# The Macroeconomic Consequences of VAT Rebates on Exports*

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## Abstract

We investigate the use of Value-Added Tax Rebates on Exports (VAT-RX), leveraging a novel Chinese industry-level data set. We find that: (1) VAT-RX has been a widely utilized policy tool in China; (2) at the cross-section, changes in VAT-RX were associated with improvements in export performance during the global financial crisis; and (3) changes in the aggregate VAT-RX is typically implemented in a countercyclical manner. We integrate these empirical findings into a two-country DSGE model estimated with Bayesian methods to evaluate the macroeconomic consequences of VAT-RX policy. We estimate that without changes to the VAT-RX policy during the global financial crisis, China's aggregate exports and GDP would have been 3.7 and 0.3 percentage points lower, respectively.

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# 1 Introduction

Recent years have seen a resurgence of active trade policy across the globe, with both developed and developing countries increasingly employing measures to influence trade flows and domestic macroeconomic conditions. The rise in tariffs and non-tariff barriers since 2018 (Fajgelbaum, Goldberg, Kennedy and Khandelwal, 2020; Fajgelbaum and Khandelwal, 2022; Chen, Hsieh and Song, 2022), particularly in the context of the US-China trade tensions, has garnered significant research attention. However, the role of export subsidies, and specifically the sustained and active use of VAT-RX by China, has received comparatively less scrutiny. While permitted under World Trade Organization rules and utilized by many countries, China's application of this policy stands out for its consistent and widespread implementation over time.

This paper addresses this gap by examining the effects of China's VAT-RX policy during the period 2004-2019. Utilizing a granular dataset exhibiting considerable variation in these rebates across sectors and over time, we document new empirical facts regarding the use of VAT-RX by the Chinese government. We integrate the empirical evidence into a dynamic stochastic general equilibrium (DSGE) model to analyze the policy's impact on trade, international prices, and the broader economy. Our analysis reveals the significant and often underestimated role of VAT-RX as a trade policy tool. Moreover, we explore the connection between changes in these rebates and fiscal devaluation under China's managed exchange rate system, drawing insights from the seminal work of Farhi, Gopinath and Itskhoki (2014).

We document three important empirical regularities concerning the use of VAT-RX in China. First, unlike the standard practice in most WTO member countries of maintaining a uniform VAT rebate on exports, we show that China has adjusted these rates across sectors and over time. This strategic variation provides a valuable setting to investigate the macroeconomic implications of actively using fiscal policy to influence international trade.

Second, we present evidence of a significant link between VAT-RX rates and sectoral export performance. To establish this, we exploit the heterogeneous changes on VAT-RX rates during the Global Financial Crisis (GFC), where some products experienced an increase in their VAT-RX while others did not. Our empirical analysis reveals that products receiving an increase in

their VAT-RX rate experienced a roughly 30 percentage point smaller reduction in export growth between 2005 and 2010. VAT-RX policy significantly mitigated the negative impact to sectoral exports arising from the GFC.

Third, at the aggregate level, we document a strong counter-cyclical pattern in China's VAT-RX policy. We find that increases in the aggregate VAT-RX rate tend to occur after periods of lower real export and GDP growth, and before periods of stronger performance. This suggest a deliberate use of the policy to manage aggregate economic fluctuations.

To address the macroeconomic implications of VAT-RX, we develop and estimate a two-country Dynamic Stochastic General Equilibrium (DSGE) model that incorporates this policy. We extend the framework of **?** by incorporating VAT and VAT-RX policies, a rich set of shocks, and trade frictions. To quantify the impact of this policy instrument, we estimate the model using Bayesian methods. This approach allows us to infer the underlying historical sequences of the model's shocks that best match the observed data. By estimating the model and these shocks, we can then identify the specific contribution of China's VAT-RX policy to its own macroeconomy and that of the rest of the world, conditional on the other shocks.

Using the estimated model, we conduct a counterfactual analysis to examine the macroeconomic response to the GFC in the absence of China's increase in its VAT-RX rates. Our results suggest that the global trade collapse would have been more severe, with Chinese exports falling by an additional 3 percentage points. The policy also helped mitigate the decline in China's GDP growth by 0.3 percentage points, albeit at the cost of a similar reduction in consumption growth. Finally, this policy effectively acted as a quasi-fiscal devaluation, since it induced effects on allocations similar to those under a exchange rate devaluations. The increase in VAT-RX after the global financial crisis boosted Chinese exports, the trade balance, and GDP, while dampening consumption.

From a policy perspective, our findings offer important lessons for governments seeking to enhance trade competitiveness and manage macroeconomic stability. While the WTO permits a uniform 100% VAT rebate on exports, China's experience highlights the potential for a more actively managed system to function as a quasi-fiscal devaluation. Our analysis provides valuable

insights into the effectiveness of such policies in influencing not only export volumes but also international relative prices and broader economic activity. China's deviation from the standard WTO approach provides a compelling case study for understanding the wider macroeconomic consequences of strategically employing fiscal tools to influence the macroeconomy beyond their direct effects on exports.

**Literature.** Our work contributes to the literature studying the impact of VAT-RX. We contribute to this literature in several dimensions. First, we are the first to estimate the macroeconomic consequences of VAT-RX within a DSGE model, with dynamic trade elasticities. Most papers, have focus on estimating the cross-section impact of VAT-RX on sectoral exports as in (Gourdon, Hering, Monjon and Poncet, 2022; Liu and Lu, 2015; Chandra and Long, 2013; Braakmann, Gao and Maioli, 2020) or have been studied it within a context of static models Bond, Duan, Ji and Lu (2023). We also show that this policy has strong similarities to fiscal devaluations (Farhi et al., 2014; Erceg, Prestipino and Raffo, 2023).

## 2 Data

We use three main data sources: aggregate quarterly macroeconomic time series, detailed product-level information on China's Value Added Tax (VAT) and rebates to export VAT, and exports at the HS-6 level from customs data, obtained from trade data monitor. The data in both cases spans from 2004 to 2019. The initial period is determined by data constraint in our VAT data, and the end by the end of COVID-19.

### 2.1 Aggregate Quarterly Data

For aggregate macroeconomic variables at the quarterly frequency, we rely on data from the International Monetary Fund (IMF), to obtain: Gross Domestic Product (GDP) for both China and the Rest of the World, real consumption, and real and nominal exports and imports, and real effective exchange rates (REER). To capture the dynamics of international relative prices, we utilize terms of trade data sourced from the World Bank. These aggregate series are the ones

we will use to feed into out Bayesian estimation of our Dynamic Stochastic General Equilibrium (DSGE) model as we will describe later.

### 2.2 Value Added Tax Data and Export Rebates

The VAT system in China, implemented in 1994, features a standard VAT rate (which has remained constant over our study period) alongside a reduced rate for certain necessities. Importantly for our research, exported goods are theoretically subject to a zero VAT rate. However, in practice, China has historically applied a system of partial VAT refunds on exports, with the rebate rate varying significantly by sector and specific commodity. This incomplete rebate effectively implies an additional tax cost for exporters whose rebate rate is lower than the applicable VAT rate, a phenomenon akin to export taxation (Feldstein and Krugman, 1990). Indeed, over the period of 2002-2012, a significant majority of tariff lines in China featured a VAT rebate rate below the prevailing VAT rate (Liu and Lu, 2015).

The rationale behind China's use of variable and often incomplete VAT rebates on exports is multifaceted. These adjustments can serve various purposes, including the manipulation of the terms of trade, supporting food security, indirectly subsidizing higher value-added industries by limiting raw material exports, stabilizing domestic prices for export producers, managing trade surpluses, increasing government revenue, and guiding the growth of specific industries, particularly those in high-technology and value-added sectors while discouraging energy-intensive and polluting ones. Notably, significant adjustments to VAT refund rates were observed in response to growing trade surpluses in the 2000s and during the Global Financial Crisis, where rates were temporarily increased for many commodities to support export growth. On top if this we argue, that at a more aggregate level they have been use in counter cyclical fashion.

We use the data available on China's VAT system, sourced directly from the Chinese government. Our primary variable of interest is the the net VAT paid by exporters, computed as the domestic VAT rate applied to domestic sales products minus the VAT rebate rate exporters faced. In our dataset bot the domestic VAT and the rebates are specified at the Harmonized System (HS) 10-digit level. The dataset also provides the specific dates for when changes get in place, and

when the rebates ar removed.

To construct the VAT and the exporter's Net VAT aggregate measures relevant for our analysis, including the overall VAT rebate, total VAT, and net VAT, we follow the following aggregation procedure. First, for each quarter, we calculate the simple average of the VAT and the rebate rates within each HS 6-digit category, aggregating across the HS 10-digit products within the corresponding HS-6 category. This step reduces the dimensionality of the data while preserving most of the product-level heterogeneity, and is due to our lack of exports at the HS 10-digit level.

Second, we weight these HS 6-digit average rates (VAT and rebates) by the export share of the corresponding HS 6-digit category in the previous quarter. Here we make use of the custom export data coming from the Trade Data Monitor. The lagged weighting scheme helps to mitigate potential bias issues where current policy changes might simultaneously affect both VAT rebates and export performance. Our underlying HS-10 digit VAT data spans from 2004 to December 2024, but in in this paper focuses on the period 2004-2019 to ensure consistency with our aggregate macroeconomic data, and avoid the COVID-19 period.

## 3 Empirical observations

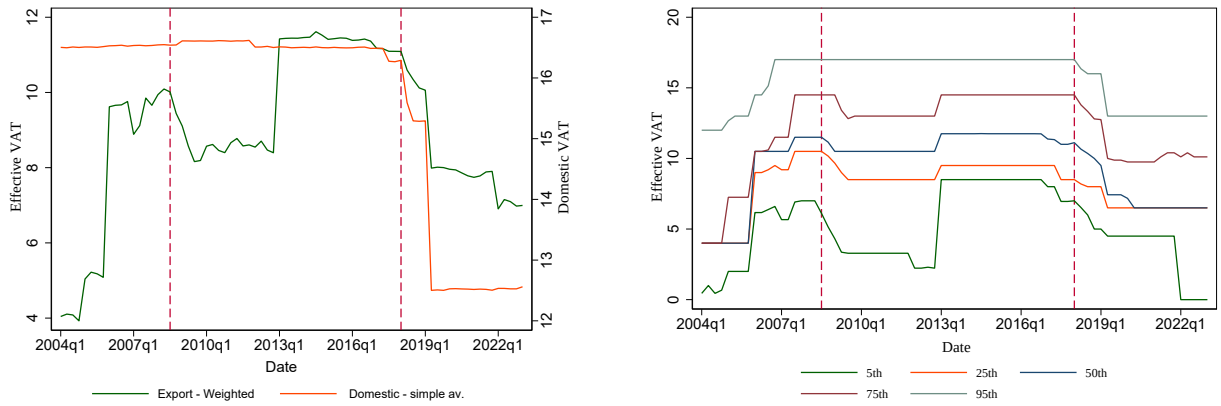
This section present three empirical observations of China's VAT-RX policy. These facts not only motivate our subsequent quantitative modeling but also provide tangible evidence of VAT-RX functioning as a quasi-fiscal devaluation tool. We present compelling evidence showing how VAT rebate policy to exports has been use as an active policy tool at the aggregate and product level in China. Then we show, how exports of products affected by a reduction in their exporter effective VAT within a year of the GFC saw a meaningful differences in their behavior. Lastly, we show how aggregate variables like exports, current account, the cyclical GDP and the fiscal balance, present dynamics correlation suggestive of the use of VAT policy as a counter-cyclical tool.

**Observation 1: China's active use of VAT rebate policy.** Figure 1 shows the evolution of the effective VAT to exports in China over time and products. While the VAT rate levied

on domestic VAT has remained relatively stable between the first quarter of 2004 and the last quarter of 2018, the average net VAT burden on exporters has experienced considerable changes, influenced directly by the VAT rebate policy as shown in Panel (a). Specifically, it is clear that VAT rebate to export increases after the beginning of the GFC, as shown by the vertical dash line in Panel a of Figure 1, which lead to a sustained reduction on exporters effective VAT until the starts of 2013. The drop was of almost 2 p.p., which is significant change at the aggregate level if it is compare to the observe changes in effective tariffs around the world since the collapse of the Bretton Woods system.

Additionally, this aggregate changes mask a even more active role at the product level as display in Panel (b). This panel, shows the evolution over time of the different percentiles of the Net VAT to exports at the HS-6 digit level. The percentiles are computed for each given date. These time series shows the movements of VAT-RX policy, suggesting an active use of this policy.

Figure 1: VAT rebate to exports: An active and time varying trade policy




(a) Average VAT Rates: Domestic vs. Exports

(b) Sectoral Export VAT Rate Dynamics

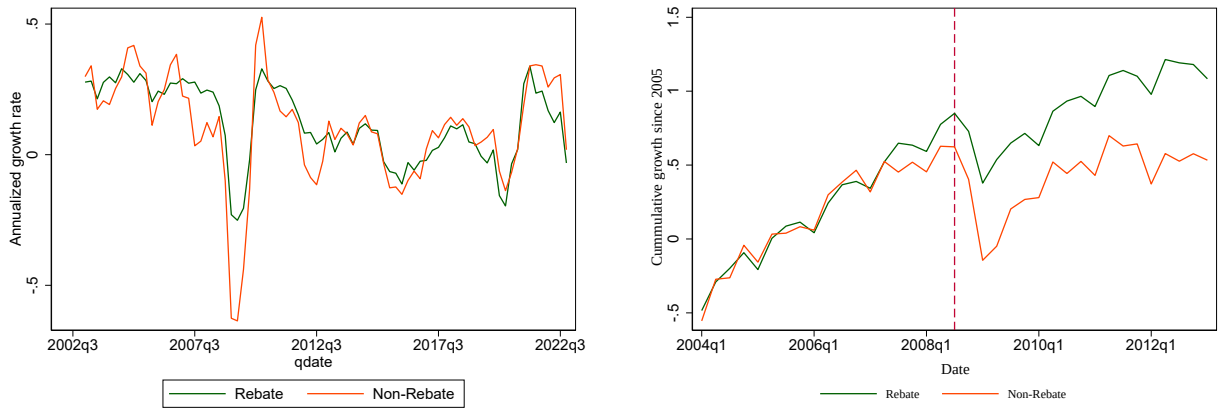
Note: Panel (a) illustrates the stable aggregate VAT rate applied to domestic sales (solid line) juxtaposed with the fluctuating aggregate net VAT rate faced by exporters (dashed line). Panel (b) provides a glimpse into the sectoral heterogeneity by showing the evolution of the VAT rate for an example sector, underscoring the targeted nature of the VAT-RX policy.

**Observation 2: VAT-RX improve export performance during GFC.** VAT-RX has significant implications for exports performance in those sectors affected by the rebate as shown in Figure 2. Two pieces of evidence support our estimate. First, Panel 2a, plots the exports mean annualized export growth over HS-6 digits of two groups: those that saw a change in their rebate at any point in time in our sample, and those that did not. It is clearly, how products non affected

by the rebate present more volatile growth rate in exports, than those ever affected.

Second, we explore how export growth evolves after the global financial crises for those products affected by an export rebate within a year window of the GFC vs those products that were not affected by rebates increases. Panel 2b, presents the mean cumulative growth relative to the average exports in 2005 among products in each of these two groups. Relative to exports in the 2005 level, the drop of products affected by the rebate was almost 30 p.p. bigger than non-affected products.

Figure 2: VAT Rebates as a Shield: Protecting Export Growth in Treated Sectors




(a) Export growth with and without VAT Rebate Support

(b) Export growth with and without VAT Rebate Support after GFC

Note: Panel (a) shows exporters effective VAT in China. The average is computed using a weighted average of last quarters export shares over the effective VAT paid by each HS-6 digit product. Panel (b) presents the percentile of effective VAT over all the HS-6 digit products exported by china. The percentiles are computed in each quarter.

### 3.1 Dynamic correlation Net VAT with aggregate variables

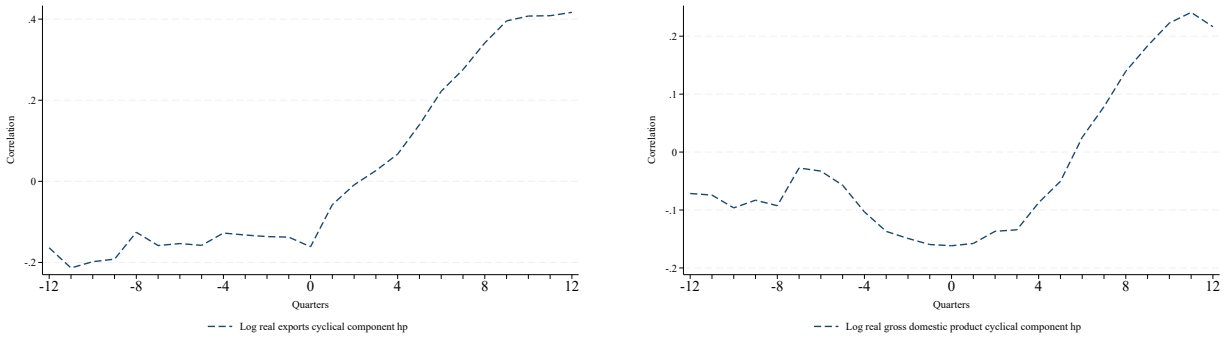
Now we turn to focus on the dynamic correlation between aggregate variables and VAT movements. We focus on four time series: cyclical component of real exports, cyclical component of GDP, the current account over GDP, and the fiscal balance over GDP. For this purpose we the dynamic correlations between a given series $x_t$, and the VAT rebate$_t$ is given by [1]:

$$Dynamic\ correlation_h = \text{Corr}(x_{t+h}, \text{VAT rebate}_t)$$

[1]We only fucus on the VAT rebate, as already shown for the period between 2004 and 2018, most of the effective VAT to exports comes from movements in the VAT rebate.

**Observation 3: Negative correlation between export VAT rebate with lags of GDP and exports, positive with leads**. Figure 3 presents the dynamic correlation between exporters VAT rebate at a given time, and the cyclical components of exports (Panel 3a) and real GDP (Panel 3b) in different time windows. Both panels shows a similar pattern. Negative correlation between VAT rebates to exports with respect to lags of GDP and exports, and a positive correlation with the leads of the variables. This suggest that both GDP and export tend to be low before increases in the VAT rebate takes place (which works as a export subsidies increase), and both are cyclical high after the increases in the rebates.

Figure 3: The External Sector's Response to Net VAT Signals




(a) Cyclical exports

(b) Cyclical GDP

Note: Panel (a) illustrates the dynamic correlation of cyclical total exports around changes in the aggregate net VAT rate, suggesting a pattern of underperformance followed by a rebound after a net VAT decrease. Panel (b) depicts a similar dynamic for the current account balance, hinting at a link between net VAT adjustments and China's external balance.

Figure 3 unveils the intriguing dynamic relationship between the aggregate net VAT rate and China's external sector. Panel (a) suggests a systematic pattern: before a reduction in the net VAT burden on exporters (an increase in rebates, effectively making exports cheaper), export growth tends to lag its cyclical trend. Subsequently, following the VAT adjustment, exports appear to experience a rebound. Panel (b) presents a similar narrative for the current account balance, where a weakening often precedes a net VAT reduction, followed by an improvement. This evidence is suggestive of the VAT-RX policy being employed to influence China's net exports, a core mechanism through which fiscal devaluations are theorized to operate by shifting expenditure towards domestically produced goods and boosting exports **?**.

In conclusion, the empirical evidence presented in this section suggest the use of VAT-RX

as an active countercylically policy tool used in China. We documented a dynamic and sectorally differentiated VAT-RX policy, targeted support for export growth through VAT rebates, and suggestive dynamic correlations between aggregate net VAT rates and key macroeconomic variables, both external and domestic. These observations provide strong motivation for our subsequent quantitative analysis, where we will embed these empirical regularities at the aggregate level within a structural DSGE model estimated using Bayesian methods. This framework will allow us to more rigorously assess the macroeconomic consequences of China's VAT-RX policy and its role as a significant, and often overlooked, quasi-fiscal devaluation tool in the global economy.

# 4 Quantitative Model

In this section, we build a quantitative two-country DSGE model to evaluate the macroeconomic consequences of VAT-RX policy. We extend Backus, Kehoe and Kydland (1994) model to include VAT and VAT-RX policy and a rich structure of shocks. We study the international transmission of VAT-RX policy in China and focus on its role during the global financial crisis.

## 4.1 Two-Country DSGE Model

There are two countries, China and the rest of the world (ROW), denoted by $i \in \{C, R\}$, which differ in their size. Intermediate firms produce differentiated goods under monopolistic competition, using capital and labor and are subject to country specific TFP shocks. Firms sell they goods in domestic and foreign markets, and are subject to a stochastic iceberg trade cost on exports. Firms in China are also subject to taxes on domestic and export value added.

Each country has a retailer aggregating bundles of domestic and imported intermediates, subject to adjustment costs in the use of imported to domestic inputs in the CES aggregator. The final non-traded good is purchased by the representative household and is used for consumption or investment. The representative household makes consumption, labor, and investment decisions, and trades a risk free bond with he foreign household, denominated in ROW currency. Households are subject to discount factor shocks.

Finally, the Chinese government collects domestic and export value added taxes on intermediate firms, which are given back to the household with lump-sum transfers. The domestic and export value added tax differ because the government provides rebates on export value added taxes. The Chinese government collect domestic and export value added taxes, and gives rebates on the export value added tax. The government follows a balanced budget, giving back tax receipts as a lump-sum transfer to the household. The value added tax and the rebate on exports follow a stochastic process. There is no government in the ROW.

There are two sources of asymmetry in the model: the size of the countries in terms of their relative GDP, and the absence of a government in the ROW. We present the model from the point of view of Chinese agents.

### 4.2 Consumer

The Chinese representative household maximizes the discounted expected utility

$$\max_{\{C_t, L_t I_t, K_{t+1}, B_{t+1}\}_{t=0}^{\infty}} \mathbb{E}_t \sum_{t=0}^{\infty} \Theta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{\eta_C L_t^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right)$$

where $C_t$ is consumption, $L_t$ is labor, $1/\sigma$ the intertemporal elasticity of substitution, $\eta_C$ the weight on labor, and $\nu$ the Frisch elasticity of labor supply, and $\Theta_t$ the discount factor at $t$. The flow budget constraint is,

$$P_t(C_t + I_t) + \frac{\mathcal{E}_t B_{t+1}}{R_t^* e^{\psi_t}} + \frac{\chi}{2}\left( \frac{\mathcal{E}_t B_{t+1}}{R_t^*} - \frac{\bar{\mathcal{E}}\bar{B}}{\bar{R}^*} \right)^2 = W_t L_t + R_t^k K_t + \mathcal{E}_t B_t + \Pi_t + T_t$$

where $P_t$ is the price index, $I_t$ is investment, $B_{t+1}$ the quantity of bonds traded internationally, $R_t^*$ the risk-free interest rate on the bond, $\mathcal{E}_t$ is the nominal exchange rate, $W_t$ is the wage, $K_t$ the stock of capital and $R_t^k$ its return, $\Pi_t$ profits of intermediate firms, and $T_t$ the lump-sum transfers from the government. The parameter $\chi$ governs the adjustment cost of internationally traded bonds and $\bar{B}$ its long-run level, included to induce stationarity to the model, and $\psi_t$ is a financial shock only faced by the Chinese household which generates a wedge relative to the return faced

by the ROW household. The stock of capital follows the law of motion,

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

where $\kappa$ governs the adjustment cost of investment following Christiano, Eichenbaum and Evans (2005). Finally, the cumulative discount factor evolves as

$$\ln(\Theta_{t+1}/\Theta_t) = \ln \beta_t = (1-\rho_b)\ln\bar{\beta} + \rho_b \ln \beta_{t-1} - \omega \ln\left(\tilde{C}_t/\bar{C}\right) + \varepsilon_{\beta,t}$$

where $\bar{\beta}$ is the steady state $\beta$, $\bar{C}$ is the steady state $C$, and $\tilde{C}_t$ is the average (aggregate) consumption in the economy, and $\varepsilon_\beta$ is a shock. The discount factor $\beta_t$ is external.

The solution to the Chinese household problem can be characterized by the labor supply condition and the Euler equations for the international traded bond and for capital. The stochastic discount factor between $t$ and $t+1$ is given by,

$$\Omega_{t,t+1} \equiv \beta_t \mathbb{E}_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}$$

### 4.3 Final Retailer

The final retailer in China aggregates bundles of domestic and imported intermediates. These bundles are given by,

$$X_{C,t} = \left(\int_0^1 X_{C,t}(j)^{\frac{\theta-1}{\theta}} dj\right)^{\frac{\theta}{\theta-1}} \quad \text{, and} \quad X_{R,t} = \left(\int_0^1 X_{R,t}(j)^{\frac{\hat{\theta}_t - 1}{\hat{\theta}_t}} dj\right)^{\frac{\hat{\theta}_t}{\hat{\theta}_t - 1}}$$

where $\theta$ is the elasticity of substitution across varieties, and $\hat{\theta}_t = \theta \mathcal{Q}_t^{\Lambda}$ a reduced form pricing-to-market friction as in Alessandria and Choi (2021) ($\mathcal{Q}_t$ is the real exchange rate and $\Lambda > 0$). This friction allows the model to generate a volatility of the terms of trade that is lower than that of the RER and an incomplete pass-though of exchange rate to prices. The CES aggregator of the

retailer is,

$$Y_t = \left[ (1-\gamma^C)^{\frac{1}{\rho}} \left( X_{C,t} \right)^{\frac{\rho-1}{\rho}} + \left( \gamma^C \right)^{\frac{1}{\rho}} \left( \varphi_t X_{R,t} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

where $X_{C,t}$ is the bundle of Chinese intermediate goods, $X_{R,t}$ is the bundle of the ROW intermediate goods, $(1-\gamma^C)$ is the home bias in China, $\rho$ the Armington elasticity between domestic and imported composite goods, and $\varphi^x$ is an adjustment cost in the use of imported to domestic intermediates as in Erceg, Guerrieri and Gust (2006), given by

$$\varphi_t = 1 - \frac{\iota}{2} \left( \frac{X_{R,t}/X_{C,t}}{X_{R,t-1}/X_{C,t-1}} - 1 \right)^2$$

Total expenditure is,

$$P_t Y_t = P_{C,t} X_{C,t} + P_{R,t} X_{R,t}$$

where $P_t$ is the price index of the final non-traded good, and $P_{C,t}$ and $P_{R,t}$ the prices of the domestic and imported goods, respectively.

The solution to the problem of the Chinese retailer is a pair of demand functions

$$P_t \frac{\partial Y_t}{\partial X_{C,t}} + E_t \left( \Omega_{t+1} P_{t+1} \frac{\partial Y_{t+1}}{\partial X_{C,t}} \right) = P_{C,t} \quad \text{, and} \quad P_t \frac{\partial Y_t}{\partial X_{R,t}} + E_t \left( \Omega_{t+1} P_{t+1} \frac{\partial Y_{t+1}}{\partial X_{R,t}} \right) = P_{R,t}$$

Finally, the ideal price index is given by

$$P_t = \left[ (1-\gamma^C) P_{C,t}^{1-\theta} + \gamma^C P_{R,t}^{1-\theta} \right]^{\frac{1}{1-\theta}}$$

### 4.4 Intermediate Firms

Chinese firms produce using labor and capital under a Cobb-Douglas technology. We omit the subscript $j$ of firms since they are all identical. Total production $Y_{C,t}$ is given by,

$$Y_t = e^{z_t} K_t^{\alpha} L_t^{1-\alpha}$$

where $z_t$ is a TFP shock, and $\alpha$ the share of capital in income. Firms can sell in the domestic and foreign market, with the resource constraint being

$$Y_{C,t} = X_{C,t} + X_C^* e^{\xi_t}$$

where $X_{C,t}$ are the quantities sold in domestic markets, $X_{C,t}^*$ the quantities exported, and $\xi_t$ is an iceberg trade of exporting to the ROW.

Chinese firms are subject to domestic and export value added taxes, so their profits are given by,

$$\Pi_t = P_{C,t} X_{C,t} \left[1 - \tau_t\right] + \mathcal{E}_t P_{C,t}^* X_{C,t}^* \left[1 - (\tau_t - \zeta_t)\right] - W_t L_t - R_t^k K_t$$

where $P_{C,t}$ is the price of goods sold domestically, $P_C^*$ the price of goods sold int he foreign market, $\tau_t$ the domestic value added tax, and $\zeta$ the rebate on the export value added tax. Hence, the effective value added tax on exports is given by $\tau_t - \zeta_t$.[2]

The solution to the problem of the intermediate firm is a pair of demand functions,

$$R_1^K K_t = \alpha Y_t MC_t$$

$$W_1 L_t = (1 - \alpha) Y_t MC_t$$

where the marginal cost of production is given by,

$$MC_t = \frac{1}{\varpi}\left[e^{-z_t}\left(R_t^k\right)^{\alpha}\left(W_t\right)^{1-\alpha}\right] \quad \text{and} \quad \varpi \equiv \left[\alpha^{\alpha}(1-\alpha)^{1-\alpha}\right].$$

and a pair of optimal prices,

$$P_{C,t} = \frac{\theta}{\theta - 1} \times \frac{MC_t}{\left[1 - \tau_t\right]}$$

$$\mathcal{E}_t P_{R,t} = e^{\xi_t} \frac{\theta Q_t^{-\Lambda}}{\theta Q_t^{-\Lambda} - 1} \times \frac{MC_t}{\left[1 - (\tau_t - \zeta_t)\right]}$$

[2]The value added tax coincides with a sales tax in this setting due to the absence of roundabout production.

### 4.5 Chinese Government

The Chinese government follows a balanced budget,

$$T_t = P_{C,t} X_{C,t} \tau_t + \mathcal{E}_t P_{R,t} X_{R,t} \left[ \tau_{,t} - \zeta_t \right]$$

The evolution of the value added tax and the export rebate are governed by the following rules,

$$\tau_t = \mu_\tau \left(1 - \rho_\tau\right) + \rho_\tau \tau_{t-1} + \sigma_\tau \varepsilon_{\tau,t}$$

$$\zeta_t = \mu_\zeta \left(1 - \rho_\zeta\right) + \rho_\zeta \zeta_{t-1} + \sigma_\zeta \varepsilon_{\zeta,t}$$

where $\mu_\tau$ and $\mu_\zeta$ are the unconditional mean of the value added tax and the export tax rebate, respectively, $\rho_\tau$ and $\rho_\zeta$ their persistence, $\varepsilon_\tau$ and $\varepsilon_\zeta$ are iid shocks,.

### 4.6 Shock Processes

There are 9 shocks in the model: TFP shocks, discount factor shocks, trade cost shocks, a financial shock, a valued added tax shock and the value added export rebate shock. It remains to define the processes for TFP, trade costs and the financial wedge,

$$z_t = \mu_z(1 - \rho_z) + \rho_z z_{t-1} + \sigma_z \varepsilon_{z,t} \quad \text{, and} \quad z_t^* = \mu_z^*(1 - \rho_z^*) + \rho_z^* z_{t-1}^* + \sigma_z^* \varepsilon_{z,t}^*$$

$$\xi_t = \rho_\xi \xi_{t-1} + \sigma_\xi \varepsilon_{\xi,t} \quad \text{, and} \quad \xi_t^* = \rho_\xi^* \xi_{t-1}^* + \sigma_\xi^* \varepsilon_{\xi,t}^*$$

$$\psi_t = \rho_\psi \psi_{t-1} + \sigma_\psi \varepsilon_{\psi,t}$$

where variables with $^*$ denote ROW variables.

### 4.7 Market clearing

Finally, market clears for labor, goods and the international bond. The Chinese country budget constraint is given by,

$$\mathcal{E}_t \frac{B_{t+1}}{R_t^* e^{\psi_t}} - B_t = NX_t - \frac{\chi}{2}\left(\frac{\mathcal{E}_t B_{t+1}}{R_t^*} - \frac{\bar{\mathcal{E}}\bar{B}}{\bar{R}^*}\right)^2$$

where

$$NX_t \equiv \mathcal{E}_t P_{C,t}^* X_{C,t}^* - P_{R,t} X_{R,t}$$

### 4.8 The International Transmission of VAT-RX Policy

Before estimating the model and quantifying the importance of VAT-RX policy for the performance of the Chinese economy during the global financial crisis, we explain the international transmission mechanism of VAT-RX policy. We study the effects of transitory and permanent VAT-RX shocks.

Figure 4, shows the impulse response of key variables of interest to a positive shock to the VAT rebate on exports. Panel (a) shows the path of the export rebate, together with the effective VAT on exports. The increase in the export rebate triggers a transitory fall in the effective VAT on exports. Panel (b) shows that this triggers a depreciation of the effective exchange rate of exporting, the exchange rate net of the VAT on exports. Panel (b) shows that the depreciation of the effective exchange rate on exports raises real exports. Panel (c) shows that the increase in real exports arises from an increase in the hours worked, which also raises GDP. Hence, VAT export rebate policy has expansionary effects on the economy. Panel (d) shows that China's terms of trade improve, due to the fall in the export prices. Finally, the China's real exchange rate appreciated. The appreciation arise from the fact that intermediate firms in China switch from selling domestically to export so that the supply of final goods in China fell. The fall in the supply triggered in increase in China's final goods prices, appreciating the real exchange rate. Figure 5 shows the same impulse responses, but for a permanent increase in the VAT rebate on exports. The results are similar to those under a transitory shock.

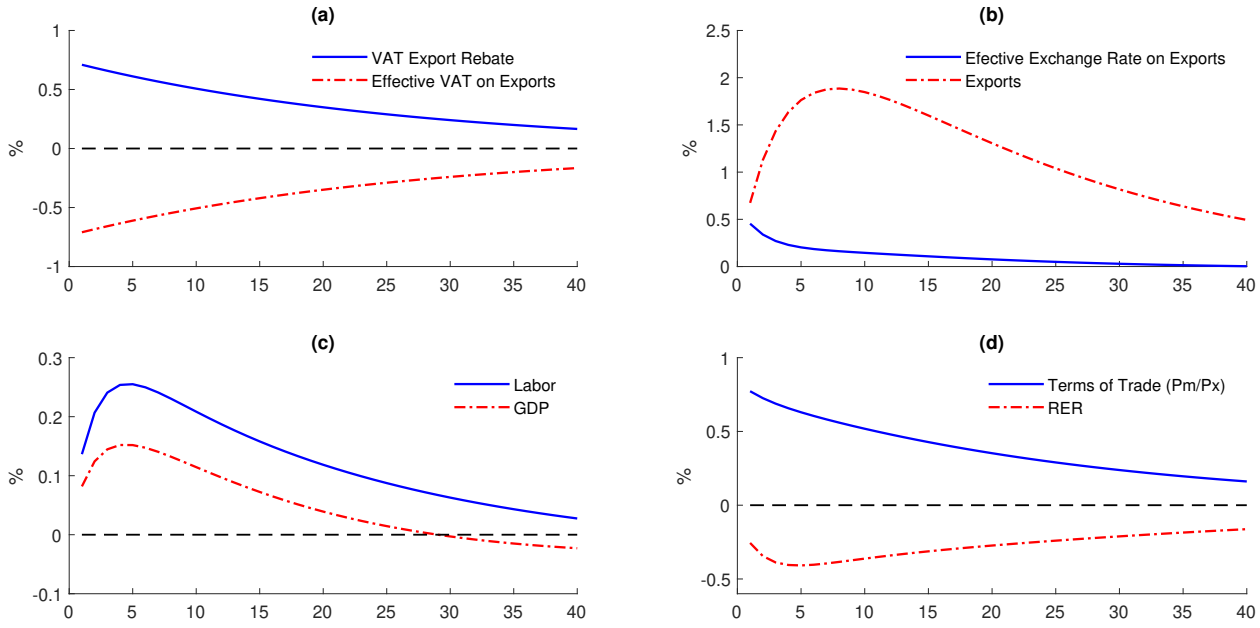



Figure 4: Impulse Response Functions to Transitory VAT-RX shock

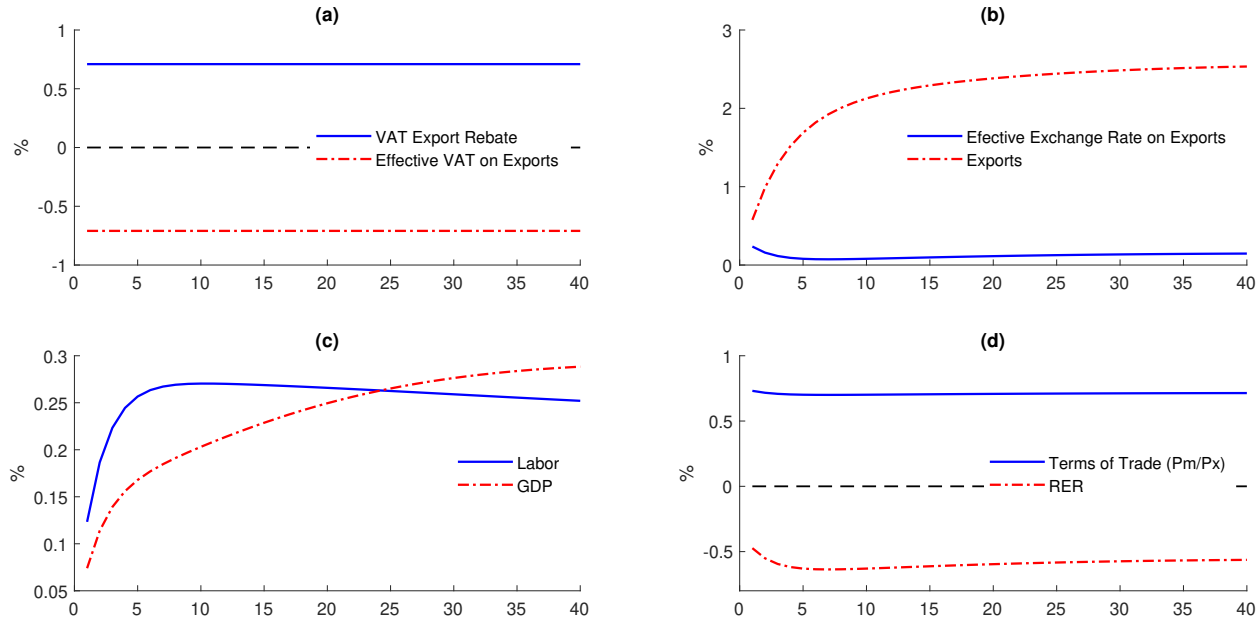



Figure 5: Impulse Response Functions to Permanent VAT-RX shock

### 4.9 Bayesian Estimation

Having described the international transmission channel of VAT export rebates policy, we turn the estimation of the model. We estimate the model using Bayesian methods, and perform counterfactual analysis using the Global Financial Crisis as a case study to evaluate the countercyclical use of VAT-RX in China. We explain the estimation strategy, and then discuss the main results.

Table 1 presents the parameters that are externally set, with its target moment or source. We normalize the steady state TFP in the ROW to one, and then set the mean of China's TFP process to match China's share in global GDP of 10%. We set the home bias in China to match the average real trade share over GDP of 50% in the sample period. Given this, we set the home bias in the ROW such that net trade is zero in the steady state.

Table 1: Calibrated Parameters

| Parameter | | Value | Target Moment or Source |
|---|---|---|---|
| Discount factor | $\beta$ | 0.99 | Annual interest rate of 4% |
| Risk aversion | $\sigma$ | 2 | Intertemporal elasticity of substitution of 0.5 |
| Weight on consumption in China | $\eta_C$ | 5.30 | Hours worked of 1/3 |
| Weight on consumption in ROW | $\eta_R$ | 0.53 | Hours worked of 1/3 |
| Macro Frisch Elasticity | $\nu$ | 1 | Frisch Elasticity |
| Capital share of income | $\alpha$ | 0.40 | Bai, Lu and Tian (2018) |
| Elasticity of substitution across varieties | $\theta$ | 4 | Producer markup of 33% |
| Armington Elasticity | $\rho$ | 6 | Estimated long-run elasticity of VAT export rebates |
| Depreciation rate | $\delta$ | 0.025 | standard |
| Average TFP in ROW | $\mu_z^*$ | 1 | Normalization |
| Average TFP in China | $\mu_z$ | 0.067 | China's GDP in world GDP |
| Home bias in China | $\gamma^C$ | 0.25 | Trade-to-GDP ratio of 50% in China |
| Home bias in ROW | $\gamma^R$ | 0.025 | Zero net exports in steady state |
| Bond adjustment cost | $\chi$ | 0.001 | stationarity of NFA |
| Steady state NFA | $\bar{B}$ | 0 | Steady state NFA of zero |
| Pricing-to-market friction | $\Lambda$ | 1.20 | 50% exchange rate pass-though to prices (Gopinath and Itskhoki, 2010) |

Since we have 9 shocks we feed 9 time series in the Bayesian estimation, displayed in Figure 6 present the time series used for the estimation. We feed the value added tax and the export rebates in China, the growth rate of aggregate real exports and imports in China, the growth rate of real GDP and consumption in China, the growth rate of nominal GDP in the ROW, the real

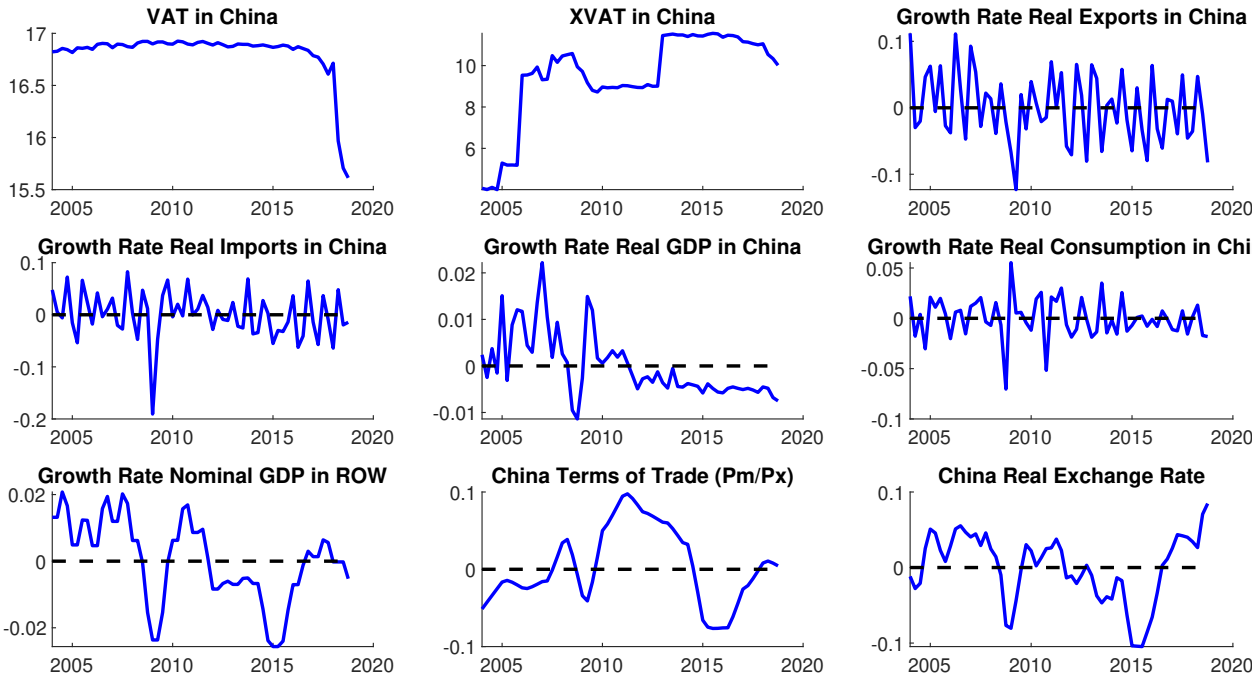



Figure 6: Data for Bayesian Estimation

exchange rate, and the terms of trade.[3] The estimated parameters are displayed in Table 2.[4]

#### 4.9.1 Quantifying the importance of Countercyclical VAT-RX Policy During the Global Financial Crisis

We use the global financial crisis between 2008 and 2012 as a case study for the countercyclical role of VAT-RX policy in China. Panel (b) in Figure 6 shows the path of the effective VAT on exports. Between the third quarter of 2008 and 2009 there was a reduction of the tax of around 187 basis points, since it fell from a a tax rate of 10.58% to 8.71%. After the third quarter of 2009 the tax rate remained almost unchanged. We study a counterfactual where the VAT rebate on exports did not change after the third quarter of 2008, so that the effective VAT on exports coincides with the domestic VAT. We interpret this case as 'shutting down' the countercyclical variation in the VAT rebate on exports.

Figure 7, presents the dynamics of key variables in the benchmark model which replicates the data and the counterfactual. Panel (a) shows the dynamics of the effective VAT on exports in

[3]The terms of trade are defined as the ratio of import to export prices.
[4]The log data density is 1109.135904.

Table 2: Estimated Parameters

| Parameter | Prior Distribution | Post. Mean | 90% Interval | Prior | Post. dev. |
|---|---|---|---|---|---|
| $\rho_z$ | 0.495 | 0.5670 | ( 0.5390 , 0.5972 ) | unif | 0.2858 |
| $\sigma_z$ | 0.250 | 0.0289 | ( 0.0258 , 0.0333 ) | unif | 0.1443 |
| $\rho_z^*$ | 0.495 | 0.9814 | ( 0.9723 , 0.9898 ) | unif | 0.2858 |
| $\sigma_z^*$ | 0.250 | 0.0314 | ( 0.0265 , 0.0361 ) | unif | 0.1443 |
| $\rho_\xi$ | 0.495 | 0.8145 | ( 0.8066 , 0.8224 ) | unif | 0.2858 |
| $\sigma_\xi$ | 0.250 | 0.1514 | ( 0.1430 , 0.1611 ) | unif | 0.1443 |
| $\rho_\xi^*$ | 0.495 | 0.8637 | ( 0.8405 , 0.8892 ) | unif | 0.2858 |
| $\sigma_\xi^*$ | 0.250 | 0.0427 | ( 0.0371 , 0.0482 ) | unif | 0.1443 |
| $\rho_b$ | 0.495 | 0.3963 | ( 0.3554 , 0.4318 ) | unif | 0.2858 |
| $\sigma_b$ | 0.250 | 0.2291 | ( 0.2117 , 0.2475 ) | unif | 0.1443 |
| $\rho_b^*$ | 0.495 | 0.4650 | ( 0.4328 , 0.4935 ) | unif | 0.2858 |
| $\sigma_b^*$ | 0.250 | 0.1626 | ( 0.1441 , 0.1786 ) | unif | 0.1443 |
| $\rho_\psi$ | 0.495 | 0.9884 | ( 0.9864 , 0.9900 ) | unif | 0.2858 |
| $\sigma_\psi$ | 0.250 | 0.0079 | ( 0.0065 , 0.0092 ) | unif | 0.1443 |
| $\rho_\tau$ | 0.495 | 0.8828 | ( 0.8583 , 0.9062 ) | unif | 0.2858 |
| $\sigma_\tau$ | 0.250 | 0.0011 | ( 0.0010 , 0.0012 ) | unif | 0.1443 |
| $\rho_\zeta$ | 0.495 | 0.9634 | ( 0.9415 , 0.9896 ) | unif | 0.2858 |
| $\sigma_\zeta$ | 0.250 | 0.0071 | ( 0.0061 , 0.0078 ) | unif | 0.1443 |
| $\iota$ | 250.000 | 2.2993 | ( 1.9302 , 2.5700 ) | unif | 144.3376 |
| $\omega$ | 0.010 | 0.0059 | ( 0.0053 , 0.0064 ) | unif | 0.0058 |
| $\kappa$ | 7.500 | 3.4908 | ( 3.1121 , 3.9387 ) | unif | 4.3301 |

both cases. Panel (b) shows that the VAT-RX policy followed by the government depreciated the effective real exchange rate on exports relative to the counterfactual. As we show in Figures 4 and 5, a more depreciated effective real exchange rate on exports stimulates real exports. This can be seen in Panel (c), where we estimate that the increase in the VAT-RX raised exports on average by 300 basis points, during the global financial crisis. Consequently, Panel (d) shows that this policy was expansionary as it raised real GDP, which was raised on average by 170 basis points. The mechanism operated through an improvement in China's terms of trade, due to the fall of the price of exports. Finally, China's real exchange rate appreciated in response to the policy.

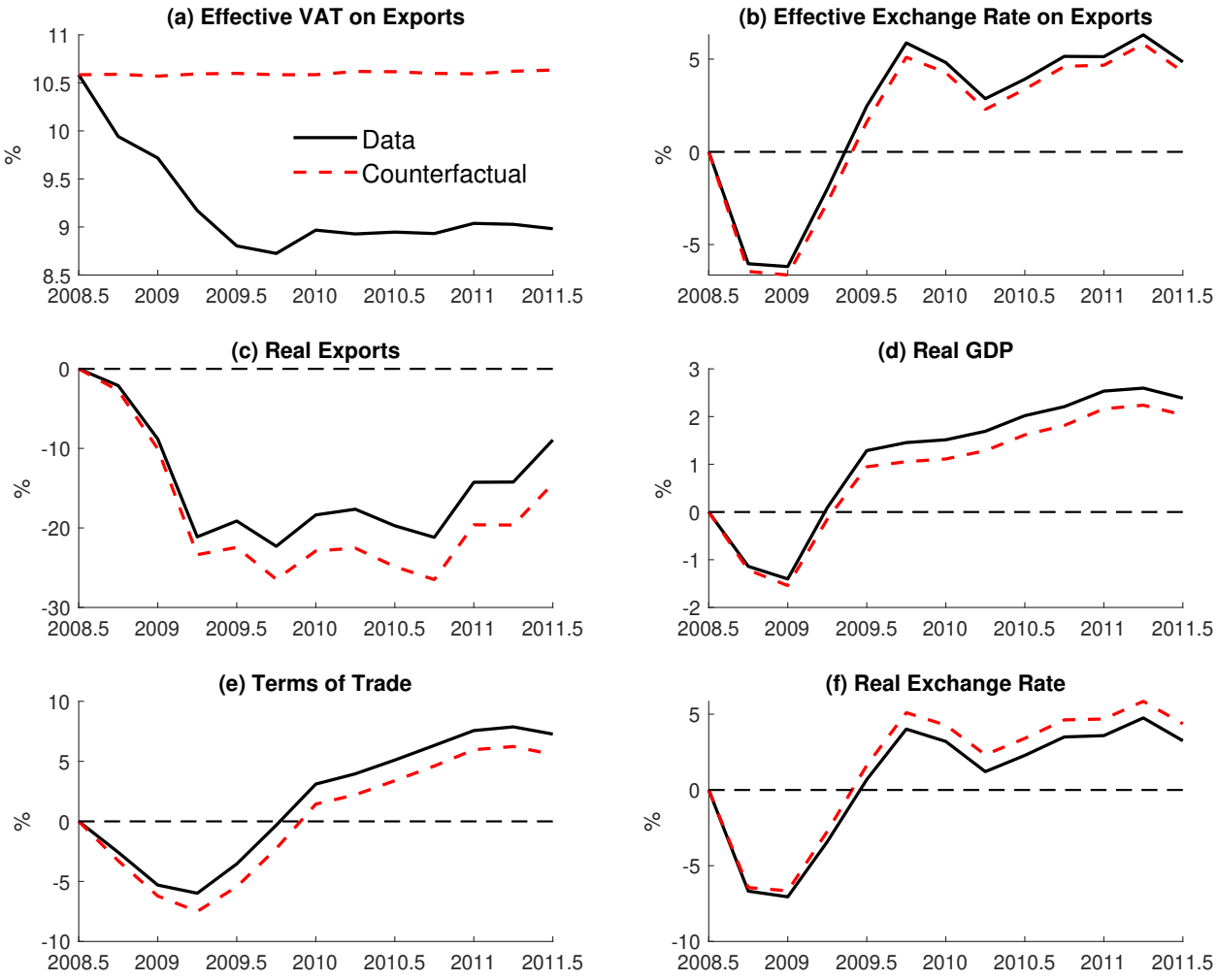



Figure 7: Global Financial Crisis: The importance of VAT-RX policy

# 5 Conclusion

This paper demonstrates the significant macroeconomic role of China's VAT-RX policy as a quasi-fiscal devaluation tool, particularly evident during the Global Financial Crisis. Our findings establish the relevance of considering fiscal instruments like VAT rebates alongside traditional monetary and exchange rate policies for macroeconomic stabilization and trade management.

Empirical evidence reveals a dynamic and sector-specific VAT-RX policy with a discernible impact on export performance and correlations with key macroeconomic indicators. We incorporate VAT and VAT-RX into a two-country DSGE model. Using the estimated model we show that China has used VAT-RX as a countercyclical macroeconomic policy. We find that absent VAT-RX policy during the global financial crisis aggregate exports and GDP in China would have been 3.7 and 0.3 percentage points lower.

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