International Trade Fluctuations and Monetary Policy*

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Abstract

This paper studies the role of trade openness for the design of monetary policy in an environment that is consistent with salient features of international trade fluctuations at business cycle frequencies. We study a standard small open economy model with nominal rigidities, and extend it to capture cyclical trade fluctuations by introducing a time-varying trade wedge that is assumed to be a function of endogenous variables of the economy. We parametrize the time-varying trade wedge to match key features of the data, and contrast the business cycle fluctuations of this economy with those of a standard model. We find that, when the monetary authority follows a Taylor rule, our model features higher levels of inflation volatility, with moderate increases in the volatility of the output gap. These findings suggest that properly accounting for the business cycle fluctuations of international trade flows may have significant consequences for the optimal design of monetary policy. Indeed, we solve a constrained Ramsey problem and find that the monetary authority should react differently to changes in inflation and the output gap under each model.

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1 Introduction

A large literature has recently studied the role of trade openness for the design of monetary policy (Gali and Monacelli 2005, Lombardo and Ravenna 2014, among others). In these papers, trade openness typically affects monetary policy through the impact of exchange rate fluctuations and foreign shocks on CPI inflation and the output gap.

However, given that these open economy models assume a constant elasticity of substitution demand system, they cannot account for the dynamics of international trade flows at business cycle frequencies – as documented by Levchenko et al (2010) and Leibovici and Waugh (2014). Specifically, while these models imply a unitary income elasticity of imports, this elasticity is typically estimated to be high and close to two in the data. Similarly, while these models are typically calibrated to feature an import price elasticity that is higher than one, this elasticity is estimated to be well below one in the data.

In this paper, we evaluate the importance of trade openness for the design of monetary policy in an economic environment that accounts for salient features of international trade fluctuations. We build upon Gali and Monacelli (2005) and extend it by introducing a time-varying and endogenous trade wedge, whose functional form is chosen to match the empirical income and price elasticities of imports. This parsimonious modeling strategy allows us to capture a number of alternative mechanisms that have been recently proposed to account for fluctuations of international trade flows as well as for the recent trade collapse (Alessandria et al. 2010, Chor and Manova 2012, Eaton et al 2013, Leibovici and Waugh 2014, among others), while remaining agnostic about the specific nature of the mechanism at play. We parametrize the trade wedge to be a function of domestic absorption and the real exchange rate in such a way that the model accounts for the empirical trade elasticities.

We first examine the implications of the model when the monetary authority follows a standard Taylor rule. We contrast the business cycle implications of our model with those implied by its counterpart with a time-invariant trade wedge (Gali and Monacelli 2005). In contrast to the standard model, our model can account for additional features of international trade fluctuations not targeted in the calibration. We find that our model generates considerably higher inflation volatility, with moderate increases in the volatility of the output gap.

These findings suggest that properly accounting for the business cycle fluctuations of international trade flows may have significant consequences for the optimal design of monetary policy. We examine whether this is indeed the case by solving a constrained Ramsey problem for each model. Specifically, we compute the Taylor rule coefficients that maximize welfare, that is, the lifetime expected utility of the representative consumer. Preliminary findings suggest that the monetary authority should react differently to changes in inflation and the output gap under each model.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 analyzes the quantitative implications of the model. Section 4 concludes.

2 Model

Consider a small open economy that trades goods and financial assets with the rest of the world. The small open economy is assumed to be infinitesimal in size relative to the rest of the world. Therefore, decisions in the small open economy do not influence variables from the rest of the world. We thus restrict attention to studying the behavior of the small open economy and its interaction with the rest of the world. Variables with subscripts H and F denote country of origin of the good concerned, superscript $*$ denotes foreign country variables, and subscript SS denotes variables at their deterministic steady-state level.

2.1 Representative household

The small open economy is populated by a representative household that maximizes lifetime expected utility, which is given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_{s,t})$$

where $\beta \in (0, 1)$, C_t denotes the amount of consumption of the final good, $N_{s,t}$ is the amount of labor supplied at competitive wage rate W_t, and E_0 is the expectations operator conditional on the information set in period zero. The period utility function is assumed to be given by $U(C, N) = \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\varphi}}{1+\varphi}$, where $\sigma > 0$ denotes the coefficient of relative risk aversion, and $\phi > 0$ is the Frisch elasticity of labor supply.

Consumption of the final good is the result of aggregating domestic and foreign goods with a constant elasticity of substitution aggregator given by:

$$C_t = \left[(1 - \alpha_{m,t})^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \alpha_{m,t}^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}\right]$$

where $\eta > 0$ is the elasticity of substitution between domestic goods $C_{H,t}$ and foreign goods $C_{F,t}$, while $\alpha_{m,t} \in [0, 1]$ is the time-varying imports trade wedge, which is inversely related to the degree of home-bias in preferences. We assume that the imports trade wedge $\alpha_{m,t}$ is time-varying and evolves according to the following function:

$$\alpha_{m,t} = \alpha + \psi_C \ln\left(\frac{C_t}{C_{ss}}\right) + \psi_{P_F} \ln\left(\frac{P_{F,t}/P_t}{P_{F,ss}/P_{ss}}\right)$$

where α is the degree of trade openness, while ψ_C and ψ_{P_F} are parameters that control the responsiveness of the time-varying trade wedge to deviations from steady-state of total absorption C_t and the relative price of imports $P_{F,t}/P_t$.

Domestic goods $C_{H,t}$ and foreign goods $C_{F,t}$ are, in turn, the result of aggregating domestic and foreign varieties with constant elasticity of substitution aggregators given by:

$$C_{H,t} = \left(\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}, \qquad C_{F,t} = \left(\int_0^1 C_{F,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where ε is the elasticity of substitution across domestic varieties $j \in [0,1]$.

Households have access to a complete set of state-contingent claims through which they can insure themselves by trading with the rest of the world. Finally, every period the representative household is subject to a lump-sum tax or transfer T_t, denominated in units of domestic currency.

The problem solved by the representative household is then given by:

$$\max_{C_t, C_{H,t}, C_{H,t}(j), C_{F,t}, C_{F,t}(j), D(s^{t+1}), N_{s,t}} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_{s,t})$$

subject to

$$\int_0^1 P_{H,t}(j) C_{H,t}(j) dj + \int_0^1 P_{F,t}(j) C_{F,t}(j) dj + \sum_{s_{t+1}} \mathcal{M}(s^{t+1}|s^t) D(s^{t+1}) \leq D_t + \Pi_t + W_t N_{s,t} + T_t$$

$$C_t = \left[(1-\alpha_t)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \alpha_t^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right]$$

$$C_{H,t} = \left(\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

$$C_{F,t} = \left(\int_0^1 C_{F,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

$$\alpha_{m,t} = \alpha + \psi_C \ln \left(\frac{C_t}{C_{ss}} \right) + \psi_{P_F} \ln \left(\frac{P_{F,t}/P_t}{P_{F,ss}/P_{ss}} \right)$$

where s^t denotes the history of aggregate states from period 0 up to an including period t, $\mathcal{M}(s^{t+1}|s^t)$ is the state-s^t price (in domestic currency) of an Arrow security that pays one unit of the domestic currency in state s^{t+1}, $D(s^{t+1})$ is the number of state-s^{t+1} Arrow securities purchased, and Π_t denotes the profits that accrue from the ownership of domestic firms. Note that $\mathcal{M}(s^{t+1}|s^t)$ is sometimes denoted as $\mathcal{M}_{t,t+1}$.

2.2 Firms

A unit measure of domestic firms produce differentiated varieties $j \in [0,1]$ with a linear technology in labor represented by production function $Y_t(j) = A_t N_{d,t}(j)$, where A_t denotes a time-varying level of aggregate productivity, while $N_{d,t}(j)$ denotes the amount of labor hired by the producer of variety j. Firms hire workers through competitive labor markets at wage rate W_t, and are subject to an ad-valorem employment subsidy τ, financed through lump-sum taxes.

We assume that firms set prices in a staggered fashion, as in Calvo (1983). That is, a measure $1-\theta$ of randomly selected firms sets new prices each period, with an individual firm's probability of re-optimizing in any given period being independent of the time elapsed since it last reset its price. Firms are thus identical ex-ante, but are ex-post heterogeneous due to staggered pricing.

Finally, we assume that aggregate productivity follows an exogenous stochastic process given by $\log A_{t+1} = \rho_a \log A_t + \varepsilon_t^A$, where ε_t^A is an iid shock with zero mean and standard deviation σ_a.

The problem solved by firm j when setting a new price in period t consists of maximizing the current value of its dividend stream, conditional on that price being effective:

$$\max_{\overline{P}_{H,t}, N_{d,t+k}} \sum_{k=0}^{\infty} \theta^k E_t \left\{ \mathcal{M}_{t,t+k} \left[Y_{t+k} \overline{P}_{H,t} - (1-\tau) W_{t+k} N_{d,t+k} \right] \right\}$$

subject to

$$Y_{t+k} \leq \left(\frac{\overline{P}_{H,t}}{P_{H,t+k}} \right)^{-\varepsilon} \left(C_{H,t+k} + C^*_{H,t+k} \right) \equiv Y^d_{t+k} \left(\overline{P}_{H,t} \right) \quad \forall k$$

$$Y_{t+k} = A_{t+k} N_{d,t+k} \quad \forall k$$

where $\mathcal{M}_{t,t+k}$ denotes the representative household's stochastic discount factor between periods t and $t+k$, and $P_{H,t}$ denotes the domestic good's price index.

In this economy with complete markets, the stochastic discount factor is equal to the pricing kernel $\mathcal{M}_{t,t+k}(s^{t+k})$ for Arrow securities, which gives the value of purchasing an Arrow security in state-s^t that pays a unit of the good in state-s^{t+k}. This is how the representative household values future profit flows of the firms he owns.

2.3 Central bank

We study an economy in which the central bank follows a standard Taylor rule, in which the monetary authority sets the nominal interest rate to smooth fluctuations in the output gap and CPI inflation:

$$\frac{R_t}{R_{ss}} = \left(\frac{R_{t-1}}{R_{ss}} \right)^{\rho} \left(\frac{Y_t}{Y_{ss}} \right)^{(1-\rho)\phi_y} \left(\frac{\Pi_t}{\Pi_{ss}} \right)^{(1-\rho)\phi_m}$$

where $\rho \in (0,1)$ is the degree of interest rate smoothing, and $\Pi_t = \frac{P_t}{P_{t-1}}$ denotes CPI inflation.

2.4 Rest of the world

We assume that the domestic economy and the rest of the world feature symmetric initial conditions, such that there are zero net foreign asset holdings, and such that they face an ex ante identical economic environment.

The domestic economy imports and exports varieties with the rest of the world, in an environment in which the law of one price is assumed to hold. That is, we have that $P_{F,t}(j) = \xi_t P^*_{F,t}(j)$ for all $j \in [0,1]$, where ξ_t is the nominal exchange rate (the price of the rest of the world's currency in terms of the domestic currency: that is, the value in domestic currency of one unit of foreign currency), and $P^*_{F,t}(j)$ is the price of the rest of the world's variety j expressed in the producer's (i.e. the rest of the world's) currency. Analogously, we also have that $P_{H,t}(j) = \xi_t P^*_{H,t}(j)$ for all $j \in [0,1]$, where $P^*_{H,t}(j)$ is the price of the domestic variety j expressed in the consumer's (i.e. the rest of the world's) currency.

The rest of the world supplies and demands goods in a symmetric fashion to the domestic economy. That is, we assume that demand for all goods produced by the domestic economy is given by $C^*_{H,t} = \alpha_{x,t}\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\eta} C^*_t$, where η denotes the elasticity of substitution between domestic and foreign goods, and $\alpha_{x,t}$ is a time-varying export trade wedge. We assume that $\alpha_{x,t}$ is given by:

$$\alpha_{x,t} = \alpha + \psi_{C^*} \ln\left(\frac{C^*_t}{C^*_{ss}}\right) + \psi_{P^*_H} \ln\left(\frac{P^*_{H,t}/P^*_t}{P^*_{H,ss}/P^*_{ss}}\right)$$

where ψ_{C^*} and $\psi_{P^*_H}$ are parameters that control the responsiveness of the time-varying export trade wedge to deviations from steady-state of total absorption in the rest of the world C^*_t and the relative price of imports made by the rest of the world $P^*_{H,t}/P^*_t$.

The representative household in the rest of the world trades a complete set of state-contingent Arrow securities with the domestic economy. Now, given that the small open economy is infinitesimaly small relative to the rest of the world, there is no distinction between the CPI and the domestic price level in the rest of the world. We thus have that $P^*_{F,t} = P^*_t$. Similarly, given that the small open economy is infinitesimally small relative to the rest of the world, we do not solve the equilibrium for the rest of the world explicitly, but assume that aggregate output, the aggregate price index, and the interest rate evolve according to the following autoregressive processes:

$$\log Y^*_{t+1} = \rho_{y^*} \log Y^*_t + \varepsilon^{Y^*}_t$$

where $\varepsilon^{Y^*}_t$ is an iid shock with zero mean and standard deviation σ_{y^*}.

2.5 Equilibrium

A competitive equilibrium of this economy consists of policy functions $\{C_t, C_{H,t}, C_{F,t}, N_{d,t}, N_{s,t}, Y_t, C^*_t, \alpha_{m,t}, \alpha_{x,t}\}_{t=0}^{\infty}$, exogenous variables $\{A_t, Y^*_t\}_{t=0}^{\infty}$, and prices $\{P_t, P_{F,t}, P_{H,t}, \Pi_t, \mathcal{M}_{t,t+1}, R_t, \xi_t, W_t\}_{t=0}^{\infty}$ such that the following conditions hold:

1. Given prices, policy functions solve representative household's problem.

2. Given prices, policy functions solve firms' problem.

3. Central bank chooses R_t following Taylor rule.

4. Labor markets clear: $N_{s,t} = \int_0^1 N_{d,t}(j)dj \ \forall t$

5. Financial markets clear: $D^*_t(s^t) = 0 \ \forall s^t \forall t$, where $D^*_t(s^t)$ denotes holdings of period-t state-s^t Arrow securities by the rest of the world.

6. Domestic variety j's market clears: $Y_t(j) = C_{H,t}(j) + C^*_{H,t}(j) \ \forall t$, where $C^*_{H,t}(j)$ denotes the consumption of the domestic variety j in the rest of the world.

2.6 Additional definitions

- Risk-free rate:
  - Taking conditional expectations on both sides of the Euler equation corresponding to the demand for Arrow securities, we find: $\beta R_t E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right] = 1$, where $R_t = \frac{1}{E_t[\mathcal{M}_{t,t+1}]}$ is the gross return on a riskless one-period discount bond paying off one unit of domestic currency in $t+1$.
  - In the rest of the world, the risk-free rate is determined by: $\beta R_t^* E_t \left[\left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\sigma} \left(\frac{P_t^*}{P_{t+1}^*} \right) \right] = 1$, where $R_t^* = \frac{1}{E_t\left[\mathcal{M}_{t,t+1}\frac{\xi_{t+1}}{\xi_t}\right]} \approx \frac{1/E_t[\xi_{t+1}]}{E_t\left[\frac{\mathcal{M}_{t,t+1}}{\xi_t}\right]}$, and $E_t\left[\mathcal{M}_{t,t+1}\xi_{t+1}\right] = \xi_t \times \frac{1}{R_t^*}$ denotes the equilibrium price (in terms of domestic currency) of a riskless bond denominated in foreign currency.
- Terms of trade: $\mathcal{S}_t = \frac{P_{F,t}}{P_{H,t}}$
- Real exchange rate: $\mathcal{Q}_t = \frac{\xi_t P_t^*}{P_t} = \frac{\xi_t P_{F,t}^*}{P_t} = \frac{P_{F,t}}{P_t}$
- Aggregate domestic output: $Y_t = \left[\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}$
- Trade balance: $nx_t = \left(\frac{1}{Y_{ss}} \right) \left(Y_t - \frac{P_t}{P_{H,t}} C_t \right)$, where Y_{ss} denotes steady-state output, and the trade balance is expressed in terms of domestic output.

3 Quantitative analysis

We now study the business cycle implications of the model and contrast it with one featuring time-invariant trade wedges. To do so, we calibrate the model following Gali and Monacelli (2005), and choose the weights in the $\alpha_{m,t}$ and $\alpha_{x,t}$ processes to match salient features of imports. We restrict attention to the price and income elasticities of imports as estimated by Leibovici and Waugh (2014). Note that combining the equilibrium imports demand equation with the expression for $\alpha_{m,t}$, we obtain $\ln C_{F,t} = [\alpha - \psi_C \ln C_{ss} - \psi_{P_F} \ln (P_{F,ss}/P_{ss})] + (\psi_{P_F} - \eta) \ln \left(\frac{P_{F,t}}{P_t} \right) + (1 + \psi_C) \ln C_t$, which allows us to map the weights on the $\alpha_{m,t}$ process directly to the price and income elasticities of imports. Therefore, to match an empirical price elasticity equal to -0.26 we set $\psi_{P_F} = -0.26 + \eta$, while we match an empirical income elasticity equal to 1.99 by setting $\psi_C = 0.99$. We choose the parameters of the $\alpha_{x,t}$ process analogously by setting $\psi_{P_H^*} = -0.26 + \eta$ and $\psi_{C^*} = 0.99$. The calibrated parameters are reported in Tables 1 and 2. We then contrast the business cycle implications of the models by comparing their impulse response function and their second moments.

Parameter	Description	Value
β	Discount factor	0.99
θ	Calvo parameter	0.75
ϕ	Elasticity of labor supply	3
ρ	Coefficient of relative risk aversion	1
η	Armington elasticity	1.5
σ	Elasticity of substitution across varieties	6
ρ_a	Persistence of domestic productivity shocks	0.66
ρ_{y^*}	Persistence of foreign output shocks	0.86
σ_a	Standard deviation of domestic productivity shocks	0.0071
σ_{y^*}	Standard deviation of foreign output shocks	0.0078
ρ_{a,y^*}	Correlation between domestic and foreign shocks	0.3

Table 1: Parameterization, Preferences and Technology

Parameter	Description	Value
α_m	Degree of trade openness	0.4
ψ_C	Consumption coefficient in trade wedge	0.99
ψ_{P_F}	Foreign price coefficient in trade wedge	0.74
ϕ_m	Taylor rule weight on expected inflation	1.50
ϕ_y	Taylor rule weight on output gap	0.50
ρ	Interest rate smoothing	0.85

Table 2: Parameterization, International Trade and Monetary Policy

3.1 Business cycle statistics

We begin by examining the implications of our model for business cycle fluctuations of international trade variables, which we contrast with moments of the data from Engel and Wang (2011). The results are reported in Table 3. We find that our model with a variable trade wedge improves significantly over the constant trade wedge model. In particular, the trade balance becomes counter-cyclical, the volatility of exports becomes larger than GDP, and the correlation of imports with GDP becomes positive — in contrast, the model with a constant trade wedge is qualitatively at odds with these features of the data. Our model also improves significantly on the quantitative fit of these moments with the data. We thus conclude that our model is better able to account for the business cycle fluctuations of international trade flows than the model with time-invariant trade wedges and, thus, serves as a better laboratory to study the role of trade openness for the design of monetary policy.

We then examine the implications of our model for the business cycle fluctuations of variables that may be potentially relevant for the decisions of the monetary authority. The results are reported in Table 4. We find that our model implies a significantly higher volatility of inflation than the standard model, while simultaneously implying a moderatly higher volatility of the output gap — the former is now 71% higher, while the latter is 18% higher. We also find that output and consumption volatility decrease, while the volatility of the real exchange rate almost doubles in magnitude.

To the extent that the central bank cares about minimizing a weighted sum of the volatility of inflation and the output gap, these findings suggest that its optimal response to domestic and foreign shocks in an economy with time-varying trade wedges may be different to its optimal response in an economy in which these are constant.

	Std. dev. relative to GDP			Correlation with GDP			
	NX/GDP	M	X	NX/GDP	M	X	corr(M,X)
Data	0.68	3.08	2.65	-0.25	0.61	0.45	0.40
Constant trade wedge	0.11	2.07	0.91	0.45	-0.02	0.81	0.57
Time-varying trade wedge	0.91	1.98	3.41	-0.36	0.99	0.56	0.65

Table 3: International Trade Fluctuations

	Standard deviation (%)					
	Y	C	Output gap	Inflation	Nominal interest rate	Real exchange rate
Constant trade wedge	0.90	0.96	0.17	0.34	0.17	0.77
Time-varying trade wedge	0.79	0.82	0.20	0.58	0.21	1.53

Table 4: Business Cycle Statistics

3.2 Impulse response functions

Finally, we contrast the impulse response functions to domestic and foreign shocks implied by these models. With a time-varying trade-wedge, there are qualitative and quantitative differences in the response of the economic variables to a domestic productivity shock relative to a model in which the trade wedge is time-invariant. While consumption increases in both models, in the standard model this is solely driven by an increase in domestic consumption, since imports in fact decrease slightly. In contrast, in the model with a time-varying trade wedge, the increase in consumption is driven by an increase of both imports and domestic consumption. The response of exports to the decrase in their relative price is now lower due to the change in the trade wedge, which leads to a lower increase in output, and thereby to a larger decrease in the output gap. Domestic inflation decreases slightly upon impact in both cases. The central bank reacts by lowering the interest rate, which causes a depreciation of the domestic currency, followed by a future appreciation. These effects are stronger for the case of a time-varying trade-wedge, generating higher volatility of the economic variables in this case, as shown in Table 4. The different reaction of imports in this model, relative to the constant trade-wedge case, changes the quantitative response of key economic variables, suggesting that the central bank should react differently to fluctuations in the economy in both cases.

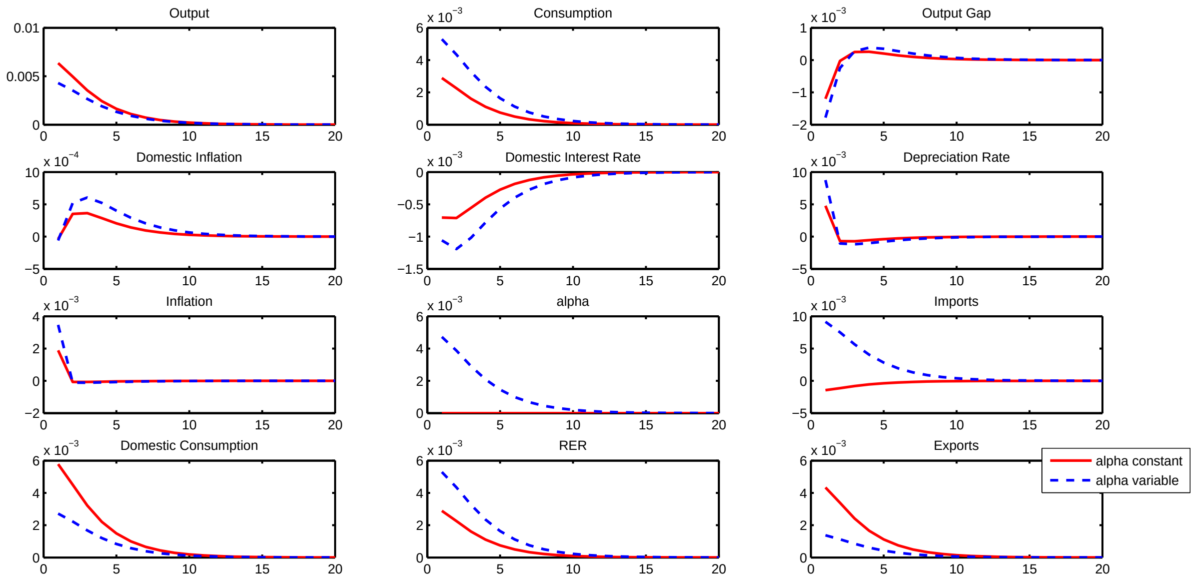

Figure 1: Impulse response to a domestic productivity shock

Finally, we analyze the response of key economic variables to a positive foreign demand shock. Once again, we observe a qualitative difference in the reaction of imports, which increase with a time-varying trade wedge. Consumption increases both domestic consumption and imports. Because exports increase less than with a constant trade wedge, final output increeases by a lower amount, which decreases the output gap. These effects translate again into higher volatility of the key economic variables, suggesting that the central bank's optimal response to economic fluctuations may be different in each of these economic environments. These results are consistent with the results reported in Table 4.

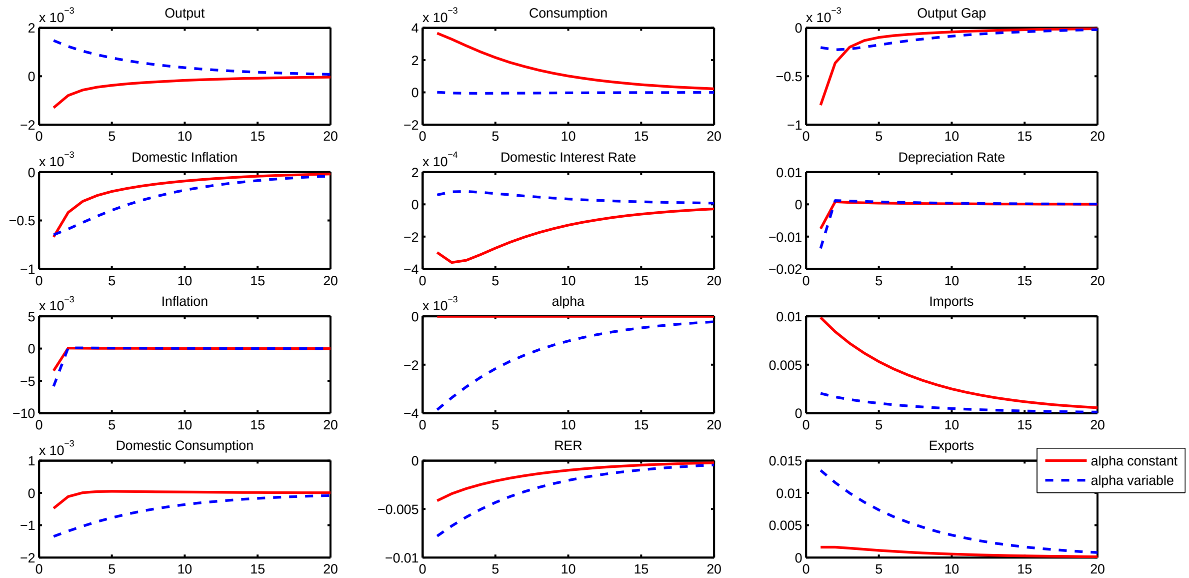

Figure 2: Impulse response to a foreign output shock

4 Conclusion

Still baking...

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