect to the foreign economy, the price of the foreign good coincides with the foreign CPI, adjusted by the exchange rate:

$$P_{Ft} = e_t P_t^*,$$

where P_t^* is the foreign CPI (in foreign currency) and e_t is the nominal exchange rate (the price of one unit of foreign currency in terms of domestic currency). From now on, we assume that $P_t^* = 1 \ \forall t$ for simplicity. Define $p_{Ht} \equiv \frac{P_{Ht}}{P_t}$ and $p_{Ft} \equiv \frac{P_{Ft}}{P_t}$ as the price of domestic and foreign goods in terms of the domestic CPI. Notice that p_{Ft} can be interpreted as the real exchange rate s_t:

$$p_{Ft} = s_t = e_t \frac{P_t^*}{P_t}. \tag{9}$$

[16] Analogous equations hold for the investment good.

5.1.2 Intertemporal problem

The representative household maximizes the utility function[17] subject to the budget constraint and the law of motion of capital:

$$\max_{\left\{c_t, i_t, h_t, k_t, B_t, B_t^f\right\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma}\left(c_t - \frac{h_t^{1+\varphi}}{1+\varphi}\right)^{1-\sigma}$$

$$s.t. \begin{cases} c_t + i_t + \frac{B_t}{P_t} + \frac{s_t B_t^f}{P_t^*} = r_t^k k_{t-1} + \frac{r_{t-1} B_{t-1}}{P_t} + \frac{s_t r_{t-1}^* B_{t-1}^f}{P_t^*} + \\ \qquad + w_t h_t + \Gamma_t - \frac{\kappa_D}{2} s_t \left(\frac{B_t^f}{P_t^*} - \bar{b}\right)^2 \\ k_t = (1-\delta)\, k_{t-1} + \left[1 - \frac{\kappa_I}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] i_t, \end{cases}$$

where h_t denotes labor; i_t denotes investment in physical capital k_t; B_t denotes holding of a one-period domestic bond denominated in domestic currency, yielding a nominal rate r_t; B_t^f denotes holding of a one-period foreign bond denominated in foreign currency, paying a gross nominal interest rate of r_t^*; r_t^k is the rental rate of capital; w_t is the real wage; Γ_t denotes profits from firms. The foreign interest rate follows an autoregressive process of order n:

$$\rho^*(L)\left(r_t^* - \frac{1}{\beta}\right) = v_t, \tag{10}$$

where L is the lag operator, $\rho^*(L) = 1 - \sum_{i=1}^{n} \rho_i^* L^i$, and $v_t \sim N(0, \omega^2)$ is a foreign interest rate shock. Notice that domestic households pay a quadratic adjustment cost when their financial position with the rest of the world is different from the steady state: this assumption ensures the existence of a determinate steady state and a stationary solution (Schmitt-Grohé and Uribe, 2003). First order conditions give the following equations. First, the Euler equation for domestic bonds:

$$\lambda_t = \beta \mathbb{E}_t\left(\lambda_{t+1} \frac{r_t}{\pi_{t+1}}\right), \tag{11}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is the CPI inflation rate and λ_t is the marginal utility of consumption:

$$\lambda_t = \left(c_t - \frac{h_t^{1+\varphi}}{1+\varphi}\right)^{-\sigma}. \tag{12}$$

[17] We assume the utility function proposed by Greenwood et al. (1988). This utility function better captures business cycle fluctuations in a small open economy.

Second, the Euler equation for foreign bonds:

$$\lambda_t \left[1 + \kappa_D \left(b_t^f - \bar{b}\right)\right] = \beta \mathbb{E}_t \left(\lambda_{t+1} r_t^* \frac{s_{t+1}}{s_t}\right), \tag{13}$$

where $b_t^f \equiv s_t \frac{B_t^f}{P_t^*}$ denotes foreign bond holdings in domestic CPI terms, and we have used the assumption that foreign inflation is 0. Third, the Euler equation for capital investment:

$$1 = \beta \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{\left[r_{t+1}^k + (1-\delta)\, q_{t+1}\right]}{q_t} \right\}, \tag{14}$$

where q_t is the investment price (Tobin-Q). Fourth, the labor supply:

$$h_t^{\varphi} = w_t. \tag{15}$$

And, finally, the Evolution of Tobin-Q:

$$1 = q_t \left[1 - \frac{\kappa_I}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 - \kappa_I \left(\frac{i_t}{i_{t-1}}\right)\left(\frac{i_t}{i_{t-1}} - 1\right)\right] + \kappa_I \beta \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} \left[\left(\frac{i_{t+1}}{i_t}\right)^2 \left(\frac{i_{t+1}}{i_t} - 1\right)\right]\right\}. \tag{16}$$

Combining and linearizing the Euler equations for domestic and foreign bonds, one can get the uncovered interest parity (UIP) condition of the model:

$$\tilde{r}_t = \tilde{r}_t^* + \mathbb{E}_t \left(\Delta \tilde{e}_{t+1}\right) + \psi \tilde{d}_t, \tag{17}$$

where $\Delta e_t \equiv \frac{e_t}{e_{t-1}}$, $d_t \equiv -b_t^f$ is external debt, $\psi \equiv \kappa_D \overline{d}$, and tilde variables denote percentage deviations from the steady state.

5.2 Final-Good firms

5.2.1 Domestic market

The representative final-good firm in the domestic market uses the following CES aggregator to produce the domestic final good y_{Ht}:

$$y_{Ht} = \left[\int_0^1 y_{Ht}(i)^{\frac{\varepsilon_H - 1}{\varepsilon_H}} di\right]^{\frac{\varepsilon_H}{\varepsilon_H - 1}}, \tag{18}$$

where $y_{Ht}\left(i\right)$ is an intermediate input produced by the intermediate firm i, whose price is $P_{Ht}\left(i\right)$. The demand function reads:

$$y_{Ht}(i) = y_{Ht}\left(\frac{P_{Ht}(i)}{P_{Ht}}\right)^{-\varepsilon_H}, \tag{19}$$

where the price index P_{Ht} is given by:

$$P_{Ht} = \left[\int_0^1 P_{Ht}\left(i\right)^{1-\varepsilon_H} di\right]^{\frac{1}{1-\varepsilon_H}}. \tag{20}$$

5.2.2 Foreign markets

There is a representative domestic final-good firm that sells the exported good to foreign households. The exported good y_{Xt} is defined as follows:

$$y_{Xt} = \left[\int_0^1 y_{Xt}(i)^{\frac{\varepsilon_X-1}{\varepsilon_X}} di\right]^{\frac{\varepsilon_X}{\varepsilon_X-1}},$$

where $y_{Xt}(i)$ is an intermediate input produced by the intermediate firm i. The demand of the exporter reads:

$$y_{Xt}\left(i\right) = y_{Xt}\left(\frac{P_{Xt}\left(i\right)}{P_{Xt}}\right)^{-\varepsilon_X}, \tag{21}$$

where $P_{Xt}\left(i\right)$ is the price of good i denominated in foreign currency and the price index P_{Xt} reads:

$$P_{Xt} = \left[\int_0^1 P_{Xt}\left(i\right)^{1-\varepsilon_X} di\right]^{\frac{1}{1-\varepsilon_X}}. \tag{22}$$

5.3 Intermediate-Good firms

There is a continuum of firms indexed by i producing a differentiated domestic input using the following Cobb-Douglas function:

$$y_t\left(i\right) = \left(k_{t-1}\left(i\right)\right)^{\alpha}\left(h_t\left(i\right)\right)^{1-\alpha}. \tag{23}$$

Firms operate in monopolistic competition, so they set the price of their own good subject to the demand of final good firms. According to dominant-currency pricing, in the domestic market prices are set in domestic currency, in foreign markets, prices are set in foreign currency. Firms pay quadratic adjustment costs $AC_{Ht}\left(i\right)$ and $AC_{Xt}\left(i\right)$ in nominal terms whenever they adjust prices with respect to the benchmark (the CPI inflation target $\overline{\pi}$ for domestic-market prices, 1 for export prices):

$$AC_{Ht}(i) = \tfrac{\kappa_{PH}}{2}\left(\tfrac{P_{Ht}(i)}{P_{Ht-1}(i)} - \overline{\pi}\right)^2 P_{Ht}y_{Ht}. \tag{24}$$

$$AC_{Xt}(i) = \tfrac{\kappa_{PX}}{2}\left(\tfrac{P_{Xt}(i)}{P_{Xt-1}(i)} - 1\right)^2 P_{Xt}y_{Xt}. \tag{25}$$

The profit maximization problem of the generic firm i, expressed in terms of the domestic CPI, is the following:

$$\max \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[\frac{P_{Ht}(i)}{P_t} y_{Ht}(i) + e_t \frac{P_{Xt}(i)}{P_t} y_{Xt}(i) - w_t h_t(i) - r_t^k k_{t-1}(i) - \frac{AC_t(i)}{P_t} - \frac{e_t AC_{Xt}(i)}{P_t} \right] \right\}$$

subject to:

$$\begin{aligned} y_{Ht}(i) &= y_{Ht}\left(\frac{P_{Ht}(i)}{P_{Ht}}\right)^{-\varepsilon_H} \\ y_{Xt}(i) &= y_{Xt}\left(\frac{P_{Xt}(i)}{P_{Xt}}\right)^{-\varepsilon_X} \\ y_{Ht}(i) + y_{Xt}(i) &= (k_{t-1}(i))^{\alpha} (h_t(i))^{1-\alpha}. \end{aligned}$$

The maximization is taken over $\{P_{Ht}(i), h_t(i), k_{t-1}(i), y_{Ht}(i), y_{Xt}(i), P_{Xt}(i)\}_{t=0}^{\infty}$. The solution of the problem gives the optimal input demand (equal for each firm i):

$$r_t^k = \alpha mc_t \frac{y_t}{k_{t-1}} \tag{26}$$

$$w_t = (1-\alpha) mc_t \frac{y_t}{h_t}, \tag{27}$$

where mc_t denotes real marginal cost. The Phillips Curve for domestic prices reads:

$$\pi_{Ht}(\pi_{Ht} - \overline{\pi}) = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t} \pi_{Ht+1}(\pi_{Ht+1} - \overline{\pi}) \frac{p_{Ht+1}y_{Ht+1}}{p_{Ht}y_{Ht}} \right] + \frac{\varepsilon_H}{\kappa_{PH}} \left(\frac{mc_t}{p_{Ht}} - \frac{\varepsilon_H - 1}{\varepsilon_H} \right), \tag{28}$$

where π_{Ht} is PPI inflation in domestic markets:

$$\pi_{Ht} = \frac{P_{Ht}}{P_{Ht-1}}, \tag{29}$$

which can be written also as follows, using only stationary variables:

$$\pi_{Ht} = \frac{p_{Ht}}{p_{Ht-1}} \pi_t. \tag{30}$$

Similarly, the Phillips Curve for foreign markets reads:

$$\pi_{Xt}\left(\pi_{Xt}-1\right)=\beta\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\pi_{Xt+1}\left(\pi_{Xt+1}-1\right)\frac{p_{Xt+1}y_{Xt+1}}{p_{Xt}y_{Xt}}\right]+\frac{\varepsilon_X}{\kappa_{PX}}\left(\frac{mc_t}{p_{Xt}}+\frac{\varepsilon_X-1}{\varepsilon_X}\right),\quad(31)$$

where $p_{Xt}\equiv\frac{e_tP_{Xt}}{P_t}$ and π_{Xt} is PPI inflation in foreign markets (EPI from now on, i.e. export price index):

$$\pi_{Xt}=\frac{P_{Xt}}{P_{Xt-1}},\quad(32)$$

which can be written also as follows, using only stationary variables:

$$\pi_{Xt}=\frac{p_{Xt}}{p_{Xt-1}}\frac{s_{t-1}}{s_t}.\quad(33)$$

By the previous equation, in steady state $\pi_X=1$: this is why the adjustment cost in foreign markets is computed around 1 as opposed to $\overline{\pi}$, in equation (25).

Notice that in this model by equations (28) and (31), p_{Ht} is not necessarily equal to p_{Xt}: the assumption of dominant currency pricing breaks the law of one price.

5.4 Policy

The monetary authority sets the nominal interest rate according to the following Taylor rule:

$$\frac{r_t}{r}=\left(\frac{r_{t-1}}{r}\right)^{\rho}\left[\left(\frac{\pi_t}{\overline{\pi}}\right)^{\phi_\pi}\left(\frac{gdp_t}{gdp}\right)^{\phi_y}\left(\frac{\Delta e_t}{\Delta e}\right)^{\phi_e}\right]^{1-\rho},\quad(34)$$

where $gdp_t\equiv p_{Ht}y_{Ht}+p_{Xt}y_{Xt}$ is gross domestic product and variables without a time index are in steady state.

5.5 Market clearing

The market clearing condition for the domestic good sold in domestic markets is the following:

$$y_{Ht}=c_{Ht}+i_{Ht}+\frac{\kappa_{PH}}{2}\left(\pi_{Ht}-\overline{\pi}\right)^2y_{Ht}.\quad(35)$$

The market clearing condition for the exported good reads:

$$y_{Xt}=f_t^*+\frac{\kappa_{PX}}{2}\left(\pi_{Xt}-1\right)^2y_{Xt},\quad(36)$$

where f_t^* denotes the foreign demand for the domestic good. Given that the domestic demand (the volume of imports) for the foreign good is given by:

$$m_t \equiv (c_{Ft} + i_{Ft}) = \gamma \left(\frac{P_{Ft}}{P_t}\right)^{-\eta} (c_t + i_t),$$

we postulate a symmetric expression for foreign demand (the volume of exports) of the domestic good:

$$f_t^* = \gamma^* \left(\frac{P_{Xt}}{P_t^*}\right)^{-\eta} (c_t^* + i_t^*),$$

which can be rewritten as follows:

$$f_t^* = \gamma^* \left(\frac{p_{Xt}}{s_t}\right)^{-\eta} y_t^*, \tag{37}$$

where y_t^* is a measure of foreign demand, which is assumed to be constant and equal to 1. Let $b_t \equiv \frac{B_t}{P_t}$ be the amount of domestic bonds in terms of domestic CPI; the domestic bond is in zero net supply:

$$b_t = 0. \tag{38}$$

Rearranging the budget constraint one can get the resource constraint of the economy:

$$\begin{aligned} gdp_t &= c_t + i_t + s_t r_{t-1}^* d_{t-1} - s_t d_t + \\ &+ \frac{\kappa_D}{2} s_t \left(d_t - \overline{d}\right)^2 + \frac{\kappa_{PH}}{2} \left(\pi_{Ht} - \overline{\pi}\right)^2 p_{Ht} y_{Ht} + \frac{\kappa_{PX}}{2} \left(\pi_{Xt} - 1\right)^2 p_{Xt} y_{Xt}. \end{aligned} \tag{39}$$

5.6 Calibration

We calibrate the parameters using typical values in the open economy DSGE literature, at the quarterly frequency. The discount factor is set to 0.99. Parameters in the utility function are set to 2 for σ and 1 for ϕ. The weight of foreign good in the domestic consumption bundle γ is calibrated to 0.3, and an equal value is chosen for its foreign counterpart γ^*. The elasticity of substitution between domestic and foreign good η is set to 1.5, within the range of typical values found in the literature. Following Gali (2015), we set the elasticity of substitution between differentiated goods ($\varepsilon_H, \varepsilon_X$) to 6. The share of capital in production α is calibrated to 0.3. The depreciation rate δ is set to 2.5%. We calibrate the steady-state debt $\overline{d}$ to 0.998, in order to have an annual external debt/GDP ratio of 15%, the 2019 mean private debt/GDP ratio in our sample. We assume a steady state with zero net inflation (so $\overline{\pi} = 1$).

The remaining parameters only affect the dynamics of the model, not the steady state. Price adjustment costs κ_{PH} and κ_{PX} are calibrated to 28, in order to get a price duration in the Calvo pricing framework of three quarters. The debt adjustment cost κ_D captures the elasticity of the risk premium to debt fluctuations: we calibrate this parameter to a small value (0.005), so that it does not affect much the dynamics of the model (see the discussion in Schmitt-Grohé and Uribe, 2003). The investment adjustment cost is set to 2.48, following Christiano et al. (2005). We set the order of the autoregressive process for the foreign interest rate to $n = 3$; we calibrate the three autoregressive parameters in equation (10) in order to match the first three periods (after period 0) of the empirical impulse response of the foreign interest rate:[18] we get $\rho_1^* = 0.85$, $\rho_2^* = 0.28$, and $\rho_3^* = -0.31$. The four parameters of the Taylor rule are estimated in the next Section. Table 2 summarizes the calibration.

Calibration

Parameters	**Description**	**Value**
β	Discount factor	0.99
σ	Inverse of elasticity of intertemporal substitution	2
φ	Inverse of Frisch elasticity	1
γ	Weight of foreign good	0.3
γ^*	Foreign demand shifter	0.3
η	Elas. of subst. between domestic and foreign good	1.5
$\varepsilon_H, \varepsilon_X$	Elas. of subst. between differentiated goods	6
α	Share of capital in production	0.33
δ	Depreciation rate	2.5%
$\overline{d}$	Steady-state external debt	0.998
$\overline{\pi}$	Gross inflation target	1
κ_{PH}, κ_{PX}	Price adjustment cost	28
κ_D	Debt adjustment costs	0.005
κ_I	Investment adjustment cost	2.48
$\rho_1^*, \rho_2^*, \rho_3^*$	AR Parameters	$0.85, 0.28, -0.31$

Table 2: Calibrated parameters.

6 DSGE Impulse Responses

In this Section, we first show the impulse response functions to a foreign monetary tightening under three suggestive Taylor rules, which broadly capture the three monetary regimes considered in the empirical model. Second, we calibrate the parameters of the Taylor rules by matching empirical and DSGE impulse response functions for each regime.

[18] We consider the US one-year government bond yield as foreign interest rate shock, as highlighted in the empirical analysis.

Third, we compare the "matched" impulse responses with the optimal policy chosen by the Ramsey social planner, and we provide a welfare metric.

6.1 Illustrative example

We compare the impulse response of a 100 basis points foreign monetary shock under three different monetary policy regimes (Table 3), in order to understand the transmission mechanism of a foreign interest rate shock. In the PEG regime, the central bank maintains a constant nominal exchange rate: we assign a high value to the Taylor parameter on the nominal depreciation and we set $\phi_y = \phi_\pi = \rho = 0$: this is almost equivalent to a rule implying a constant exchange rate $\Delta e_t = \Delta e = 1$, where the second equality is implied by assuming a steady-state domestic inflation equal to the steady-state foreign inflation (see equation 9). In the IT regime, the central bank keeps inflation constant: we assign a high value to the Taylor parameter on inflation, and we set $\phi_y = \phi_\varepsilon = \rho = 0$: this is almost equivalent to a strict inflation targeting rule $\pi_t = \bar{\pi}$. In the FLOAT regime, we calibrate $\phi_\pi = 1.5$, $\phi_y = 0.25$, and $\rho = 0.8$ with no weight on the exchange rate, a standard calibration in DSGE model.[19]

In the PEG regime, the central bank raises the policy rate to avoid a nominal depreciation (Figure 8, black dotted line); the domestic tightening is almost 1:1 with the foreign tightening, given the UIP condition (equation 17). The increase in the domestic rate brings down inflation, through the standard intertemporal substitution channel: consumption and investment fall, GDP decreases. The inflation reduction leads to a mild real depreciation. Producers reduce the price of domestic goods in domestic and in foreign markets by an equal amount, to face the reduction in marginal costs: dominant currency pricing under a constant exchange rate is not relevant, as far as other conditions in domestic and foreign markets are the same. The higher cost of borrowing abroad reduces the stock of foreign debt, opening a trade surplus.

In the FLOAT regime, the foreign monetary tightening leads to both a nominal and a real depreciation. (Figure 8, blue line): imports are more expensive and CPI increases. Given that domestic and foreign goods are not perfect complements, households increase the demand for domestic goods, leading to a rise in domestic producer price index (PPI): this channel raises CPI. The central bank responds by raising the policy rate, though the monetary tightening is smaller compared to that observed under the PEG regime: consumption and investment fall. The trade surplus more than offsets the reduction in consumption, bringing about a mild increase in GDP. Export prices are lower, given the nominal depreciation: absent dominant currency pricing, the fall in export prices would

[19]In both IT and FLOAT the exchange rate regimes is floating and monetary policy targets inflation: the two regimes differ in the aggressiveness against inflation fluctuations.

have been stronger.

Compared to the FLOAT regime, in the IT regime the central bank raises the interest rate by more in order to completely dampen the inflation rise: the domestic monetary tightening also mitigates the nominal and the real depreciation, and it amplifies the fall in consumption and investment. In general, the responses under the IT regimes lie between the response under PEG and FLOAT.

The DSGE analysis provides theoretical content to the empirical results: inflation falls under the exchange rate peg given the domestic monetary tightening, which is necessary to maintain a constant exchange rate. Inflation increases in a floating exchange rate regime, given the nominal depreciation, which increases the price of import goods and, via substitution effects, of domestic goods. If the floater country is also a strict inflation targeter, the increase in inflation is milder by the mechanism of inflation targeting. Notice that under all the monetary policy frameworks considered, the policy rate rises: in a peg, the domestic tightening is needed to limit the nominal depreciation; in a floater (with and without IT), the domestic tightening is more temporary and it is needed to limit the rise in inflation.

Calibrated Taylor rules

Parameter	ϕ_π	ϕ_y	ϕ_e	ρ
PEG	0	0	100	0
IT	100	0	0	0
FLOAT	1.5	0.25	0	0.8

Table 3: Calibrated parameters.

Foreign interest rate shock: comparing policy regimes

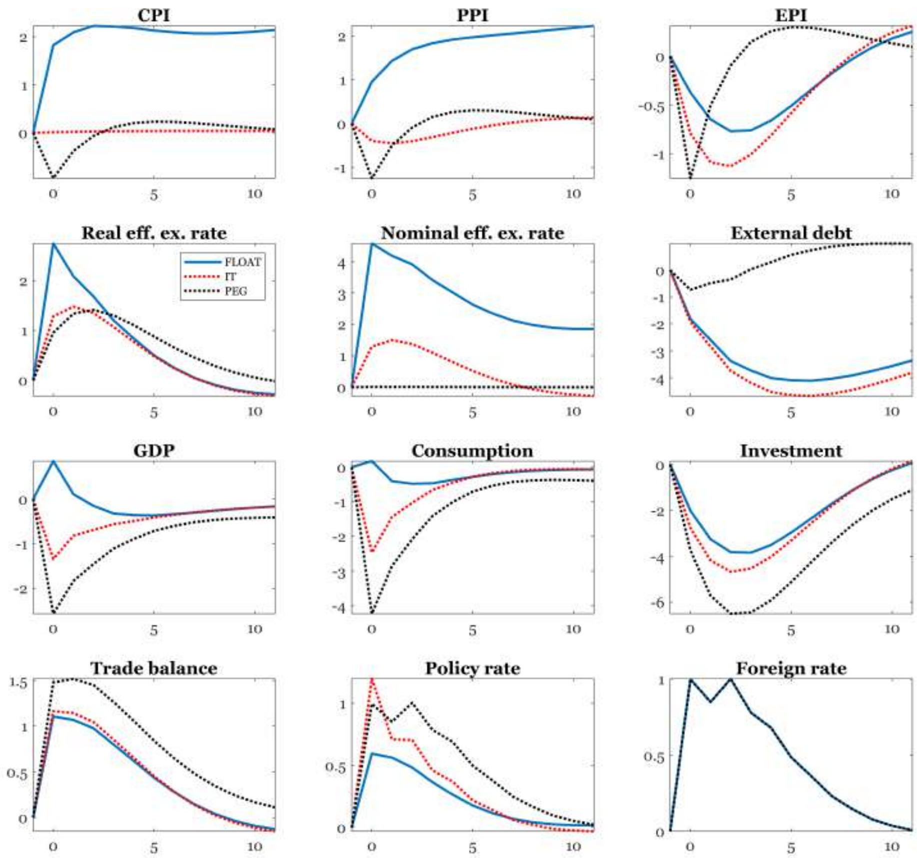

Figure 8: IRFs to 100 basis point foreign interest rate shock in each regime, using the parameters for the Taylor rule in Table 3. The shock hits in period 0, in period -1 the economy is in the steady state. Responses are in log-deviation from the steady state, except interest rates (in level deviations) and the trade balance (in percentage of steady state GDP). The CPI, PPI, EPI, and NEER response are the cumulated response of π_t, Δe_t π_{Ht}, π_{Xt} respectively, in log-deviations from the steady state. REER and NEER increases are domestic depreciations. Blue solid line: floating regime. Black dotted line: peg regime. Red dotted line: inflation targeting.

6.2 Impulse response matching

In this section we set the parameters of the Taylor rule in order to match the impulse response of key endogenous variables. For each regime, we define the following vector of parameters:

$$\zeta^r = \left\{ \phi_\pi^r, \phi_y^r, \phi_e^r, \rho^r \right\}. \tag{40}$$

We set ζ^r to match the first 12 periods of the empirical and theoretical impulse response of CPI, GDP, and effective nominal exchange rate: these are the variables that we include in the Taylor rule. As in Christiano et al. (2005), the estimator of ζ_r is the solution to the following minimization problem:

$$\min_{\zeta_r} \left[\hat{\Psi}_r - \Psi(\zeta_r)\right]' \boldsymbol{V_r} \left[\hat{\Psi}_r - \Psi(\zeta_r)\right],$$

where $\hat{\Psi}_r$ is a vector with the empirical IRF in regime r, $\Psi(\zeta_r)$ is a vector with the theoretical IRF, $\boldsymbol{V_r}$ is a diagonal matrix with the inverse of sample variances of $\hat{\Psi}_r$.

We numerically solve this problem for each regime. We set a grid $[0, 100]$ for the first three parameters in ζ_r; the grid for ρ^r is $[0, 0.9]$, to ensure stationarity and avoid a large inertia of the interest rate.

We simulate a 100 basis point increase in the foreign interest rate and we compare the DSGE (blue solid line, Figure 9) and the empirical response (black solid line, Figure 9), for each regime. The DSGE response of CPI and the nominal exchange rate are given by the cumulative response of π_t and Δe_t respectively, in log-deviations from the steady state.

Our estimation assigns a *de-facto* peg ($\phi_e = 100$) in the DSGE model, to match the DSGE response with the empirical responses under a PEG regime (Table 4, first row). To maintain the peg in response to the foreign monetary tightening, in the DSGE model the central bank tightens monetary policy, driving a fall in inflation, consistently to what we observe in the data (Figure 9, first row). The monetary tightening also reduces GDP on impact in the DSGE model, while in the empirical model GDP falls only after several periods.[20]

Our estimation assigns a strict inflation targeting in the DSGE model, to match the DSGE response with the empirical responses under an IT regime (Table 4, second row). The CPI increases on impact, but the effect is highly transitory, matching the empirical impulse response (Figure 9, second row). The fall in GDP is lower compared to the PEG regime. The exchange rate depreciates on impact, consistent to what we observe in the data, though the matching is not perfect.

Our estimation recognizes that in floating regimes (with no strict inflation targeting), the central bank does not respond to the exchange rate ($\phi_e = 0$) (Table 4, third row). We find that the central bank responds only to inflation, but less compared to the IT case. The CPI increases on impact in the DSGE, driven by the nominal depreciation: the match with the empirical response is fairly good (Figure 9, third row).

Overall, the matching exercise confirms the results shown in the illustrative example: consistently with empirical estimates, inflation falls in the peg regimes, and it increases

[20]To keep the setup simple, our DSGE model does not have some features typical in large-scale models, which may delay the response of economic variables, as we observe in the data (wage rigidity, inflation indexation, habits in consumption, etc.).

in flexible regimes. In inflation targeters, inflation only slightly increases.[21]

Estimated parameters

Parameter	ϕ_π	ϕ_y	ϕ_e	ρ
Grid	$[0, 100]$	$[0, 100]$	$[0, 100]$	$[0, 0.9]$
PEG	0	0	100	0
IT	58.58	0	0	0.9
FLOAT	3.49	0	0	0.08

Table 4: Parameters estimated by matching impulse responses.

Foreign interest rate shock: DSGE vs empirical model

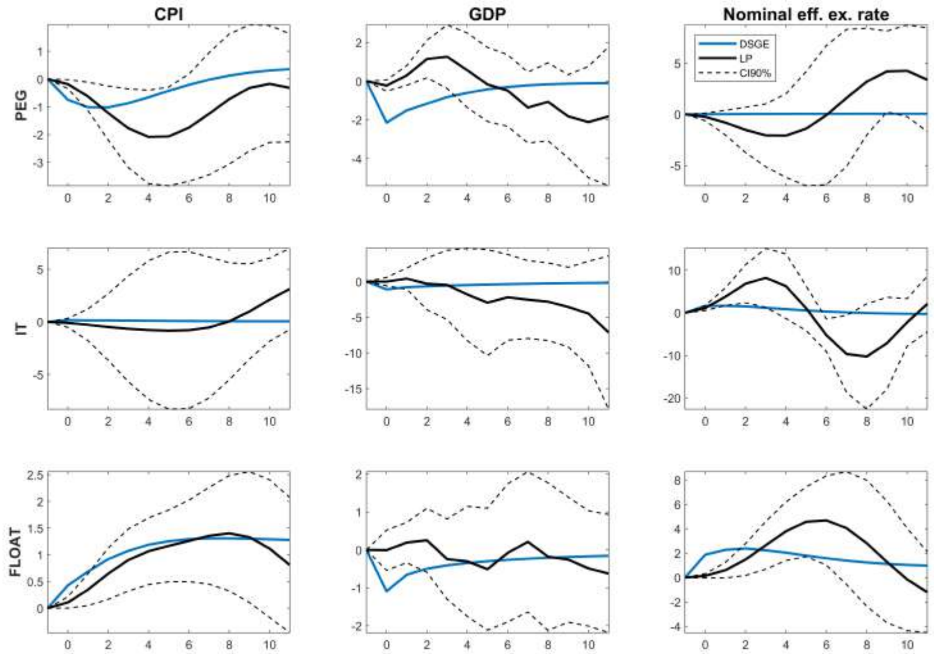

Figure 9: IRFs to 100 basis point US foreign interest rate shock in each regime, using the parameters in Table 4 for the three regimes. The shock hits in period 0, in period -1 the economy is in the steady state. The DSGE CPI and NEER responses are the cumulated response of π_t and $-\Delta e_t$ respectively, in log-deviations from the steady state. The DSGE GDP response is the response of gdp_t, in log-deviations from the steady state. A NEER increase is a domestic depreciation. Blue solid line: DSGE response. Black solid line: empirical response. Black dotted line: 90% confidence intervals.

[21] We show that the empirical response of GDP is not statistically different from zero (90% confidence intervals) across all monetary policy frameworks (Figure 9). The empirical evidence is consistent with the estimated DSGE model, featuring a GDP response that goes back towards its steady state after few periods. The conclusions of the normative analysis would not be invalidated by an improvement of the matching exercise for GDP: in our model, characterized by price adjustment frictions, output fluctuations are not *per se* inefficient.

6.3 Optimal monetary policy

The matching exercise paves the way for a normative analysis, carried out along relevant policy parameters. In this section, we show the impulse response functions resulting from the solution of the Ramsey problem and we compare them with the impulse response obtained by the matching methodology. We solve the problem of a social planner that chooses the domestic policy rate by maximizing the utility function of households, subject to all the equations of the competitive equilibrium. Compared to the previous exercises, the social planner's interest rule may respond to all the variables of the models, rather than inflation, output, and exchange rate only. The social planner can improve upon the competitive equilibrium because the model features several frictions and externalities.

First, as it is standard in the New Keynesian literature, domestic firms operate in monopolistic competition and are subject to nominal rigidities (price adjustment costs). Monopolistic competition creates a wedge between marginal costs and marginal products of inputs (labor and capital), making domestic production sub-optimal, other things equal. Second, price adjustment costs imply wasted resources and make the wedge between marginal costs and marginal products time varying. Third, consistently with a recent literature (Gopinath et al., 2020), we assume market segmentation between the domestic and foreign markets: the law of one price does not necessarily hold for export goods. Fourth, a terms of trade externality arises in our model, because the social planner may exploit the foreign downward-sloping demand for the domestic good by affecting the terms of trade: this externality is common in models featuring a domestic and a foreign good that are not perfect substitutes (including Gali and Monacelli, 2005 and Farhi and Werning, 2016, among others). Fifth, debt adjustment costs are wasted resources that the social planner may try to minimize: this friction is needed to ensure a stationary equilibrium, and we set the relevant parameter to a small value, in order to reduce its importance.

We compare the optimal response of the Ramsey social planner to a foreign monetary shock with the impulse responses obtained under the three Taylor rules estimated by the matching methodology (Figure 10). We plot all the nominal price indexes in growth rates (as opposed to what we have done in previous figures), to emphasize inefficient inflation fluctuations. Three results are worth to mention.

First, the optimal response of the Ramsey social planner suggests that it is efficient to minimize producer-price inflation in domestic markets (PPI), in order to save price adjustments costs (Figure 10, green circled line): this is a standard result in the New Keynesian open economy literature, since Gali and Monacelli (2005).

Second, the social planner allows for a reduction in EPI, yet smaller than the other three regimes, despite export prices are subject to inefficient adjustment costs too, other things equal. Formally, this social planner choice occurs because it is not possible to stabilize PPI and EPI inflation simultaneously using the policy rate only, when the economy is hit by foreign interest rate shocks. If this were possible, by the Phillips curves (equations 28 and 31) we would have, up to a linear approximation:

$$\tilde{p}_{Ht} = \tilde{p}_{Xt}, \tag{41}$$

which implies by the definition of PPI and EPI (equations 30 and 32):

$$\tilde{p}_{Ht} - \tilde{p}_{Ht-1} + \tilde{\pi}_t = 0 \tag{42}$$

and

$$\tilde{p}_{Ht} - \tilde{p}_{Ht-1} - (\tilde{s}_t - \tilde{s}_{t-1}) = 0. \tag{43}$$

Combining the previous equations, we get:

$$\tilde{\pi}_t = -\left(\tilde{s}_t - \tilde{s}_{t-1}\right), \tag{44}$$

which holds if and only if the nominal exchange rate is constant. However, this is not possible: under a peg the social planner is not able to stabilize both PPI and EPI (Figure 8, black dotted line). This is also in line with Egorov and Mukhin (2020), who argue that monetary policy cannot directly stimulate a country's exports under dollar pricing: what monetary policy can do is to stabilise domestic prices to guarantee that local demand for domestically produced goods is at the optimal level.

Third, impulse responses under a peg are quite different from the responses under optimal policy: this suggests that a peg is largely inefficient in our model. To rank policy regimes, we conclude the section with the following welfare analysis.

Following Faia and Monacelli (2007), we approximate the model up to a second order and we define the following measure, based on the previously specified period utility, of conditional welfare for each regime R:

$$W_t^R = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j U\left(c_{t+j}^R, h_{t+j}^R\right), \tag{45}$$

where in period t the economy is in steady state. In order to give an economic content to the welfare definition, we provide a measure of consumption equivalent (Ω^R) for each regime. We define the consumption equivalent as the fraction of steady-state consumption needed to equate welfare in a given regime, with welfare in a baseline regime B:

$$W_t^R = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j U\left(\left(1+\Omega^R\right) c_{t+j}^B, h_{t+j}^B\right). \tag{46}$$

The definition of consumption equivalent for a given regime implies that a positive value of Ω^R means that welfare is higher in regime R compared to the baseline policy. We set the baseline regime using the following calibration:

$$\phi_\pi = 1.5,\ \phi_y = 0.25,\ \phi_e = 0,\ \rho = 0.8,$$

which is the calibration used for the floating regime in the illustrative example in Section 6.1.[22] As standard in the literature, we assume that foreign monetary shocks feature a standard deviation of 25 basis points.

The IT regime is the one with the highest welfare gain: as shown by the impulse response functions, targeting CPI inflation also imply low PPI inflation fluctuations, which is a policy close to that of the Ramsey social planner. The PEG gives the lowest welfare gain, compared to the baseline policy (Table 5).

[22]The choice of the baseline regime does not affect the ranking between regimes, but only the size of the welfare gain.

Ramsey optimal policy vs estimated policies

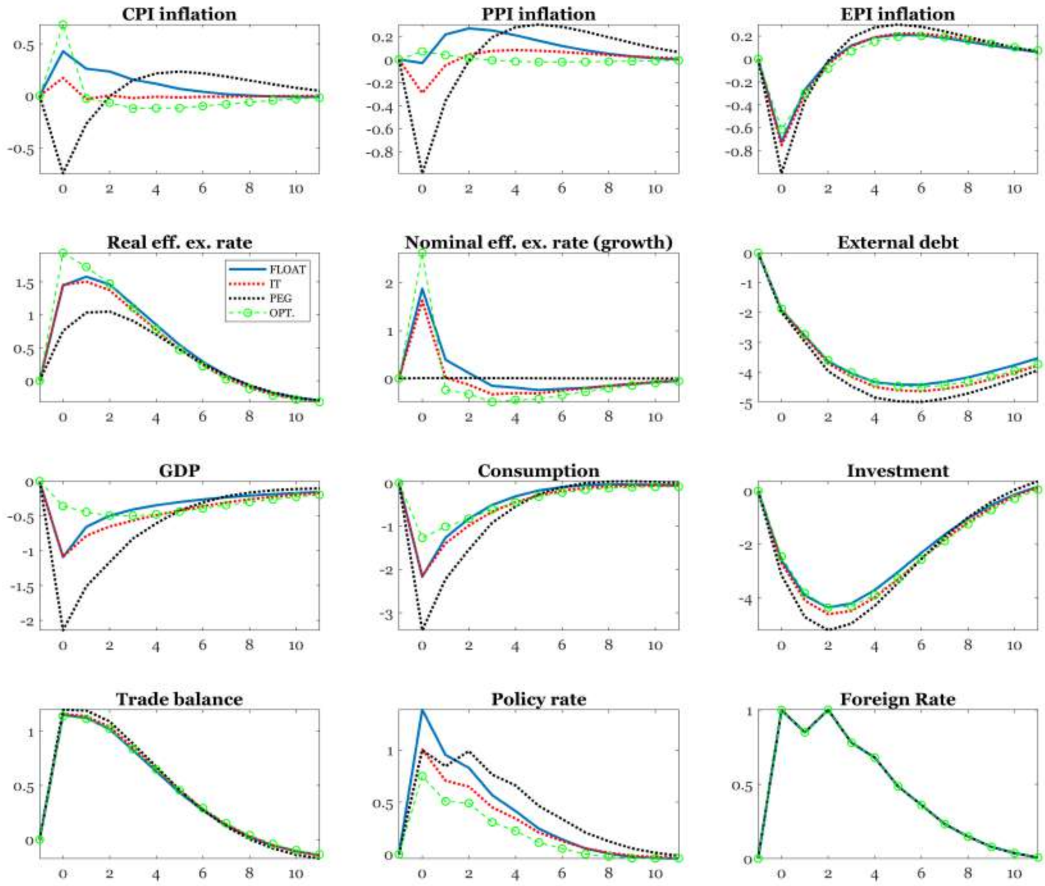

Figure 10: IRFs to 100 basis point foreign interest rate shock in each regime, using the parameters for the Taylor rule in Table 4. The shock hits in period 0, in period -1 the economy is in the steady state. Responses are in log-deviation from the steady state, except interest rates (in level deviations) and the trade balance (in percentage of steady state GDP). Positive NEER and REER responses denote a domestic depreciation. Blue solid line: floating regime. Black dotted line: peg regime. Red dotted line: inflation targeting. Green circled line: optimal policy.

Welfare analysis

Regime	Ω
PEG	-0.009%
IT	0.01%
FLOAT	0.007%

Table 5: Consumption equivalent under each regime

6.4 Other policy instruments

EME that peg the exchange rate usually rely on other policy instruments, on top of interest rate policies. Consistently with the empirical section, we study whether CPI inflation falls under a peg regime, if the policy maker can use FX interventions or cyclical capital controls, on top of interest-rate policies. We also analyze a scenario where the economy is ex ante more closed to foreign capital flows.

6.4.1 FX interventions

In our baseline model, the public sector is missing: the only policy instrument is the the nominal interest rate, which is set according to a Taylor; moreover, domestic bonds are in zero net supply (equation 38). In this section we explicitly model the balance sheets of the central bank, introducing new variables:

$$b_{Ct} + s_t b^f_{Ct} = mb_t, \tag{47}$$

where b_{Ct} denotes holding of domestic bonds by the central bank, b^f_{Ct} denotes foreign reserves, and mb_t denotes the domestic monetary base; these three variables are defined in terms of the domestic CPI. We assume that monetary base does not have non-pecuniary returns and that it is a perfect substitute with domestic bonds, so it pays the same nominal interest rate r_t: we interpret the monetary base as reserves of the private sector that are held at the central bank: this justifies a positive interest rate. The profits of the central bank read:

$$\Gamma_{Ct} = \left(r^*_{t-1} s_t - \frac{r_{t-1}}{\pi_t} \right) b^f_{Ct-1}, \tag{48}$$

which are fully transferred to households, in lump-sum fashion. Given the perfect substitutability between domestic bonds and monetary base, it is as if there exists a unique market for domestic assets, whose market clearing condition is the following:

$$b_t + b_{Ct} = mb_t. \tag{49}$$

The previous condition states that domestic assets (held by households and the central banks) corresponds to domestic liabilities (the monetary base), as these assets are not traded abroad. Together with equation (47), this also implies that:

$$b_t = s_t b^f_{Ct}, \tag{50}$$

which means that private domestic bonds equal foreign reserves. Given that in our model a fiscal sector is missing, thus debt issued by the government is 0, domestic liabilities are issued only by the central bank; the only way to buy foreign reserves for the central bank is to issue net domestic liabilities (i.e to increase $mb_t - b_{Cy}$); however domestic liabilities are traded only inside the domestic economy, so they can be purchased only by domestic households; as a result, domestic assets held by households (private domestic bonds) are equal to foreign reserves.[23]

We define the net financial asset position (NFA) as the sum of public and private foreign assets (in terms of foreign CPI):

$$nfa_t = b_t^f + b_{Ct}^f. \tag{51}$$

In this new version of the model we compare three different interest rate-FX combinations that fully stabilize the exchange rate: in the three policy options we always impose $\Delta e_t = 1$. The first policy is the baseline, and it prescribes that FX reserves are not used:

$$b_{Ct}^f = b_C^f. \qquad \text{P1} \tag{52}$$

Under this policy, FX reserves stay constant at the steady state,[24] so that the nominal interest rate carries the entire burden of delivering exchange rate stability. This policy is approximately equivalent to the peg regime in the illustrative calibration in Section 6.1, where we set a very high coefficient on the exchange rate in the Taylor rule: here, instead of specifying a Taylor rule that stabilizes the exchange rate, we are directly imposing $\Delta e_t = 1$. The response to a foreign interest rate shock under P1 (Figure 11, blue solid line) implies an increase in the domestic interest rate, which in turn drives a recession and a fall in inflation.

The second policy option sets a constant interest rate:

$$r_t = r, \qquad \text{P2} \tag{53}$$

so that FX reserves will adjust in order to keep the nominal exchange rate constant (Figure 11, red dotted line). This policy implies a huge sale of FX reserves: the public NFA falls by around 25% of GDP[25] and the exchange rate is stabilized. Given that the policy rate does not rise, the recession is avoided. The UIP premium decreases (the foreign yield is relatively higher) and households reduce external debt (d_t), meaning that the private NFA (b_t^f) improves. How many reserves the central bank has to deploy to defend the peg

[23] In a model with a fiscal sector issuing public debt b_t^G traded only inside the domestic economy, equation (50) would be $b_t = b_{Gt} + s_t b_{Ct}^f$. Our results would not change.

[24] We calibrate the steady state FX-GDP ratio to 20%, the average value in our sample of emerging markets.

[25] Given that the FX reserves-GDP ratio is 20%, the central bank ends up with borrowing in foreign currency.

crucially depends on the risk-premium elasticity κ_D. If $\kappa_D = 0$, foreign and domestic bonds are perfect substitutes and their return is the same: every FX intervention is offset by the private sector, which takes the opposite position in order to exploit the potential arbitrage opportunity. If $\kappa_D > 0$, households pay adjustment costs when they change their foreign asset position: even if the foreign yield is relatively higher, household do not indefinitely invest in foreign bonds. In our calibration, κ_D is positive, yet very small: the intervention is successful but it requires a very large sale of foreign assets that are held by the central bank. This is clear looking at the UIP condition (equation 17): after a foreign monetary tightening, constant nominal exchange and interest rates (policy P2) imply a rise in the private foreign asset position (a lower d_t), and the magnitude of this rise is decreasing in parameter κ_D.

The third policy prescribes to sell FX assets whenever US monetary policy tightens:

$$b^f_{Ct} = b^f_C \left(\frac{r^*_t}{r^*}\right)^{-\phi_{FX}} . \quad \text{P3} \tag{54}$$

As in P1, the policy rate endogenously adjusts to defend the peg. Unlike P1, in P3 the sale of foreign assets helps to avoid a nominal depreciation when US monetary policy tightens. We set ϕ_{FX} such that the central bank sells reserves by 10% of GDP, if the US interest rate increases by 100 basis points.[26] The response of the economy lies in between policy P1 and P2 (Figure 11, black dashed line). The sale of foreign assets by the central bank implies that the policy rate has to be raised in order to defend the peg, though by a smaller amount with respect to the baseline scenario (P1). The milder domestic monetary tightening mitigates the recession, compared to P1: if the central bank intervenes in FX markets, inflation still falls in the peg regime, after a foreign monetary tightening. The response of inflation reaches an upper bound with P2: if the central bank use only FX intervention to defend the peg, inflation barely moves after the foreign shock. These results are consistent with the empirical evidence provided in Figure 5.

6.4.2 Cyclical capital controls

In EME, policy makers sometimes use capital controls to manage the financial account. Following the literature, we model capital controls as a tax τ_t on private external debt d_t, whose revenues are transferred lump-sum to households (Bianchi, 2011, Korinek, 2011, and Nispi Landi, 2020). The Euler equation on foreign bonds (equation 11) changes as follows:

$$\lambda_t \left[1 - \tau_t + \kappa_D \left(b^f_t - \bar{b}\right)\right] = \beta \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\lambda_t} r^*_t \frac{s_{t+1}}{s_t}\right), \tag{55}$$

[26] This implies $\phi_{FX} = 50.05$.

where a positive value for τ_t means that investment in foreign bonds is subsidized (or borrowing from abroad is taxed). The new linearized UIP condition (equation 17) also accounts for the capital-control tax:

$$\tilde{r}_t = \tilde{r}_t^* + \mathbb{E}_t\left(\Delta\tilde{e}_{t+1}\right) + \kappa_D \overline{d}\tilde{d}_t + \tau_t. \tag{56}$$

We compare three policy scenarios. In the first (baseline) scenario the capital-control tax is constant at a steady state of 0: this is equivalent to policy P1 in the previous section, and we plot it again in Figure 12 (blue solid line). In the second scenario we simulate the extreme case in which the policy rate is not adjusted and the policy maker defends the peg by lowering the capital-control tax, thus subsidizing foreign borrowing:

$$r_t = r. \qquad \text{P2b} \tag{57}$$

Under P2b, the reduction in the capital control tax almost offsets the foreign shock, shielding the domestic economy (Figure 12, red dotted line): this is an illustrative extreme case, because it is unlikely that a country is able to immediately remove sizable capital controls or to subsidize foreign borrowing. Therefore, we also simulate an intermediate scenario in which capital controls respond to the foreign interest rate, with a rule analogous to P3:

$$1 + \tau_t = \left(\frac{r_t^*}{r^*}\right)^{-\phi_{CC}}. \qquad \text{P3b} \tag{58}$$

We calibrate $\phi_{CC} = 0.5$ such that the tax decreases by 50 basis points, if the foreign interest rate rises by 100 basis points. This policy mitigates the shock, without fully shielding the economy (Figure 12, black dashed line): the domestic interest rate rises in order to defend the peg, reducing the CPI inflation rate. These results are consistent with the empirical evidence provided in Figure 6.

6.4.3 Financial openness

The response of pegger countries to foreign shocks may also depend on the level of capital controls in place when the shock hits. In our model, parameter κ_D measures the sensitivity of the risk premium to external debt, thus it is a good proxy for the degree of financial openness: when κ_D is relatively high, the volatility of capital flow is relatively low, and vice versa.

We plot the response to a foreign interest rate shock under three values for κ_D: 0.005 (Figure 13, blue solid line), which is the baseline value, 0.05 (Figure 13, red dotted line), and 0.5 (Figure 13, black dashed line). We find that the higher κ_D the smaller the reaction of the economy to a foreign interest rate shock. When κ_D is relatively high the improvement in the net financial position of the country is smaller: in order to defend the peg a lower domestic monetary tightening is required. It turns out that inflation falls by less when the country is more closed to foreign capital flows, consistently with the empirical evidence reported in Figure 6.

Peg regime: Interest rate vs FX intervention

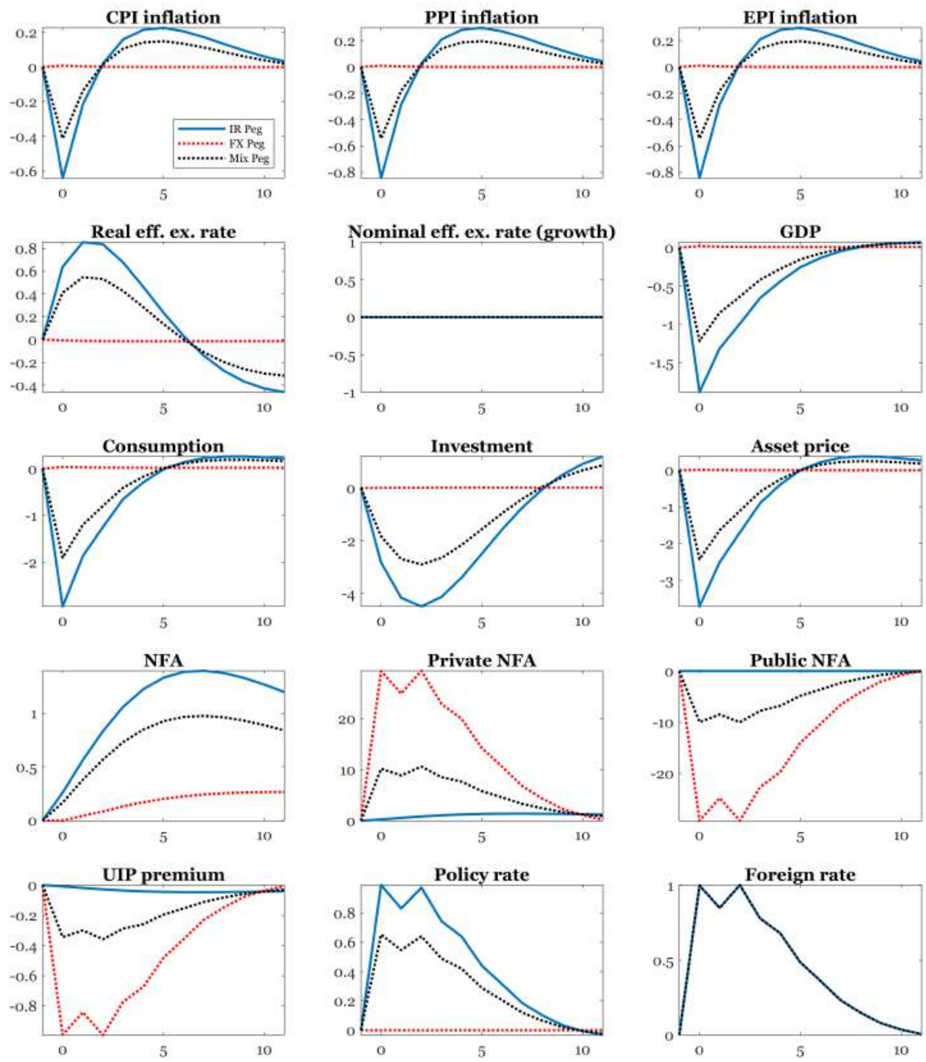

Figure 11: IRFs to 100 basis point foreign interest rate shock. The shock hits in period 0, in period -1 the economy is in the steady state. Responses are in log-deviation from the steady state, except interest rates and UIP premium (in level deviations) and NFAs (in percentage of steady state GDP). Positive NEER and REER responses denote a domestic depreciation. A lower UIP premium means that foreign yield is relatively higher. Blue solid line: peg through interest rate (P1). Red dotted line: peg through FX intervention (P2). Black dotted line: peg through interest rate and FX intervention (P3).

Peg regime: interest rate vs capital controls

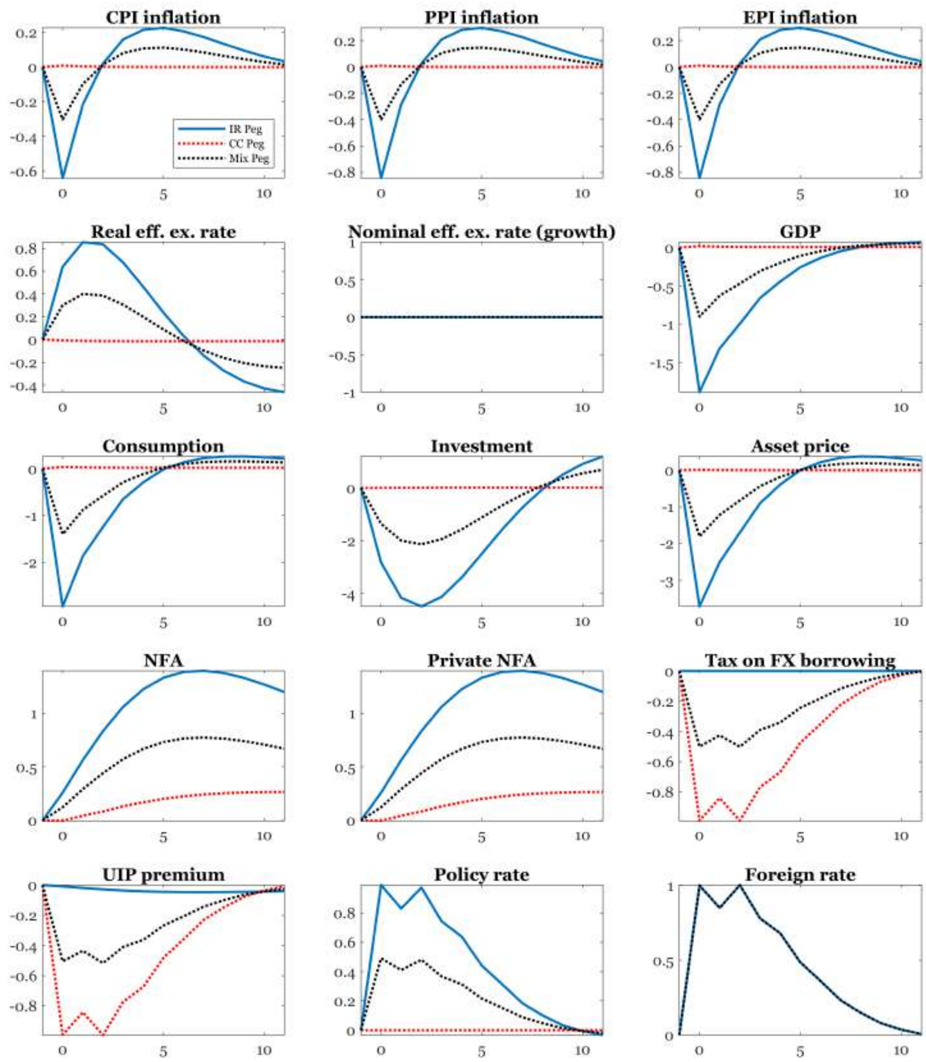

Figure 12: IRFs to 100 basis point foreign interest rate shock. The shock hits in period 0, in period -1 the economy is in the steady state. Responses are in log-deviation from the steady state, except interest rates and UIP premium (in level deviations) and NFAs (in percentage of steady state GDP). Positive NEER and REER responses denote a domestic depreciation. A lower UIP premium means that foreign yield is relatively higher. Blue solid line: peg through interest rate (P1). Red dotted line: peg through capital controls (P2b). Black dashed line: peg through interest rate and capital controls (P3b).

Peg regime: high vs low financial openness

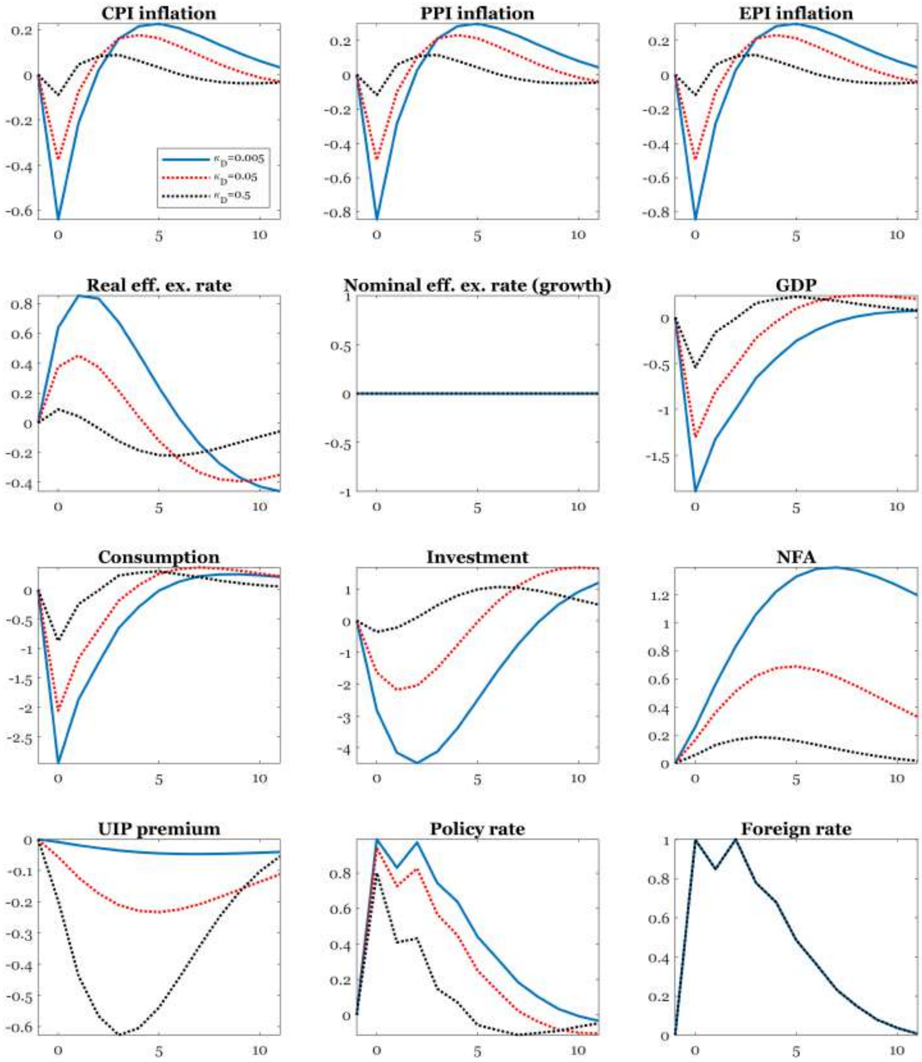

Figure 13: IRFs to 100 basis point foreign interest rate shock. The shock hits in period 0, in period -1 the economy is in the steady state. Responses are in log-deviation from the steady state, except interest rates and UIP premium (in level deviations) and NFA (in percentage of steady state GDP). Positive NEER and REER responses denote a domestic depreciation. A lower UIP premium means that foreign yield is relatively higher. Blue solid line: $\kappa_D = 0.005$. Red dotted line: $\kappa_D = 0.05$. Black dashed line: $\kappa_D = 0.5$.

7 Conclusions

We have provided empirical evidence on the spillover effects of US monetary policy to CPI inflation in emerging markets. We find that i) inflation falls in countries pegging the exchange rate; ii) inflation increases in floater countries that do not target inflation; iii) inflation barely responds in floater countries that do target inflation. These results are consistent with a standard DSGE model with nominal rigidities: in peggers countries, the domestic tightening that is necessary to defend the peg reduces inflation; in floaters countries that do not target inflation, the resulting nominal depreciation makes import prices more costly, raising domestic demand and thus inflation; in inflation targeters, the response of inflation is small by definition. From a normative perspective, we show that, even in a model characterized by dominant currency pricing, targeting CPI inflation yields the highest welfare gains compared to the other two monetary policy frameworks. A CPI inflation targeting implies a policy very close to the optimal one, which prescribes to target PPI inflation, in order to minimize costly adjustment costs. However, the optimal monetary policy does not recommend to reduce costly export-price fluctuations: domestic monetary policy is not able to directly affect export prices, which are set in the dominant currency.

These results are particularly relevant for emerging market policy makers that are interested in disentangling domestic price dynamics in response to foreign interest shocks. Our results inform policy makers that pegging the exchange rate may generate excessive and inefficient inflation volatility, compared to a flexible exchange rate regime.

We believe that our findings could be extended along several dimensions. For instance, in our analysis domestic financial markets are frictionless: as long as financial frictions exacerbate the recessionary effects of foreign monetary policy shocks, our welfare ranking may change.

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Appendix

A Data and Exchange Rate Regime Classification

Exchange rate regime classification (Ilzetzki et al., 2019)

Category	Decription
1	No separate legal tender or currency union
2	Pre announced peg or currency board arrangement
3	Pre announced horizontal band that is narrower than or equal to $+/-2\%$
4	De facto peg
5	Pre announced crawling peg;
	de facto moving band narrower than or equal to $+/-1\%$
6	Pre announced crawling band that is narrower than or equal to $+/-2\%$
	or de facto horizontal band that is narrower than or equal to $+/-2\%$
7	De facto crawling peg
8	De facto crawling band that is narrower than or equal to $+/-2\%$
9	Pre announced crawling band that is wider than or equal to $+/-2\%$
10	De facto crawling band that is narrower than or equal to $+/-5\%$
11	Moving band that is narrower than or equal to $+/-2\%$
	(i.e., allows for both appreciation and depreciation over time)
12	De facto moving band $+/-5\%$; Managed floating
13	Freely floating
14	Freely falling
15	Dual market in which parallel market data is missing

Table A.1: Exchange rate regime classification of Ilzetzki et al. (2019), which is the basis of the *PEG* dummy.

Observations across monetary policy frameworks

	Monetary policy framework		
	PEG	FLOAT	IT
Number of obs.	287	839	274
Percent	20.5%	59.9%	19.6%
Total obs.		1400	

Table A.2: IT denotes floating exchange rate with an inflation target; PEG denotes fixed exchange rate regime; FLOAT denotes floating exchange rate regime, without an explicit commitment to inflation. The table is computed by considering the sample of 24 EMEs for the period, $1991:2-2009:3$, and the currency is anchored to the USD. Exchange rate regime classification is based on Ilzetzki et al. (2019).

Emerging market economy data coverage I

Countries	CPI	GDP	NEER	Policy Rate
Argentina	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	2002:1-2019:4
Armenia	1993:1-2019:4	1990:1-2019:4	1994:1-2019:4	2000:1-2019:4
Bolivia	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
Brazil	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1996:3-2019:4
Chile	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
China	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1991:2-2019:4
Colombia	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1995:2-2019:4
Costa Rica	1990:1-2019:4	1991:1-2019:4	1990:1-2019:4	1990:1-2019:4
Ecuador	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
Egypt	1990:1-2019:3	1990:1-2019:4	1990:1-2019:4	2005:3-2019:4
Georgia	1994:1-2019:3	1990:1-2019:4	1993:4-2019:4	2008:1-2019:4
Guatemala	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	2005:1-2019:4
India	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	2000:3-2019:4
Indonesia	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	2005:3-2019:4
Malaysia	1990:1-2019:3	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
Mexico	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1997:1-2019:4
Paraguay	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	2011:1-2019:4
Peru	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
Philippines	1990:1-2019:3	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
Poland	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
South Africa	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
Thailand	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4
Turkey	1990:1-2019:4	1990:1-2019:4	1990:1-2019:4	1992:2-2019:4
Ukraine	1992:1-2019:3	1990:1-2019:4	1993:1-2019:4	1990:1-2019:4

Table A.3: The acronyms of NEER stands for Nominal Effective (i.e. trade-weighted) Exchange Rate. Data sources are: IFS (IMF International Financial Statistics database); and Datastream (Thomson-Reuters Datastream database), if the former is not available.

Emerging market economy data coverage II

Countries	FX reserves	Cap. controls	Nominal GDP
Argentina	1990:1-2019:4	1995:1-2017:4	1993:3-2019:3
Armenia	1992:1-2019:4	no data	1994:4-2019:3
Bolivia	1990:1-2019:4	1995:1-2017:4	1990:1-2018:3
Brazil	1990:1-2019:4	1995:1-2017:4	1991:1-2019:3
Chile	1990:1-2019:4	1995:1-2017:4	1996:1-2019:3
China	1990:1-2019:4	1995:1-2017:4	1992:1-2019:3
Colombia	1990:1-2019:4	1995:1-2017:4	2005:1-2019:3
Costa Rica	1990:1-2019:4	1995:1-2017:4	1991:1-2019:3
Ecuador	1990:1-2019:4	1995:1-2017:4	1991:1-2019:1
Egypt	1990:1-2019:4	1995:1-2017:4	2002:1-2013:4
Georgia	1995:4-2019:4	1995:1-2017:4	1996:1-2019:1
Guatemala	1990:1-2019:4	1995:1-2017:4	2001:1-2018:3
India	1990:1-2019:4	1995:1-2017:4	2004:1-2018:4
Indonesia	1990:1-2019:4	1995:1-2017:4	1990:1-2019:3
Malaysia	1990:1-2019:4	1995:1-2017:4	1991:1-2018:4
Mexico	1990:1-2019:4	1995:1-2017:4	1993:1-2019:3
Paraguay	1990:1-2019:4	1995:1-2017:4	1994:1-2018:2
Peru	1990:1-2019:4	1995:1-2017:4	1990:1-2017:1
Philippines	1990:1-2019:4	1995:1-2017:4	1990:1-2018:4
Poland	1990:1-2019:4	1995:1-2017:4	1995:1-2019:4
South Africa	1990:1-2019:4	1995:1-2017:4	1990:1-2001:4
Thailand	1990:1-2019:4	1995:1-2017:4	1993:1-2019:4
Turkey	1990:1-2019:4	1995:1-2017:4	1990:1-2019:4
Ukraine	1992:2019:4	1995:1-2017:4	2000:1-2018:4

Table A.4: Data sources are: IFS (IMF International Financial Statistics database); and Datastream (Thomson-Reuters Datastream database), if the former is not available. The index of aggregate controls on capital inflows is obtained by Fernandez et al. (2015), where is denoted by “kai”. In the main text, the variable FX reservs-GDP ratio refers to the ratio between FX reserves and nominal GDP.

US and global variables

Variable	Description	Time Span	Source
1-year gov. bond yield	US 1-year gov. bond yield	1990:1-2019:4	FRED
REA	Real economic activity index	1990:1-2019:4	Kilian (2009)
Real oil price	$\frac{\text{Cushing OK WTI Spt Price FOB U\$/BBL}}{\text{US CPI}}$	1990:1-2019:4	Datastream
VXO	CBOE S&P 100 Volatility Index	1990:1-2019:4	FRED
z_t	US monetary policy instrument	1991:1-2009:4	MR

Table A.5: The acronyms correspond to the following sources. Datastream: Thomson-Reuters Datastream database; FRED: Federal Reserve Economic Data. MR: Miranda-Agrippino and Ricco (2021). REA time series is updated, by Kilian, till the end of 2019.

B Model Equations

The equilibrium conditions of the model are the following:

$$\lambda_t = \left(c_t - \frac{h_t^{1+\varphi}}{1+\varphi}\right)^{-\sigma} \tag{A.1}$$

$$1 = \beta \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\lambda_t}\frac{r_t}{\pi_{t+1}}\right) \tag{A.2}$$

$$1 = \beta \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\lambda_t} r_t^* \frac{s_{t+1}}{s_t}\right) + \kappa_D \left(d_t - \overline{d}\right) \tag{A.3}$$

$$1 = \beta \mathbb{E}_t \left\{\frac{\lambda_{t+1}}{\lambda_t}\frac{\left[r_{t+1}^k + (1-\delta) q_{t+1}\right]}{q_t}\right\} \tag{A.4}$$

$$h_t^{\varphi} = w_t \tag{A.5}$$

$$\begin{aligned} 1 = {} & q_t \left[1 - \frac{\kappa_I}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 - \kappa_I \left(\frac{i_t}{i_{t-1}}\right)\left(\frac{i_t}{i_{t-1}} - 1\right)\right] + \\ & + \kappa_I \beta \mathbb{E}_t \left\{\frac{\lambda_{t+1}}{\lambda_t} q_{t+1} \left[\left(\frac{i_{t+1}}{i_t}\right)^2 \left(\frac{i_{t+1}}{i_t} - 1\right)\right]\right\} \end{aligned} \tag{A.6}$$

$$k_t = (1-\delta) k_{t-1} + \left[1 - \frac{\kappa_I}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] i_t \tag{A.7}$$

$$y_t = k_{t-1}^{\alpha} h_t^{1-\alpha} \tag{A.8}$$

$$r_t^k = \alpha m c_t \frac{y_t}{k_{t-1}} \tag{A.9}$$

$$w_t = (1-\alpha) m c_t \frac{y_t}{h_t} \tag{A.10}$$

$$y_t = y_{Ht} + y_{Xt} \tag{A.11}$$

$$\begin{aligned} \pi_{Ht}\left(\pi_{Ht} - \overline{\pi}\right) = {} & \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t}\pi_{Ht+1}\left(\pi_{Ht+1} - \overline{\pi}\right)\frac{p_{Ht+1} y_{Ht+1}}{p_{Ht} y_{Ht}}\right] + \\ & + \frac{\varepsilon_H}{\kappa_{PH}}\left(\frac{m c_t}{p_{Ht}} - \frac{\varepsilon_H - 1}{\varepsilon_H}\right) \end{aligned} \tag{A.12}$$

$$\pi_{Ht} = \frac{p_{Ht}}{p_{Ht-1}}\pi_t \tag{A.13}$$

$$\begin{aligned} \pi_{Xt}\left(\pi_{Xt} - 1\right) = {} & \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{\lambda_t}\pi_{Xt+1}\left(\pi_{Xt+1} - 1\right)\frac{p_{Xt+1} y_{Xt+1}}{p_{Xt} y_{Xt}}\right] + \\ & + \frac{\varepsilon_X}{\kappa_{PX}}\left(\frac{m c_t}{p_{Xt}} + \frac{\varepsilon_X - 1}{\varepsilon_X}\right) \end{aligned} \tag{A.14}$$

$$\pi_{Xt} = \frac{p_{Xt}}{p_{Xt-1}} \frac{s_{t-1}}{s_t} \tag{A.15}$$

$$y_{Ht} = (1-\gamma)(p_{Ht})^{-\eta}(c_t + i_t) + \frac{\kappa_P}{2}(\pi_{Ht} - \overline{\pi})^2 y_{Ht} \tag{A.16}$$

$$y_{Xt} = \gamma^* \left(\frac{p_{Xt}}{s_t}\right)^{-\eta} y_t^* + \frac{\kappa_{PX}}{2}(\pi_{Xt} - 1)^2 y_{Xt} \tag{A.17}$$

$$\begin{aligned} gdp_t &= c_t + i_t + s_t r_{t-1}^* d_{t-1} - s_t d_t + \frac{\kappa_D}{2} s_t \left(d_t - \overline{d}\right)^2 + \\ &\quad + \frac{\kappa_{PH}}{2}(\pi_{Ht} - \overline{\pi})^2 p_{Ht} y_{Ht} + \frac{\kappa_{PX}}{2}(\pi_{Xt} - 1)^2 p_{Xt} y_{Xt} \end{aligned} \tag{A.18}$$

$$\frac{r_t}{r} = \left(\frac{r_{t-1}}{r}\right)^{\rho} \left[\left(\frac{\pi_t}{\overline{\pi}}\right)^{\phi_\pi} \left(\frac{gdp_t}{gdp}\right)^{\phi_y} \left(\frac{\Delta e_t}{\Delta e}\right)^{\phi_e}\right]^{1-\rho} \tag{A.19}$$

$$\frac{s_t}{s_{t-1}} = \frac{\Delta e_t}{\pi_t} \tag{A.20}$$

$$gdp_t = p_{Ht} y_{Ht} + p_{Xt} y_{Xt} \tag{A.21}$$

$$1 = (1-\gamma)(p_{Ht})^{1-\eta} + \gamma (s_t)^{1-\eta} \tag{A.22}$$

$$r_t^* - \frac{1}{\beta} = \rho_1^* \left(r_{t-1}^* - \frac{1}{\beta}\right) + \rho_2^* \left(r_{t-2}^* - \frac{1}{\beta}\right) + \rho_3^* \left(r_{t-3}^* - \frac{1}{\beta}\right) + v_t \tag{A.23}$$

There are 23 equations for 23 endogenous variables:

$$X_t \equiv \left[\lambda_t, c_t, r_t^k, w_t, h_t, y_{Ht}, y_t, y_{Xt}, p_{Xt}, \pi_{Xt}, k_t, q_t, i_t, r_t, mc_t, \pi_t, d_t, s_t, p_{Ht}, \pi_{Ht}, gdp_t, \Delta e_t, r_t^*\right],$$

and one exogenous shock v_t.

C Steady State

Variables without time subscript denote the steady-state level. We compute the steady state as a function of $\{gdp, p_H, h\}$. Real exchange rate:

$$s = \left[\frac{1-(1-\gamma)(p_H)^{1-\eta}}{\gamma}\right]^{\frac{1}{1-\eta}}. \tag{A.24}$$

The stochastic process for the foreign interest rate imply:

$$r^* = \frac{1}{\beta}. \tag{A.25}$$

The domestic Euler equation implies in the steady state implies:

$$r = \frac{\pi}{\beta}; \tag{A.26}$$

which implies by the Taylor rule:

$$\pi = \overline{\pi} \tag{A.27}$$

$$r = \frac{\overline{\pi}}{\beta}. \tag{A.28}$$

By (28), and the definition of π_H and Δe it holds:

$$mc = \tfrac{\varepsilon_H - 1}{\varepsilon_H} p_H \tag{A.29}$$

$$\pi_H = \overline{\pi} \tag{A.30}$$

$$\Delta e = \overline{\pi}. \tag{A.31}$$

Use the Phillips curve of exporters:

$$p_X = \tfrac{\varepsilon_X}{\varepsilon_X - 1} mc \tag{A.32}$$

$$\pi_X = 1. \tag{A.33}$$

Foreign demand:

$$y_X = \gamma^* \left(\frac{p_X}{s}\right)^{-\eta}. \tag{A.34}$$

Production for domestic markets:

$$gdp = p_H y_H + p_X y_X \tag{A.35}$$

$$y_H = \frac{gdp - p_X y_X}{p_H}. \tag{A.36}$$

Total production:

$$y = y_H + y_X. \tag{A.37}$$

Calibrate ex ante the yearly external debt GDP ratio:

$$D = \frac{s \cdot d}{4gdp}$$

and compute $\overline{d}$ ex post. By (13) it holds in the steady state:

$$d = \overline{d}, \tag{A.38}$$

which implies:

$$d = \frac{4D \cdot gdp}{s}. \tag{A.39}$$

In the steady state (16) implies:

$$q = 1, \tag{A.40}$$

which gives according to (14):

$$r^k = \frac{1}{\beta} - (1 - \delta). \tag{A.41}$$

Once we have r^k, we can get the steady state of k by (26):

$$k = \frac{\alpha y}{r^k} mc \tag{A.42}$$

and in turn we get i from the law of motion of capital:

$$i = \delta k. \tag{A.43}$$

Using (27) we can find w:

$$w = \frac{(1 - \alpha) y}{h} mc. \tag{A.44}$$

Use the resource constraint to find consumption:

$$c = gdp - i - \overline{d} \left(\frac{1}{\beta} - 1 \right). \tag{A.45}$$

We are left with three equations:

$$y_H = (1 - \gamma) (p_H)^{-\eta} (c + i) \tag{A.46}$$

$$w = h^{\varphi} \tag{A.47}$$

$$y = k^{\alpha} h^{1-\alpha}, \tag{A.48}$$

where all variables depend on $\{gdp, h, p_H\}$: by solving this system of three equations we find the steady state of the model.

D Additional Figures

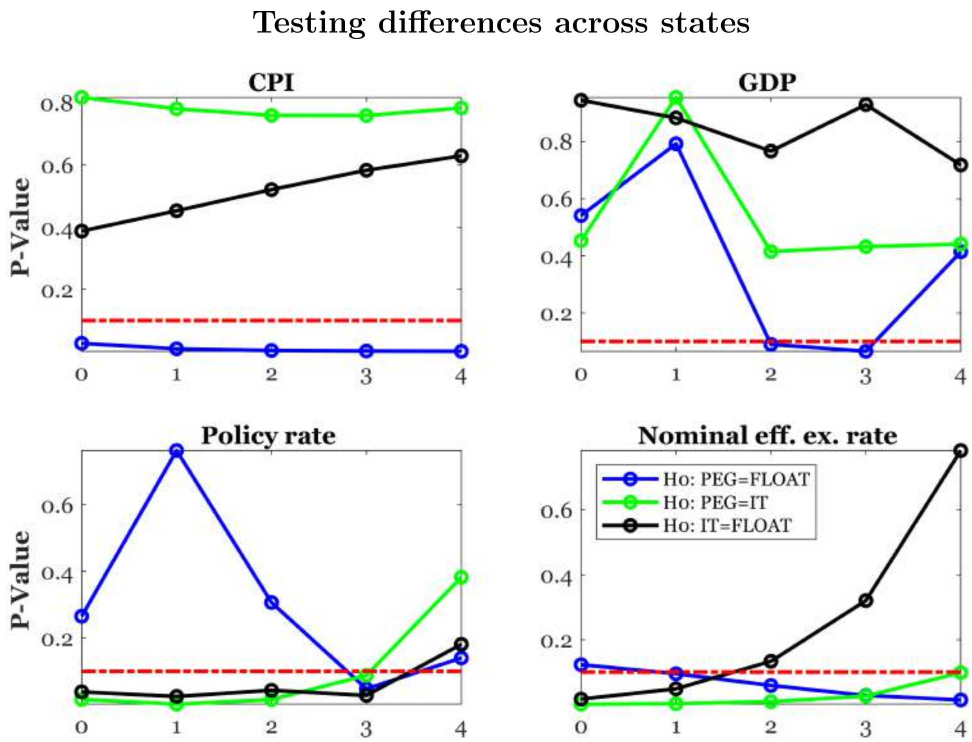

Figure A.1: The circled lines show the p-values associated to testing the hypothesis that the difference between the responses to a US monetary policy shock, which determines a 1% increase at impact in the 1-year US government bond yield, is zero across states. In particular, for the initial four quarters we carry out a battery of tests: PEG vs FLOAT (blue), PEG vs IT (green), and IT vs FLOAT (black). Red dotted lines describes the 10% significance level threshold (0.1).

Chapter 3
Global Risk Aversion and Sovereign Debt in Emerging Markets*

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Abstract

This paper studies the impact of global risk aversion on the cost of borrowing for emerging market economies. In a sample of five emerging markets we show that in response to risk aversion shocks that lower global risk appetite: spreads rise, at all maturities; and borrowing long term becomes *cheaper*. In fact, on average, emerging markets pay a higher risk premium on long-term than short-term bonds. In periods of high risk aversion the difference across the two risk premia *decreases*. Our result can be rationalized by considering that passing from periods of low to high risk aversion, the risk-reward trade-off (Sharpe ratio) changes in favour of longer maturities. As a consequence, holding long term bonds becomes more convenient for investors. Our results are robust to different specifications of the global risk aversion time series, and to measures of country-specific investor risk aversion.

Keywords: Bond Spreads, Emerging Markets, Risk Aversion, Term Structure.
JEL Codes: E43, G10, G12, G15.

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1 Introduction

One of the key challenges for policy makers in emerging market economies is to secure a consistent flow of funds in order to roll-over extant debt and implement government spending programs. During the past decades, emerging market economies (henceforth EMEs) have experienced recurring financial crises and rollover problems. Salient examples are Latin American debt crisis of the 2000s (e.g. Brazil 2002), the Global Financial Crisis in 2008 and the financial distress related to the spread of the Covid-19 pandemic in 2020.

A thorough analysis of sovereign financial crisis in EMEs is particularly relevant given the central role of government fiscal packages in emerging economies, in both providing stimulus for the economy and rescuing relevant domestic sectors. As shown by recent events of the Covid-19 pandemic and related systemic crisis, at a time when emerging markets would need to borrow to support their economy (e.g. by strengthening their health systems), they exhibit difficulties in accessing capital markets (Velasco, 2020). In addition, given the high level of foreign currency (e.g. USD) debt in the domestic economy, during financial turmoils emerging markets would need to receive fresh hard-currency resources, as shown by the 2020 soar in the IMF financial support lines in response to the Covid-19 related financial distress.[1] A shift in risk preferences by market participants may severely affect the cost of funding for EMEs and trigger a liquidity crisis, especially in case of excessive reliance on short-term borrowing.

The risk associated with short term borrowing has prompted several authors in studying why emerging markets keep borrowing short term. A common view is that, during financial crisis, emerging markets borrow short term because of demand-side factors, mainly related to a moral-hazard problem on the debtor side.[2] As emphasized by Arellano and Ramanarayanan (2012) and Aguiar et al. (2019), in case the government lacks commitment over future policies, lenders anticipate the lower incentives to default when the maturity structure is short, as any increase in interest rates would induce higher refinancing costs. As a consequence, shorter maturity structures serve as a commitment device for the government and may increase welfare ex-ante.[3] On the other hand, a relevant contribution by Broner et al. (2012) proposes a different view based on supply-side factors: during crisis, investors charge a higher risk premium on long-term bonds than on short-term ones, making cheaper for emerging markets to borrow short term and, thus,

[1] By April 20^{th}, 103 countries approached the IMF for emergency financing, as pointed out by IMF Managing Director Kristalina Georgieva at the 2020 IMF Spring Meetings.

[2] Here we consider the borrowing country as the "demand-side" of the international sovereign debt market, while lenders represent the supply-side.

[3] Recent contributions that underline the role of short-term debt as a commitment device in the framework of sovereign international lending are: Arellano (2008), Arellano and Ramanarayanan (2012), Aguiar et al. (2019), and Bocola and Dovis (2019).

debt issuance shifts towards shorter maturities.[4]

A separate strand of literature underlines the role of risk-taking behavior of global financial intermediaries in determining cross-country financial flows (Rey, 2013; Miranda-Agrippino and Rey, 2020a; and Miranda-Agrippino and Rey, 2020b). The authors push forward the idea of a time-varying measure of risk aversion of the global financial system that affects capital flows across banks located in different countries.[5] These studies mainly focus on banking flows, given their role in the build-up of imbalances that led to the Global Financial Crisis, and partially neglect a thorough analysis of debt (both sovereign and corporate) flows across countries. A recent analysis by Hofmann et al. (2019) shows that changes in the global risk aversion, proxied by a broad dollar index, affects EME sovereign bond spreads at the 5-year maturity, independently of the currency of denomination of debt.[6]

We aim at unifying the focal points of these separate strands of literature by answering the following questions. Does global risk aversion affect the cost of borrowing for emerging market governments? Does higher global risk-aversion make borrowing long-term more expensive for emerging markets?

To answer these questions, we collect data on zero-coupon sovereign bond yields, denominated in USD, over the last three decades for five emerging market economies (Brazil, Colombia, Korea, Mexico, and Turkey) and one benchmark "safe" advanced economy (United States). We use zero-coupon curves as they permit to compare yields at certain maturities across countries and time, while raw data on bond prices would refer to maturity and coupon structure of debt that differ across countries in each point of time. We consider only bonds invoiced in USD due to the central role of USD denominated debt in EMEs (Bruno and Shin, 2015a; and Bruno and Shin, 2015b). This choice allows us to focus on the risk-reward trade off to explain the difference in yields and term premia between "risky" EMEs and "safe" US, mitigating the role for exchange rates.

Our empirical analysis is conducted via a panel local projection model (Jorda, 2005) fed with risk aversion shocks. We use a US-based proxy for global risk aversion, as we rely on the measure of risk aversion for the US financial markets provided by Bekaert et al. (2021). Risk aversion innovations are identified by regressing the series on contemporaneous and lagged US interest rates, and the shock is estimated as the residual of that

[4]Other papers underlying supply-side factors as determinant of risk premia in EME sovereign debt are: Borri and Verdelhan (2011) and Hofmann et al. (2019).

[5]Miranda-Agrippino and Rey (2020b) motivate a time-varying measure of risk aversion of the global financial system by referring to the heterogeneous risk-taking behaviour across financial intermediaries, whose relative importance varies over time.

[6]According to Hofmann et al. (2019) and BIS (2019), a broad US dollar index may represent a barometer of risk-taking behavior of financial intermediaries investing in EME assets.

regression.[7] The essence of the identification scheme is close to Akinci (2013) and aims to disentangle the exogenous component of the US-based proxy for global risk aversion from the one predicted by US interest rates, i.e. US financial conditions and monetary policy. Perhaps interesting, the "small" dimension of each emerging market economy allows us to safely assume no feedback effects with international financial markets. As a consequence, the estimated global risk aversion shocks might be considered truly exogenous for EMEs.

Our findings show that in response to risk aversion shocks that lower global risk appetite, spreads (i.e. the gap between EME and US sovereign bond yields) rise at all maturities and borrowing long term becomes *cheaper*. Before we proceed, it is important to clarify what we mean by the cost of borrowing. We define it as the expected amount of repayment per unit of dollar borrowed. Consider a borrower that needs funds for 1 year. The borrower is taking into account two options: (a) issuing a 1-year bond; (b) issuing a 2-year bond and buying it back after 1 year.[8] If the borrower does not default, under case (a) she pays back the yield on the one year bond; while under case (b) the repayment depends on both the stochastic price at which the borrower can buy back the bond after one year and the two-year bond yields. In case lenders are risk averse, borrowing long term will be more costly than borrowing short term. Our analysis is centred on this difference, which is usually referred as term premium. In particular, we focus on the gap in the term premium between emerging markets and advanced economies (i.e. US), as a positive term premium is exhibited also by advanced economies. We label this difference as *excess term premium*.

According to our results, during periods of high global risk aversion, the excess term premium *decreases* across all set of maturities, with larger drops at longer maturities. In fact, on average, EMEs pay a higher risk premium on long-term than short term bonds. However, in periods of high risk aversion, the difference between the two risk-premia (i.e. excess term premium) decreases, making it *cheaper* for emerging markets to borrow long term. Our findings can be rationalized by considering the risk-reward trade-off for bonds of different maturities. Passing from period of low to high risk aversion, the risk-reward trade-off (Sharpe ratio) changes in favour of longer maturities: the amount of reward for unit of risk decreases at all maturities, but it drops more for EME sovereign short term bonds than long term bonds. As a consequence, holding long term bonds becomes more convenient for investors. Our findings are consistent with a theoretical setup featuring households with time-varying risk aversion that respond to an increase in short-term risk

[7] The choice of 1-year interest rates as representative of the monetary policy stance and financial conditions in the US is standard in the literature (Gertler and Karadi, 2015 and Miranda-Agrippino and Ricco, 2020, among others).

[8] This clarifying example is taken from Broner et al. (2012).

by investing long-term, as in Grasso and Natoli (2018).[9] Our results are in contrast with the outcomes of previous studies (e.g. Broner et al., 2012) that associate, in a similar setup, financial crisis with long-term borrowing being *more expensive* in EMEs. It is worth noticing that the extant literature has focused on the response of excess term premium to country-specific financial crisis, while we consider its response to a US-based proxy of global risk aversion.[10]

The paper is organized as follows: Section 2 describes the literature; Section 3 presents the data; Section 4 shows the behaviour of yields and spreads; Section 5 defines excess term premia; Section 6 presents the econometric setup; Section 7 describes the results; Section 8 displays the robustness analysis; and Section 9 concludes.

2 Review of the literature

With a particular focus on the empirical literature, the relationship between EME sovereign debt spreads and global risk aversion has been extensively studied in the past decades.[11] With the notable exception of Broner et al. (2012), the vast majority of the literature is characterized by one, or more, of the following elements: (i) measuring risk-aversion via the VIX (i.e. CBOE S&P 500 implied volatility index); (ii) using the EMBI spread as a measure of EME sovereign debt spread (i.e. the gap between EME and US sovereign bond yields);[12] (iii) not considering term premia.

Our empirical analysis aims at innovating along all the dimensions listed above. First, we plan to provide a new measure of risk aversion that, differently from the VIX, distinguishes between risk aversion (price of risk) and uncertainty (quantity of risk). In fact, building on the contribution of Bekaert et al. (2021), we implement a US-based proxy of global risk aversion. Second, our analysis implements EME zero-coupon yield curve data that allow to implement country-specific yield curves and estimate spreads across different maturities, thus improving upon the use of the EMBI spread. Third, although the majority of the literature has focused on yield spreads, our analysis would also con-

[9]During financial distress the short-term default probability is higher than expected future default probability, since defaults take place during crisis, and turmoils do not last for an extended period of time.

[10]For a thorough comparison of our results with the literature, see the robustness analysis.

[11]Recent empirical studies that focus on the effects of financial crisis and global risk aversion on EME sovereign yield spreads are: Gonzalez-Rozada and Levy Yeyati (2008), Bellas et al. (2010), Broner et al. (2012), Csonto and Ivaschenko (2013) and Kennedy and Palerm (2014). For the impact of global risk aversion on "domestic spreads" (i.e. spreads between central bank policy rates and short-term rates) in emerging market economies, see Kalemli-Ozcan (2019).

[12]The data on the EMBI spread are collected from JP Morgan on the series labeled EMBI Global. They include EME sovereign bonds issued in USD, with an high degree of liquidity and with a typical maturity of $2-3$ years.

sider the impact of global risk aversion on excess term premia (i.e. the gap in term premia between emerging economies and "safe" advanced economies). As a consequence, our empirical study provides novel evidences to the literature on EME sovereign debt by analyzing the impact of global risk-aversion shocks on the term structure of interest rate spreads and excess term premia.

The paper that is mostly related to ours is Broner et al. (2012). As underlined above, the authors show, for debt issued in foreign currency (i.e. USD and Euro), that periods of EME financial crisis are associated with a soar in the cost of issuing long term debt, and with a shortening of debt maturity.[13] We depart from their analysis along one key dimension: building on the literature of risk-taking behavior of financial intermediaries (e.g. Rey, 2013), we estimate the response of spreads and excess term premia of EME sovereign debt to global risk aversion shocks, rather than to financial crisis specific to EMEs.

Finally, this study could provide evidence of financial crises, wide-spread across emerging economies, led by sudden stop in portfolio debt flows and generated by spike in global risk aversion. This result would enrich the standard findings of the empirical literature, which mainly explains sudden stop events by referring to banking flow reversals (e.g. Forbes and Warnock, 2020).

3 Data

Our data set includes country-specific and global variables that span the period $1990-2020$, at a daily frequency.[14] Country-specific data are collected for five emerging economies: Brazil, Colombia, Mexico, Korea, and Turkey. The sample has a different starting point for each country and variable, according to when data become available. We select countries and sample period mainly due to data availability. For each emerging market we collect data on zero-coupon sovereign bond yields at different maturities, denominated in US Dollar (USD). As a benchmark to calculate spreads and excess term premium, we also include data on "risk-less" zero-coupon bond yields issued by the United States in USD (Table A.1). We rely on a US-based proxy of global risk aversion (i.e. a measure of risk aversion of US financial markets) provided by Bekaert et al. (2021). The series is constructed as a linear function of a set of observable financial variables, at the

[13] Broner et al. (2012) define crisis those periods in which the 9-year spread between "risky" emerging markets and "safe" advanced economies is greater than a threshold, given by the average of the spread in the previous six months plus 300 basis points.

[14] As key financial variables are available only for business days, our empirical estimation is based on them, rather than calendar days.

daily frequency.[15] In the robustness analysis we provide an alternative US-based proxy for global risk aversion, which is based on: the S&P 500 implied volatility index (VIX); and daily non-parametric measures of realized volatility for the S&P 500, provided by Heber et al. (2009) (Table A.3). Finally, we include macroeconomic variables to control for alternative potential factors that may affect interest rates in emerging markets. For each country, we consider: the stock market price index (in logs), denominated in US Dollars; and the bilateral nominal exchange rate with USD (in logs) (Table A.2). We also control for changes in international commodity prices by including nominal oil price (in logs), denominated in USD (Table A.3).

4 Yields and Spreads

In order to compare the yields of bonds at certain maturities across countries and over time we need, as a preliminary step, to estimate yield curves. To do so we use the standard methodology of Diebold and Li (2006), in the framework of Nelson and Siegel (1987), on daily zero-coupon yield data for our sample of EMEs and US.[16] As a second step, we estimate the spread $s_{i,t,\tau}$ for country-i and maturity-τ, as the difference between the yield on emerging market bond denominated in USD $yield^{USD}_{i,t,\tau}$, and the yield, $yield^{USD}_{US,t,\tau}$, for the same maturity of US bonds:

$$s_{i,t,\tau} = yield^{USD}_{i,t,\tau} - yield^{USD}_{US,t,\tau}.$$

The estimated yields and spreads are very volatile, and the gap between long and short term maturities varies significantly over time (Figure 1 and Figure 2). When global risk aversion is low, long term yields (spreads) are usually higher than short term ones. On the contrary, when global risk aversion is high, the difference between long and short term yields (spreads) narrows and sometime reverses: the yield (spread) curve flattens or inverts.

We compute the mean and standard deviation of country spreads for selected maturities across periods of high (above-median) and low (below-median) global risk-aversion (Table 1). It is immediate to notice that in periods of high global risk aversion spread mean and volatility rises sharply, at all maturities. In order to compare the risk-reward trade-off for period of high and low global risk aversion we compute the Sharpe ratio,

[15] Bekaert et al. (2021) build a dynamic asset-pricing model, featuring time-varying risk aversion and economic uncertainty. Then, via a model-based approach, the authors construct a series of time-varying risk aversion as a linear function of key financial variables, such as credit spreads and equity risk-neutral variances.

[16] In particular, we adopt a fixed scaling parameter for the curvature factor, using the value of Diebold and Li (2006).

Mean and standard deviation of annualized spreads, during periods of high and low global risk-aversion, over comparable US bonds.

	Spread 3 years	Spread 9 years	Spread 12 years	Spread 15 years
		Low global risk-aversion periods		
Mean	1.39	2.12	2.26	2.34
Standard Deviation	0.96	1.35	1.45	1.51
		High global risk-aversion periods		
Mean	3.01	4.03	4.22	4.33
Standard Deviation	2.96	3.25	3.33	3.39
		All periods		
Mean	2.16	3.03	3.19	3.28
Standard Deviation	2.30	2.62	2.70	2.76

Table 1: The table shows the means and standard deviations of annualized daily spreads over comparable US sovereign bonds. Results are presented for periods of high global risk-aversion (above-median), periods of low global risk-aversion (below-median), and all periods. Unit of measure: percentage points.

defined as the ratio of mean spreads over their standard deviations (Sharpe, 1994). The Sharpe ratio decreases in periods of high global risk aversion at all maturities, with a major drop experienced at shorter maturities: during periods of high global risk aversion the amount of reward per unit of risk decreases *less* for long term bonds than short term ones. Therefore, in periods of high global risk aversion, holding long term bonds become more convenient for international investors (Table 2).[17]

5 Excess Term Premia

To obtain excess term premia is necessary to compute excess returns for emerging market and comparable US bonds, across different maturities. The excess return is the risk premium on a bond with maturity τ, paid by EME governments. It is computed by applying a two-step approach proposed by Broner et al. (2012) and focusing on coupon paying bonds, as emerging markets rarely issue zero-coupon bonds. First, spreads $s_{i,t,\tau}$

[17]To clarify this result, consider an investor that can borrow at the "safe" sovereign US rate and can invest in USD-denominated "risky" emerging market sovereign bonds and, earning profits on the difference between these two interest rates. Assume also that she decides to minimize the risk of maturity-mismatches by borrowing and lending at the same maturity. Upon deciding which maturity-portfolio to hold, an investor would compare the expected risk-return trade-off across maturities.

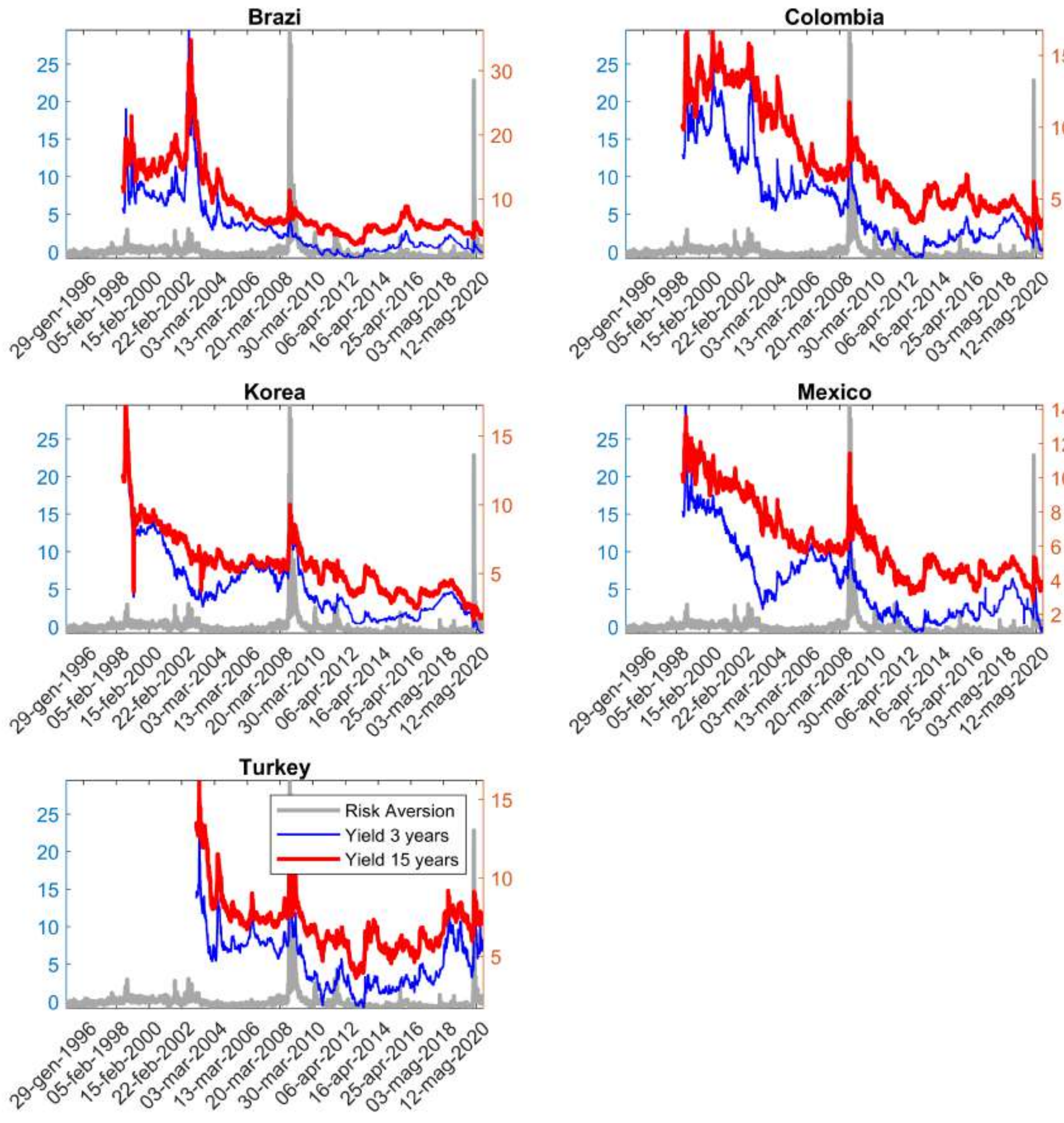

Figure 1: Time series of short term yields, long term yields, and global risk aversion shocks (left scale). Unit of measure for yields are annualized percentage points.

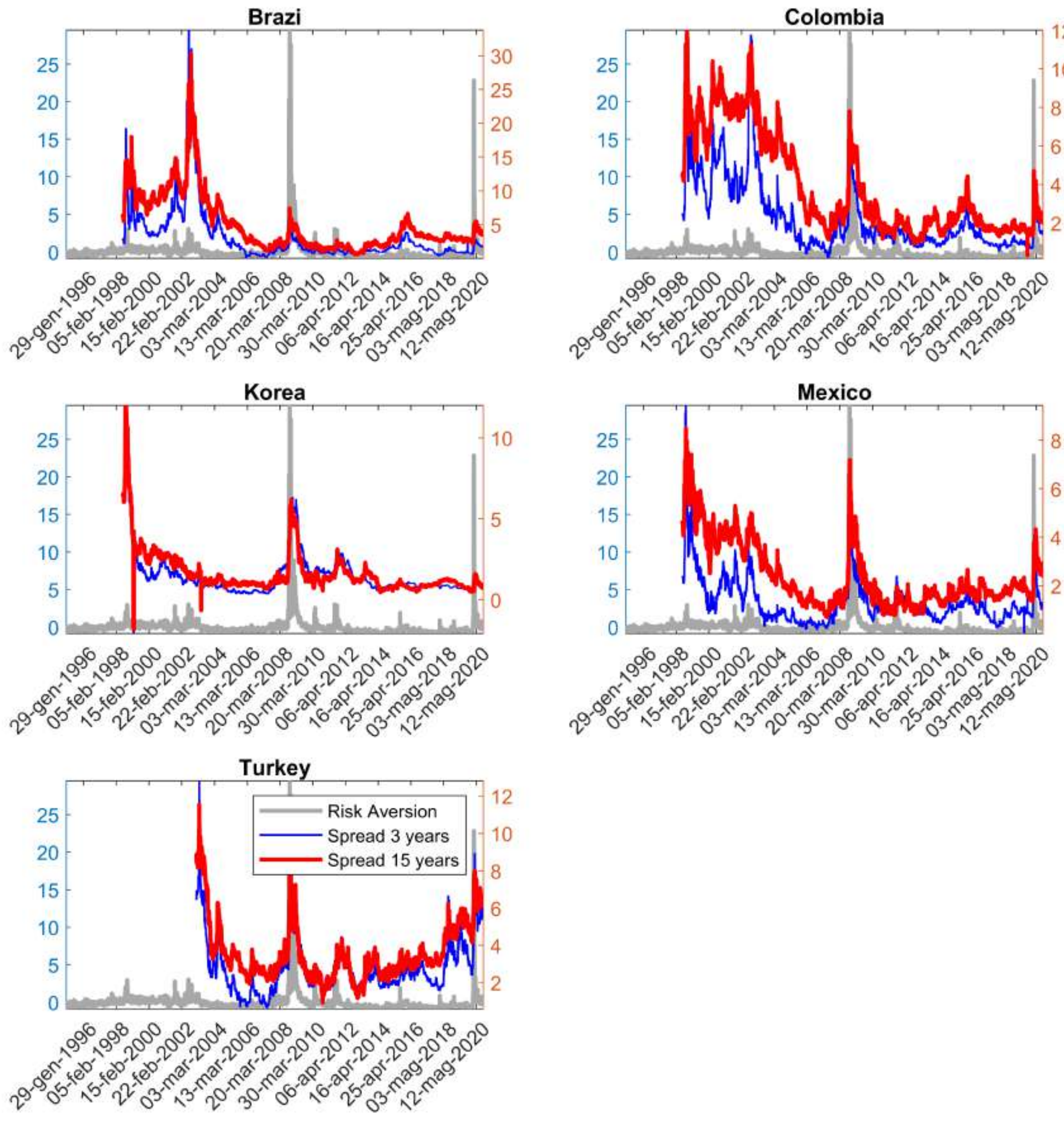

Figure 2: Time series of short term spreads, long term spreads, and global risk aversion shocks (left scale). Unit of measure for spreads are annualized percentage points.

Sharpe ratio during high, and low risk-aversion periods

	Spread 3 years	Spread 9 years	Spread 12 years	Spread 15 years
		Low global risk-aversion periods		
Sharpe ratio	1.44	1.57	1.56	1.55
		High global risk-aversion periods		
Sharpe ratio	1.01	1.24	1.26	1.27
		All periods		
Sharpe ratio	0.93	1.15	1.18	1.19

Table 2: The table shows the sharpe ratios of annualized daily spreads over comparable US sovereign bonds. Sharpe ratios are computed as the ratio of spread mean over its standard deviation. Results are presented for periods of high global risk-aversion (above-median), periods of low global risk-aversion (below-median), and all periods.

are used to compute “spread-prices” :

$$P_{i,t,\tau} = \sum_{k=1}^{\tau} e^{-k \cdot s_{i,t,k}} \cdot c_{t+k} + e^{-\tau s_{i,t,\tau}}, \tag{1}$$

where c_{t+k} is the coupon at period $t+k$. Second, excess-returns are obtained as:

$$er_{i,t,\tau} = \frac{P_{i,t+1,\tau-1}}{P_{i,t,\tau}} - 1. \tag{2}$$

Then, excess returns are winsorized at both sides at the 2.5% threshold, in order to remove outliers and avoid extreme measurement errors.[18] Computing excess returns from “spread-prices” allows to compare bonds with different yield structure.[19]

[18]Our baseline results are robust to removing extreme observations for excess returns.

[19]An alternative, but equivalent, approach consists in estimating returns separately for EME and US bonds, using yields. Then excess returns are obtained by subtracting EM returns and US ones. The difficulty of this procedure relies on constructing comparable risky and risk-less bonds. In fact, implementing bonds with the same maturity and coupon structure might be misleading, as the EME display significantly higher yields, which affect significantly the payment structure. For a thorough analysis of this point, see Broner et al. (2012).

Excess term premium during high, and low global risk-aversion periods

	er9-er3	er12-er3	er15-er3
	Low global risk-aversion periods		
Excess term-premium	0.30	0.41	0.50
	High global risk-aversion periods		
Excess term-premium	0.08	0.09	0.11
	All periods		
Excess term-premium	0.19	0.26	0.31

Table 3: The table shows the annualized mean excess term-premium, which is computed as the average difference of excess returns (er) of EM sovereign securities over comparable US bonds. Excess returns (er) are estimated using holding period returns of one month and for a coupon rate of 7.5%. er3, er9, er12, and er15 stand for three-, nine-, twelve-, and fifteen-year excess returns. Results are presented for periods of high global risk-aversion (above-median), periods of low global risk-aversion (below-median), and all periods. Unit of measure: percentage points.

We define *excess term premium* as the difference between the excess return on long term bonds with maturity τ_2 and short term bonds with maturity τ_1, as:[20]

$$etp_{i,t,\tau_2-\tau_1} = er_{i,t,\tau_2} - er_{i,t,\tau_1}. \tag{3}$$

Table 3 shows the average excess term premium obtained by comparing one short term bond, with maturity of three years, with a set of long term bonds, with maturities of nine, twelve and fifteen years. In computing the results, we assume an annual coupon rate of 7.5% (paid semiannualy), as the majority of EME bonds display a coupon payment. The selected maturity and coupon structure are representative of EME sovereign bonds (Broner et al., 2012). The excess term premium decreases in period of high (above-median) risk aversion across all set of maturities, with larger drops at longer maturities. In fact, in low risk-aversion periods, emerging markets pay a risk premium 0.5% higher when issuing 15−year bonds than 3−year ones. However, in periods of high risk-aversion, the excess term premium reduces to 0.1%. As a consequence, on average, borrowing long term becomes *cheaper* in periods of high global risk aversion.

6 Econometric Setup

In this Section we define the methodology we intend to apply in our empirical estimation. In the baseline analysis, we rely on the US-based proxy for global risk aversion

[20]Our definition of *excess term premium* follows Broner et al. (2012).

(i.e. risk aversion of US financial markets) provided by Bekaert et al. (2021).

In the robustness analysis (Section 8), we describe the procedure to obtain an alternative US-based proxy for global risk aversion, based on Bekaert et al. (2013), and show the robustness of our baseline results to the new measure. Moreover, we replicate our analysis with a dummy crisis that would capture the increase in risk aversion of international investors specific to each EME, as in Broner et al. (2012). Our main results are robust across global risk aversion variables and using country-specific measure of investor risk aversion.

6.1 Identifying global risk aversion shocks

We identify global risk aversion shocks by regressing the series on contemporaneous and lagged US interest rates, and using the residuals as the identified shocks. In particular, we obtain global risk aversion shocks u_t from the following regression, estimated at the daily frequency:

$$RA_t = \theta_0 + \Theta_1(L) Z_t + u_t, \tag{4}$$

where RA_t is the global risk aversion measure provided by Bekaert et al. (2021), Z_t is the 1-year US sovereign zero-coupon yield, and $\Theta_1(L)$ is a lag polinomia of order 1.[21] The essence of the identification scheme is close to Akinci (2013) and aims to disentangle the exogenous component of the US-based proxy for global risk aversion from the one predicted by US interest rates, reflecting US financial conditions and monetary policy.[22] In the baseline specification we control for one lag of US interest rates, i.e. one business day, as financial variables are assumed to incorporate without delay any information on the current or perspective state of the economy.[23] Figure (1) and Figure (2) plot the identified global risk aversion shocks. The largest increase in the series are in 2008, during the Global Financial Crisis, and in the first half of 2020, at the onset of the financial turmoil related to the spread of the Covid-19 pandemic. Therefore, our estimated global risk aversion shocks seem to capture well the shifts in "risk-appetite" of US-based investors across the past decades.

[21] The choice of 1-year interest rates as representative of the monetary policy stance and financial conditions in the US is standard in the literature (Gertler and Karadi, 2015 and Miranda-Agrippino and Ricco, 2020, among others).

[22] Akinci (2013) estimates a VAR at a quarterly frequency and defines "global financial shock" the innovations in US financial risk variables that are orthogonal to present and lagged (1 lag) US interest rates.

[23] Another study that employs, at a daily frequency, data on US financial markets and uses 1-day lagged controls is Wright (2012).

6.2 Estimating the responses of spreads and excess term premia to global risk aversion shocks

With the identified global risk aversion shocks at hand, we estimate the dynamic responses of spreads and excess term premia via a panel local projection model (Jorda, 2005):[24]

$$y_{i,t+h,\tau} = \alpha_{h,\tau} + \gamma_{i,h,\tau} + \beta_{h,\tau} u_t + \delta_{h,\tau} u_{t-1} + \omega_{h,\tau}(L) y_{i,t-1,\tau} + B_{h,\tau}(L) X_{t-1} + v_{i,t+h,\tau}, \quad (5)$$

where $\alpha_{h,\tau}$ is the constant term; $\gamma_{i,h,\tau}$ denotes country fixed effect; u_t is the global risk aversion shock, whose first lag is included to control for potential predictability and autocorrelation. X_{t-1} denotes country-specific and global controls, such as: first-difference of country i stock price index (in logs), controlling for expected macroeconomic conditions related to country i;[25] the first-difference of country i bilateral nominal exchange rate with USD (in logs), controlling for a depreciation in domestic currency that may occur at the time of high global risk aversion and affect the financial stability of the EME; and the first-difference of the nominal oil price (in logs) to control for changes in commodity prices.[26] Finally, $y_{i,t+h,\tau}$ is the EME i financial variable, at horizon h, for USD-denominated sovereign bonds issued at maturity τ. We estimate the dynamic responses of two EME financial indicators: spreads ($y_{i,t,\tau} = s_{i,t,\tau}$) and excess term premia ($y_{i,t,\tau} = etp_{i,t,\tau 2-\tau 1}$). In particular, we consider excess term premia obtained by comparing one short term bond, with maturity of three years (τ_1), with a set of long term bonds, with maturities of nine, twelve and fifteen years (τ_2). We estimate standard errors robust to cross-sectional and time-series correlation, following Discroll and Kraay (1980).[27]

7 Results

In this Section we report the responses to a global risk aversion shock that increases the 15-year spread by 10 basis points, on impact. The responses are computed up to

[24]With respect to vector autoregressive (VAR) models, local projections are considered more robust to mispecification since they do not impose restrictions on the dynamic responses of the variables of interest.

[25]Broad stock market price indexes reflect the (average) returns across the cross sections of firms that are quoted in the country stock exchange. If firms quoted in the stock exchange are also operating in the same country, then the stock market index is, at least in part, reflecting the average (expected) performances (i.e. returns) of the overall economy.

[26]In the baseline analysis, we employ a lag polinomia or order zero, i.e. L=0. In other words, we use only the first lag of country-specific and global variables as controls.

[27]Discroll and Kraay (1980) represents a suitable econometric tool for panel local projection analysis, which are potentially characterized by cross-sectional correlation across countries, and time-series correlation in the residuals of the estimations.

22 business days, representing one calendar month. Global risk aversion shocks increase spreads, at all maturities (Figure 3). The response is statistically significant and consistent with the literature (e.g. Hofmann et al., 2019), which associates an increase in the risk aversion of international financial markets with a rise in spreads between emerging market sovereign bonds and comparable bonds issued by the United States.

Then, we estimate regression (5) using as a dependent variable the excess term premium. Our findings show that in response to global risk-aversion shocks, the excess term premium *decreases*, at a statistically significant level, for all maturities (Figure 4). This result is opposite to the view, proposed by Broner et al. (2012), that during periods of distress financial intermediaries charge a higher risk premium on long term bonds than short term ones, making it cheaper for emerging markets to borrow short term.

Our finding can be rationalized by considering the change in the risk-reward trade-off across maturities, passing from periods of low to high global risk aversion. As underlined in Section 4 the Sharpe ratio decreases in periods of high global risk aversion at all maturities, with a major drop experienced at shorter maturities: during periods of high global risk aversion the amount of reward per unit of risk decreases *less* for long term bonds than short term ones (Table 2). Therefore, in periods of high global risk aversion, holding long term bonds become more convenient for international investor and, thus, issuing long term debt is *cheaper* for EMEs.

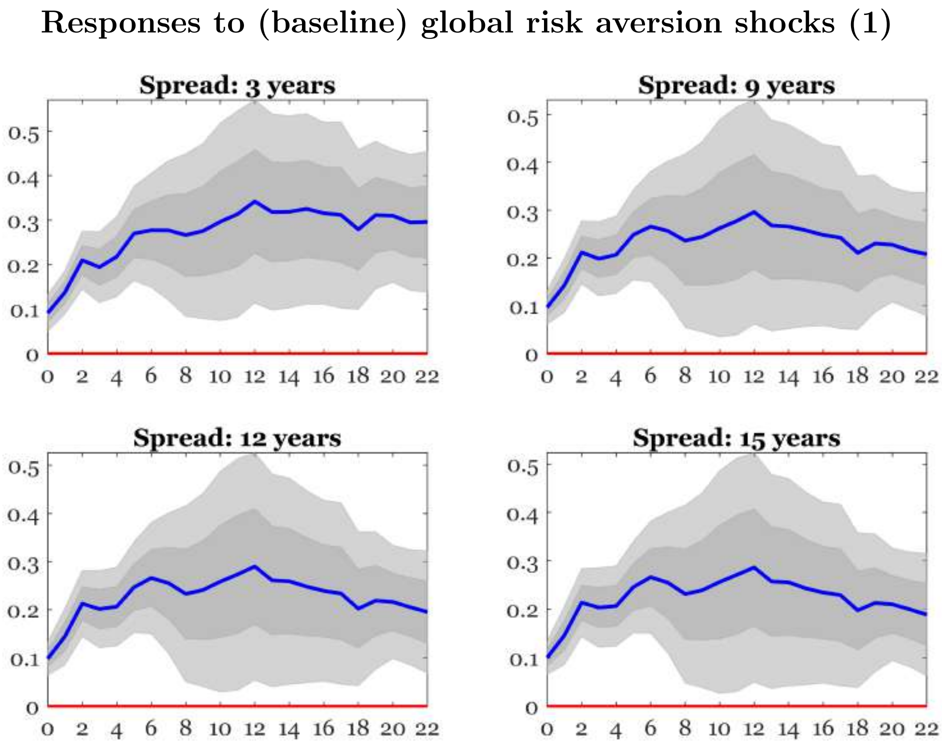

Figure 3: Impulse response functions to a global risk aversion shock (baseline estimate) that determines a 10 basis point increase in the 15-year spread, on impact. Solid lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 95% confidence intervals. The x-axis shows business days after the shock. Unit of measure: percentage points.

Responses to (baseline) global risk aversion shocks (2)

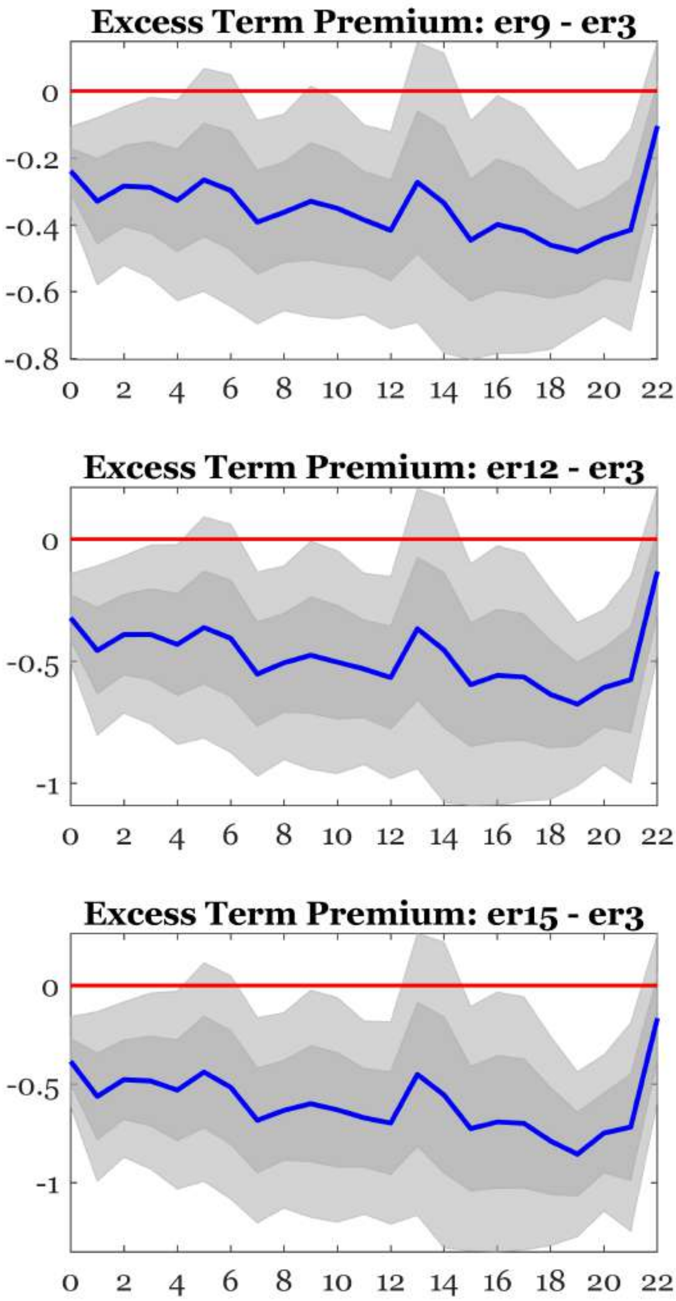

Figure 4: Impulse response functions to a global risk aversion shock (baseline estimate) that determines a 10 basis point increase in the 15-year spread, on impact. Solid lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 95% confidence intervals. The x-axis shows business days after the shock. Unit of measure: percentage points.

8 Robustness Analysis

The results outlined in Section 7 lend support to the view that shocks to global risk aversion significantly affect the financial conditions at which EMEs can borrow in the international financial markets. In particular, we show that an increase in global risk aversion determines: a rise in spreads, and a drop in excess term premia. In this Section we explore the robustness of these findings by considering an alternative measures of US-based global risk aversion. In addition, in order to link our results to the literature, we replicate our estimation with a "dummy crisis", proposed by Broner et al. (2012), that would capture the country-specific increase of investor risk aversion.

8.1 An alternative measure of global risk aversion

An alternative US-based proxy for global risk aversion, at a daily frequency, can be obtained by implementing the approach of Bekaert et al. (2013). The procedure is based on decomposing the (squared) VIX_t into a risk aversion, RA_t, and a pure volatility component, $\widehat{RV}_t$, measured by the expected monthly variance of the S&P 500 returns. An intuition for the suggested decomposition is that the squared VIX_t well approximates the expected value of (30-day) return variance for the S&P index based on "risk-neutral" probabilities (Carr and Wu, 2009); while the S&P expected variance, $\widehat{RV}_t$, builds on "physical", or actual, probabilities. The difference between "risk-neutral" and "physical" expected variance is the "variance risk premium", accounting for the price investors are willing to receive to be exposed to variance risk, which is increasing in risk aversion (Bekaert and Hoerova, 2013).[28]

This approach is implemented in two steps. First, we obtain a measure of S&P 500 *predicted* monthly variance of returns, $\widehat{RV}_t$, that is interpreted as the degree of uncertainty that financial markets expect over the following month. To do so, we calculate the monthly realized variance as the sum of daily variances of S&P 500 returns within the same month;[29] then, we project the monthly realized variance of returns onto the lagged squared VIX (divided by 120000)[30] and lagged realized monthly variance, as:

$$RV_t = c_0 + c_1 VIX^2_{t-22} + c_2 RV_{t-22} + e_t. \tag{6}$$

[28]In the finance literature the variance premium is the negative of the variable employed. By switching the sign, the measure of variance premium is increasing with risk aversion.

[29]In order to obtain daily measures of monthly realized variances, we simply sum the observations of daily variances over a fix time span of 22 business days (one calendar month), as in Bekaert et al. (2013). Heber et al. (2009) provide an array of daily measure of S&P 500 return variances, by following Barndorff-Nielsen et al. (2008) we choose the realized kernel variance (non-flat parzen) (Table A.3).

[30]Note that the VIX is a measure of volatility, which is annualized and expressed in percentages. Therefore, in order to make it comparable to the estimated monthly realized variance of returns, we divide it by a scaling factor of 120000.

The fitted value of the regression (6), $\widehat{RV}_t$, is the *predicted* variance of returns of the S&P 500 over a month horizon. We follow the convention of considering one calendar month composed of 22 business days, as in Bekaert et al. (2013).

As a second step, we decompose the squared VIX into a risk aversion and an uncertainty component and extrapolate global risk aversion, RA_t, according to the procedure presented above:

$$RA_t = VIX_t^2 - \widehat{RV}_t. \tag{7}$$

We label the alternative US-based measure of global risk aversion shocks "volatility-based", as it crucially builds on stock market volatilities.

8.1.1 Alternative measure of risk aversion: discussion of the results

Then, we fed the alternative US-based measure of global risk aversion shocks into the model (equations 4 and 5) and replicate the empirical analysis. Similarly to the baseline estimation, volatility-based global risk aversion shocks determine both an increase in spreads and a drop in the excess term premia, at all maturities (Figure A.1 and Figure A.2).

8.2 Dummy crisis

We next investigate whether our baseline results are robust to an increase of country-specific investor risk aversion, proxied by a "dummy crisis". This variable captures episodes of financial crisis specific to each EME and, as a consequence, it could proxy for changes in the risk attitude of international investors towards a specific country. We build this variable along the lines of Broner et al. (2012). We set the beginning of a crisis when the nine-year spread is greater than a threshold, computed as the average of the nine-year spreads over the previous six months plus 300 basis points. The crisis terminates after the first four week period (20 business days) in which the spread remains below the threeshold. This procedure allows us to use only ex-ante information in defining the crisis periods, i.e. we use only the information available to market participants at time t. Then, we use our crisis definition to compute a "dummy crisis" that take the value of 1 during crisis periods, and 0 otherwise. The crisis periods obtained cover all the major crisis identified by the literature:[31] the Brazilian crisis at the end of the 90s; the financial turmoil for Brazil and Colombia in 2002; the 2008 distress related to the Global Financial Crisis, which affected all the countries; and the one related to the spread of

[31] See, for example, Reinhart and Rogoff (2009) and Reinhart (2021).

the Covid-19 pandemic (Figure A.5 and Figure A.6). In order to investigate whether our baseline results are robust to country-specific increase of investor risk aversion, we implement the analysis outlined in Section 6.2 by considering our "dummy crisis" as the shock; i.e. $u_t = \text{dummy crisis}_t$, in equation (5).

8.2.1 Dummy crisis: discussion of the results

In this Section we explore the robustness of our baseline results to a measure of investor risk aversion that is country-specific, rather than associated to distress in the US financial markets. Figure (A.3) and Figure (A.4) present the response of spreads and excess term premia to the dummy crisis. As it is immediate to see, crisis events determine an increase in spreads and a drop in excess term premia, at all maturities. The robust finding is that even for country-specific risk-aversion shocks, the same pattern of responses emerge for spreads and excess term premia. Table (A.4) - Table (A.5) provide further evidence for the mechanism outlined in Section (4) and Section (5).

Our results are in contrast with the ones obtained by Broner et al. (2012), although reached with a similar methodology. However, this comparison is subject to several caveats. First, on the most superficial level, the findings may differ due to the time-span or set of countries taken into account.[32] Second, the authors compare the returns of emerging market sovereign bonds with two "risk-less" benchmarks: bonds issued by Germany, and denominated in Deutsche mark or euro; and bonds issued by the United States in USD. In case the behavior of these two benchmarks has diverged in the past decades, different results can be obtained by focusing only on one of them. Third, in our sample large emerging market economies are over represented (Brazil, Korea, Mexico, and Turkey); while this does not occur in Broner et al. (2012), in which the sample is balanced between large and medium-scale emerging markets. Arguably, large emerging markets are more financially open and, thus, may respond to financial shocks differently from smaller and closer economies.

9 Conclusions

In this analysis we study the impact of global risk aversion shocks on emerging market borrowing costs. In a sample of five emerging markets we show that in response to global risk aversion shocks: spreads rise, at all maturities; and borrowing long term becomes *cheaper*. In other words, periods of high global risk aversion are characterized by an

[32]Broner et al. (2012) implement their study over the period 1990 − 2009, and consider eleven emerging market economies: Argentina, Brazil, Colombia, Hungary, Mexico, Poland, Russia, South Africa, Turkey, Uruguay, and Venezuela.

increase in the cost of borrowing at all maturities, but they make borrowing long term more favourable compared to low risk aversion periods. In fact, on average, emerging markets pay a higher risk premium on long-term than short-term bonds. In periods of high risk aversion the difference across the two risk premia *reduces*. We can rationalize our findings by considering that passing from period of low to high risk aversion, the risk-reward trade-off (Sharpe ratio) changes in favour of longer maturities: the amount of reward for unit of risk decreases at all maturities, but it drops more for EME sovereign short term bonds than long term bonds. Thus, holding long term bonds become more convenient for international investors. Our findings provide novel evidences on the impact of global risk aversion shocks on excess term premia in emerging markets. Our results are robust to alternative specifications of the global risk aversion variable, and to changes in the risk attitude of international investors towards a specific country. An extension of the present research would investigate the impact of global risk aversion shocks on the maturity of bonds issued by emerging markets.

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Appendix

A Data

Yield Data

Countries	Start	End	Observed maturities
Brazil	30-Jun-1998	13-Oct-2020	3 and 6 months; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 15 years.
Colombia	30-Jun-1998	13-Oct-2020	3 and 6 months; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 15 years.
Korea	30-Jun-1998	13-Oct-2020	3 and 6 months; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 15 years.
Mexico	30-Jun-1998	13-Oct-2020	3 and 6 months; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 15 years.
Turkey	17-Jan-2003	13-Oct-2020	3 and 6 months; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 15 years.
US	29-Dec-1994	13-Oct-2020	3 and 6 months; 1, 8, 9, 10, and 30 years.

Table A.1: Data source: Bloomberg, zero-coupon yield curves related to sovereign securities invoiced in USD.

Stock market and bilateral exchange rate data

Countries	Stock market price index	Exchange rate
Brazil	2/01/90 - 13/10/20	10/10/94 - 13/10/20
Colombia	31/12/92 - 13/10/20	27/11/91 - 13/10/20
Korea	2/01/90 - 13/10/20	2/01/90 - 13/10/20
Mexico	2/01/90 - 13/10/20	11/10/94 - 13/10/20
Turkey	2/01/90 - 13/10/20	2/01/90 - 13/10/20

Table A.2: Exchange rate refers to the bilateral nominal exchange rate with USD: $\frac{\#LC}{1USD}$. Stock market price index refers to the MSCI (Morgan Stanley Capital International) domestic stock market price index, denominated in USD. Data source: Thomson-Reuters Datastream database.

Additional variables

Variable	Description	Time Span	Source
Oil price	Cushing OK WTI Spt Price FOB U$/BBL	02/01/90 - 13/10/20	Datasetream
VIX	CBOE S&P 500 Volatility Index	02/01/90 - 13/10/20	FRED
RA	Risk aversion	02/01/90 - 13/10/20	Bekaert et al. (2021)
RV	Realized kernel variance (non-flat parzen) of S&P 500	03/01/00 - 13/10/20	Heber et al. (2009)

Table A.3: The acronyms correspond to the following sources. Datastream: Thomson-Reuters Datastream database; FRED: Federal Reserve Economic Data. Heber et al. (2009) extends their dataset until July 2021 (current library version: 0.3).

B Robustness

B.1 Figures

Responses to volatility-based global risk aversion shocks (1)

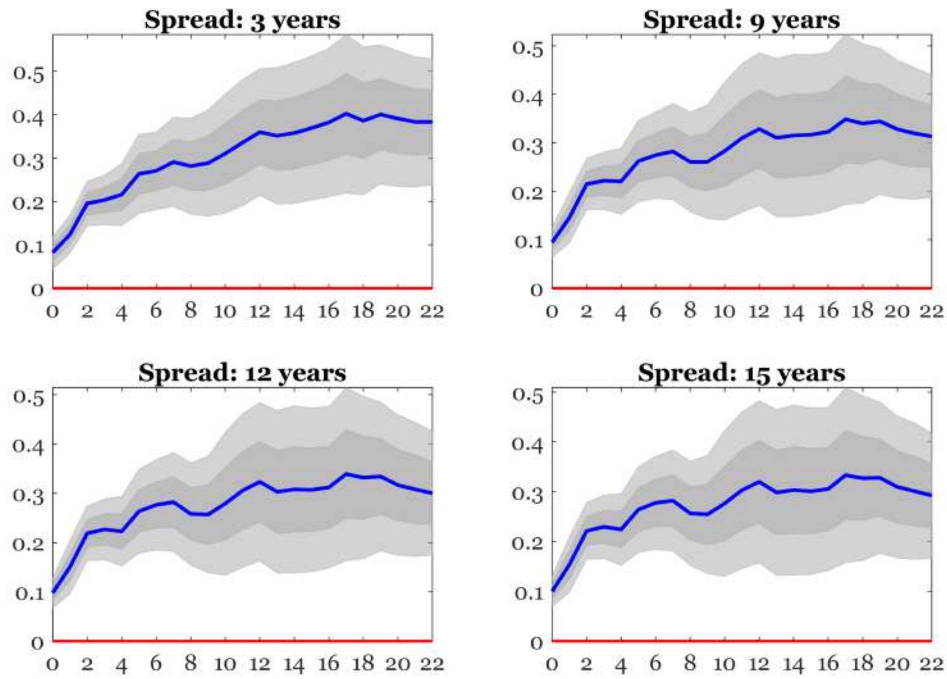

Figure A.1: Impulse response functions to a volatility-based global risk aversion shock that determines a 10 basis point increase in the 15-year spread, on impact. Solid lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 95% confidence intervals. The x-axis shows business days after the shock. Unit of measure: percentage points.

Responses to volatility-based global risk aversion shocks (2)

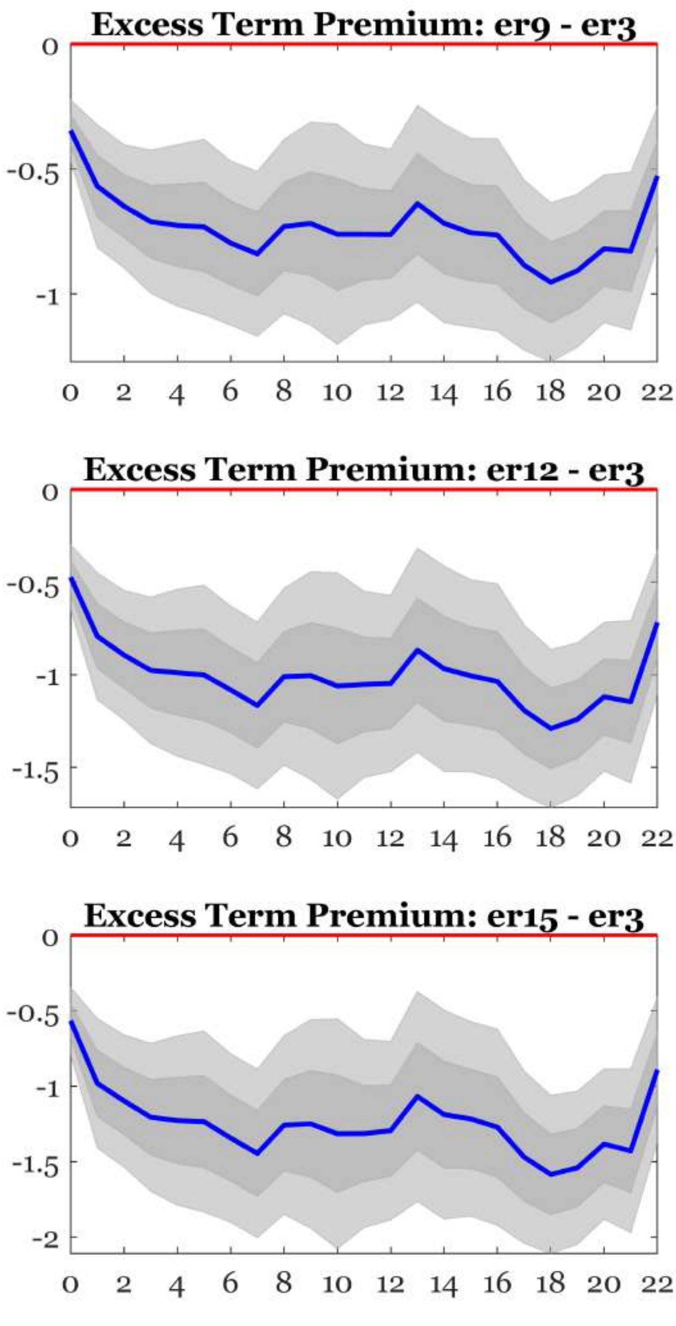

Figure A.2: Impulse response functions to a volatility-based global risk aversion shock that determines a 10 basis point increase in the 15-year spread, on impact. Solid lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 95% confidence intervals. The x-axis shows business days after the shock. Unit of measure: percentage points.

Responses to a dummy crisis (1)

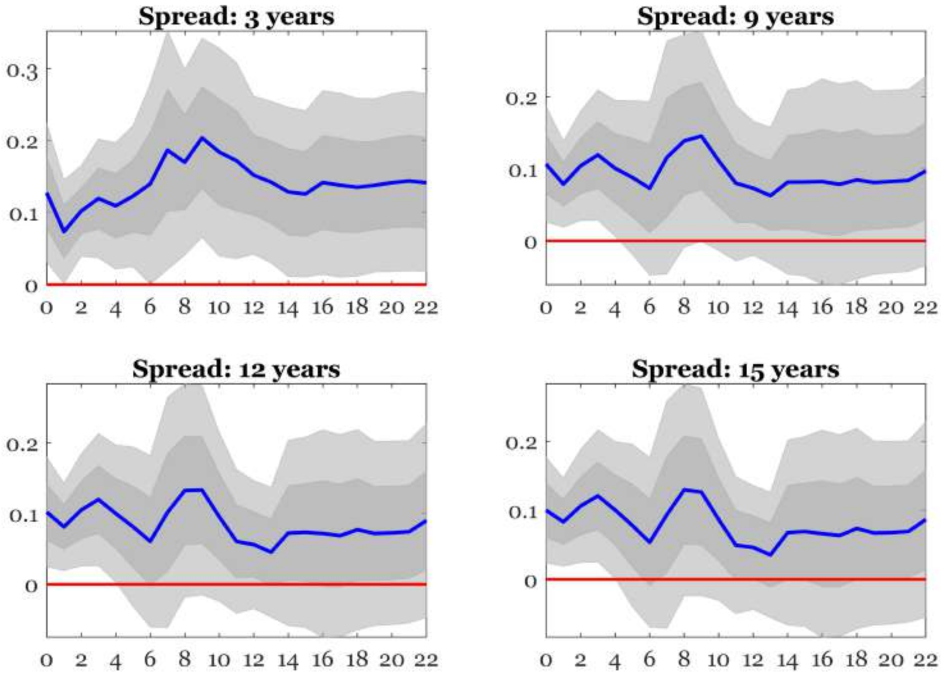

Figure A.3: Impulse response functions to a dummy crisis that determines a 10 basis point increase in the 15-year spread, on impact. Solid lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 95% confidence intervals. The x-axis shows business days after the shock. Unit of measure: percentage points.

Responses to a dummy crisis (2)

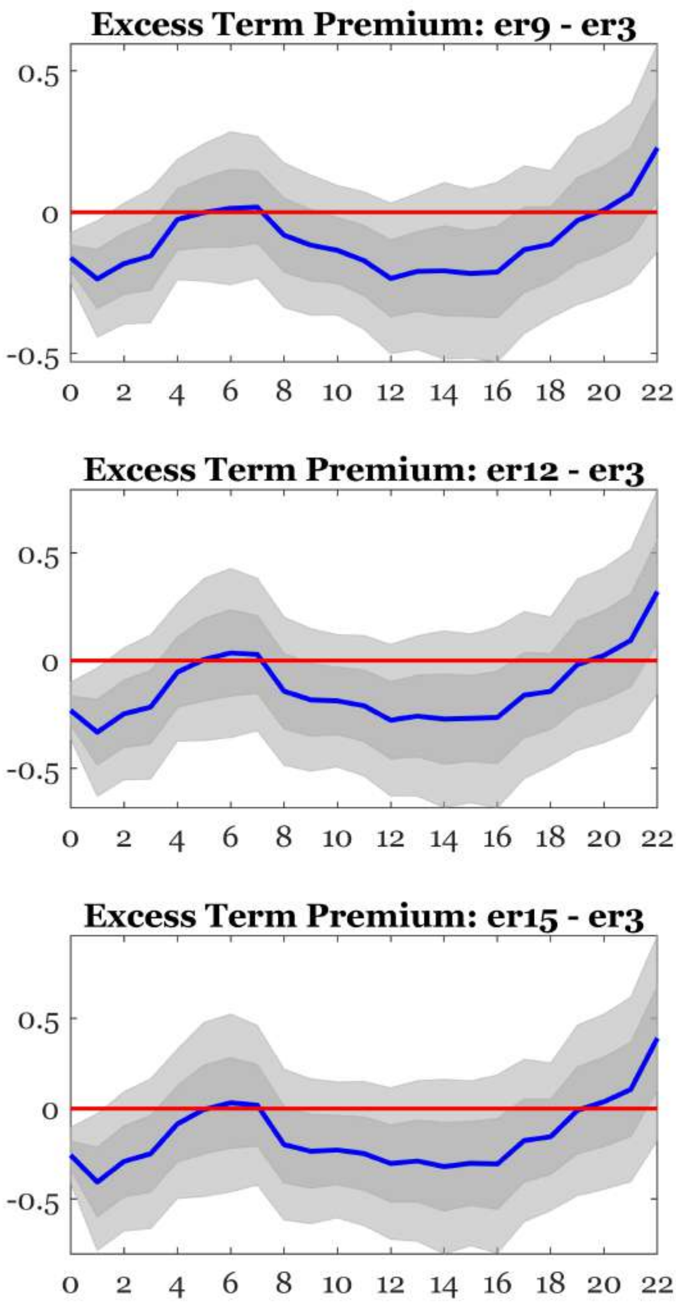

Figure A.4: Impulse response functions to a dummy crisis that determines a 10 basis point increase in the 15-year spread, on impact. Solid lines: point estimates; dark gray area: 68% confidence intervals; light gray shaded area: 95% confidence intervals. The x-axis shows business days after the shock. Unit of measure: percentage points.

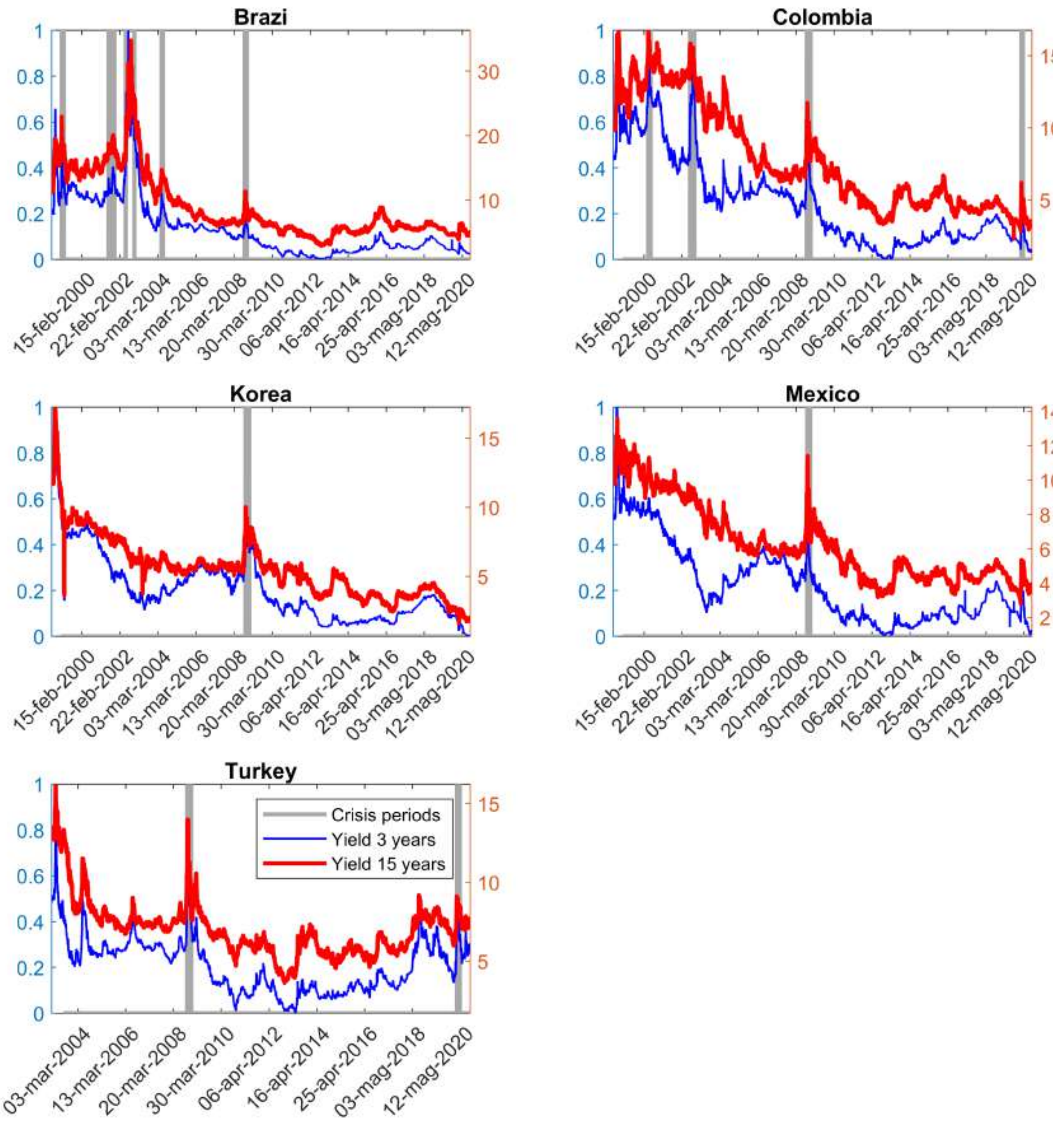

Figure A.5: Time series of short term yields, long term yields, and crisis dummy (left scale). Unit of measure for yields are annualized percentage points.

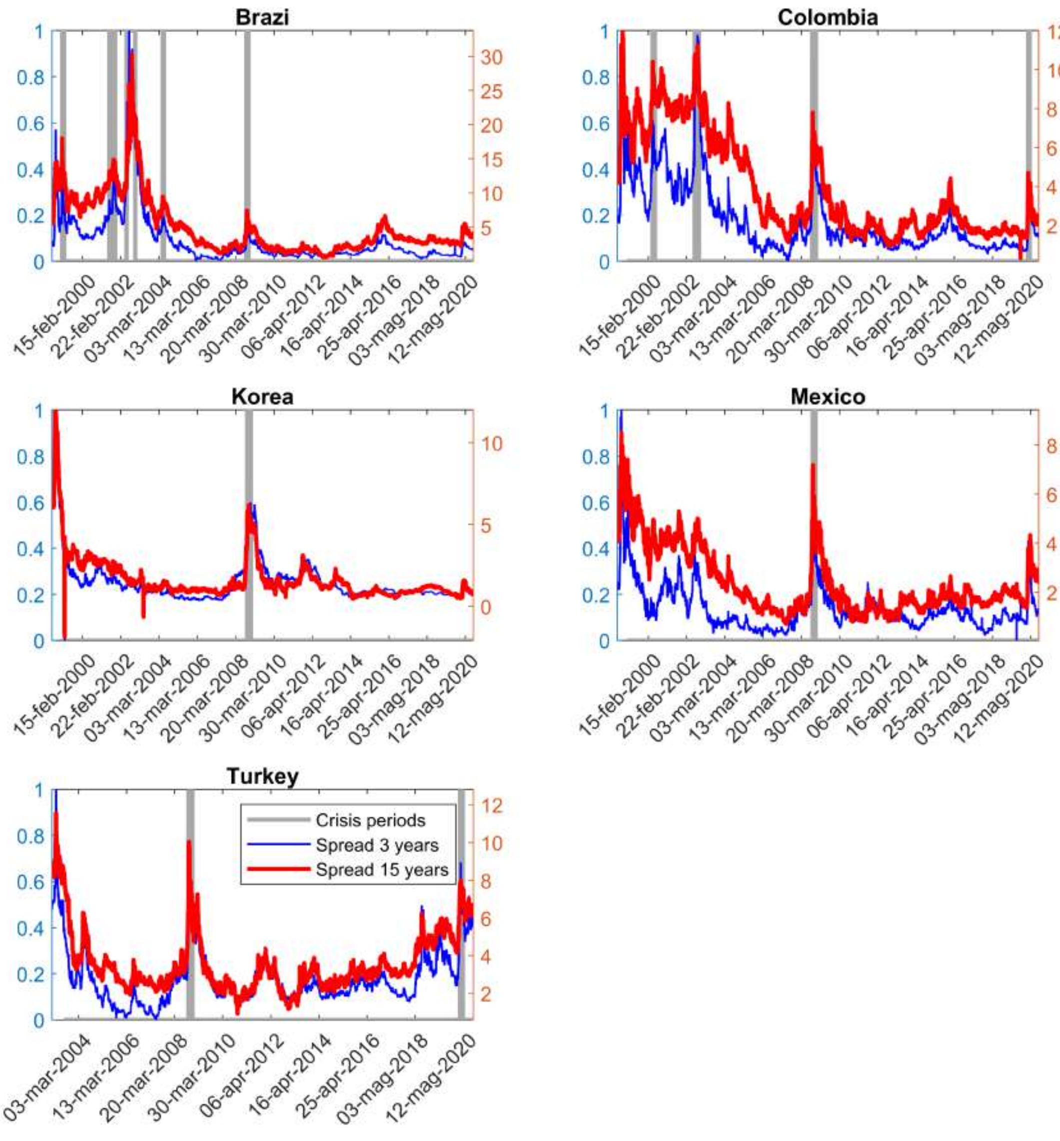

Figure A.6: Time series of short term spreads, long term spreads, and crisis dummy (left scale). Unit of measure for spreads are annualized percentage points.

B.2 Tables

Mean and standard deviation of annualized spreads, during crisis and non-crisis periods, over comparable US bonds.

	Spread 3 years	Spread 9 years	Spread 12 years	Spread 15 years
		No-crisis periods		
Mean	1.88	2.74	2.90	3.00
Standard Deviation	1.56	2.10	2.22	2.30
		Crisis periods		
Mean	9.84	10.30	10.34	10.36
Standard Deviation	6.89	5.94	5.78	5.70
		All periods		
Mean	2.16	3.03	3.19	3.28
Standard Deviation	2.30	2.62	2.70	2.76

Table A.4: The table shows the average and standard deviation of the annualized daily spread over comparable US sovereign bonds. Results are presented for crisis periods (595 observations), no-crisis periods (26,637 observations), and all periods (27,232 observations). Unit of measure: percentage points.

Sharpe ratio during crisis, and non crisis periods

	Spread 3 years	Spread 9 years	Spread 12 years	Spread 15 years
		No-crisis periods		
Sharpe ratio	1.20	1.30	1.30	1.30
		Crisis periods		
Sharpe ratio	1.42	1.73	1.78	1.81
		All periods		
Sharpe ratio	0.93	1.15	1.17	1.18

Table A.5: The table shows the sharpe ratio of annualized daily spread over comparable US sovereign bonds. Sharpe ratios are computed as the ratio of spread mean over their standard deviation. Results are presented for crisis periods (595 observations), no-crisis periods (26,637 observations), and all periods (27,232 observations).

Excess term premium during crisis, and non crisis periods

	er9-er3	er12-er3	er15-er3
	No-crisis periods		
Excess term-premium	0.24	0.32	0.39
	Crisis periods		
Excess term-premium	−1.64	−2.02	−2.38
	All periods		
Excess term-premium	0.19	0.26	0.31

Table A.6: The table shows the annualized mean excess term premium, which is computed as the average difference of excess returns (er) of EM sovereign securities over comparable US bonds. Excess returns (er) are estimated using holding period returns of one month and for a coupon rate of 7.5%. er3, er9, er12, and er15 stand for three-, nine-, twelve-, and fifteen-year excess returns. Results are presented for crisis periods (595 observations), no-crisis periods (26,637 observations), and all periods (27,232 observations). Unit of measure: percentage points.