

# The international transmission of productivity and shocks: empirics

Giancarlo corsetti

EUI

2010

## The issue

- ▶ Understanding international interdependence requires structural investigations.
- ▶ Work devoted to the analysis of monetary and fiscal policy shocks.
- ▶ Wanted: structural studies of fundamental productivity/demand shocks to trace real and financial channels of the international transmission (including the dynamics of saving and investment, relative prices, asset returns and portfolio allocation).
- ▶ Examples: long-run restrictions/sign restrictions CDL (ISOM 2007 and 2009).

## Demand and productivity shocks in the US using sign restrictions

- ▶ CDL 2009: Identification of *demand and productivity shocks to US manufacturing using sign restrictions* (after Uhlig [2005] and subsequent literature).
- ▶ Use restrictions encompassing a large class of models:
  - ▶ Focus on *manufacturing* as a measure of tradables T.
  - ▶ Restrictions based on standard theory — e.g. demand (supply) shocks move real prices and quantities in opposite (same) direction.
- ▶ Emphasize the dynamics of demand (private consumption and investment), trade, asset prices, international asset position, and international relative prices of goods with different degree of tradability.

## Main findings: Productivity shocks to US manufacturing

- ▶ Raise aggregate US consumption and investment relative to other OECD countries.
- ▶ Cause an increase in imports and a persistent trade deficit, worsening the US net foreign wealth (adjusted for valuation effects).
- ▶ Raise US equity prices relative to Foreign ones, opening a persistent interest differential.
- ▶ Cause real dollar appreciation, also driven by prices of traded goods.

## Main findings: Demand shocks to US manufacturing

- ▶ Expected effects qualitatively, but overall much weaker and less persistent than productivity shocks.
- ▶ Raise investment yet by less than productivity shocks. Scant evidence of substantial impact on relative consumption
- ▶ No substantial effect on trade and Net Foreign Assets.
- ▶ Cause real dollar appreciation, although with delay.

## A (partial) review of empirical literature

- ▶ Clarida and Galí (1994) use *long-run restrictions* to identify (aggregate) demand and supply shocks, finding that both appreciate the US real exchange rate.
- ▶ CDL also use long-run restrictions to identify technology shocks in the manufacturing sector in a sample of 5 OECD countries:
  - ▶ Permanent productivity shocks open a trade deficit, and appreciate both the real exchange rate and the terms of trade in the case of the US (and Japan).
- ▶ Literature on government spending (as a form of demand shock)
  - ▶ Mixed evidence on effects on net trade and real exchange rate, terms of trade.

# Plan

1. Identifying restrictions
2. Review of the methodology
3. Empirical analysis: Findings and some interpretation
4. Sensitivity analysis

# 1. Identifying restrictions

- ▶ Motivation
- ▶ Definition of restrictions
- ▶ Some caveats and qualifications
- ▶ A close up analysis of the theoretical underpinning of our restrictions

## General identification strategy

- ▶ Focus on a minimal set of restrictions on the response of key macroeconomic variables to specific shocks, consistent with a range of models and parameters.
- ▶ Restrict only variables whose behavior in response to shock is unambiguous according to theory, and uncontroversial.
- ▶ Variables for which theory presents a range of prediction should instead be left unconstrained (i.e. not be employed in identification strategy).
  - ▶ On the contrary, theoretical and empirical controversies define open questions of interest.

## Sign and long-run restrictions

- ▶ Sign-restrictions: weak yet theoretically founded identification restrictions
- ▶ Long-run theoretical exclusion restrictions need to be combined with atheoretical, auxiliary assumptions on the time series properties of the data.
- ▶ Exact restrictions, such as exclusion restrictions, are likely not to be robust to small perturbations to model specification and parameterization. Issues in trend- and difference-stationarity of variables.

## Basic idea

- ▶ Supply-side shifts should move relative prices and quantities in opposite directions, while demand shifts move them in the same direction.
- ▶ Especially powerful idea when applied to sector- or industry-specific shocks: a natural focus for studies of the international transmission mechanism is on the tradable sector — identified with manufacturing.
- ▶ In most open economy models, both productivity and demand shocks in this sector increase relative tradable output; however, productivity gains unambiguously raise the relative price of nontradables — a well-known prediction of the standard Harrod-Balassa-Samuelson theory; demand shocks unambiguously reduce it.

## Why shocks to the manufacturing sector?

- ▶ Clear-cut industry (i.e. manufacturing/non-manufacturing) effects for identification. Both demand and supply shock raise relative tradable output. The former however lowers the relative price of nontradable, the latter increases it.
  - ▶ relative price of tradable/nontradable key to analysis.
  - ▶ Superior choice over international relative price (i.e. terms of trade). Reasons are clear from theory: international price responses can vary across economies with different features.
- ▶ Improve not only identification, but also interpretation of results, relative to economy-wide shocks with unspecified industry origin.

## Isolating US shocks relative to the rest of the world

- ▶ To derive clear-cut implications for the international transmission, we need to capture shocks affecting the US manufacturing sector asymmetrically.
- ▶ Following the empirical literature we use *cross-country differentials* — e.g. see Clarida and Galí [1994] and Glick and Rogoff [1995].
- ▶ This approach is parsimonious but implies ‘symmetry’.. Robustness exercises are needed to verify this assumption. Check for the effects of introducing US variables in levels.

## Sign restrictions: Productivity

Positive supply shock raising relative productivity in US manufacturing should:

1. Raise manufacturing output *relative* to aggregate output in the US ( $Y_T - Y$ ).
2. Lower relative price of manufacturing — HBS effect.
  - ▶ Supply shifts should move price and quantity in *opposite* direction.
3. Raise manufacturing output *relative* to Foreign manufacturing output ( $Y_T - Y_T^*$ ).
4. US labor productivity in manufacturing should rise *relative* to Foreign.
  - ▶ Isolate US relative shocks.

## Sign restrictions: Demand

Positive demand shock in favor of US manufacturing should:

1. Raise manufacturing output *relative* to aggregate output in the US ( $Y_T - Y$ ).
2. Raise relative price of manufacturing.
  - ▶ Demand shifts should move price and quantity in the *same* direction.
3. Raise manufacturing output *relative* to Foreign manufacturing output ( $Y_T - Y_T^*$ ).
  - ▶ Isolate US relative shocks.

## Caveats and qualifications

- ▶ Identified productivity shocks obviously capture 'RBC' technology shocks — Yet, with endogenous productivity, they could also correspond to other supply shocks, e.g.:
  - ▶ Investment shocks
  - ▶ Labor supply shocks
- ▶ Similarly, our demand shocks may have US or foreign origin.
- ▶ A risk is that, if different shocks have different effects on unconstrained variables, we may find our shocks have little effect on the latter.
- ▶ To the extent that we do recover effects, however, we will provide useful evidence for candidate shocks:
- ▶ We check sensitivity in the case of demand requiring a 2-year consumption increase.

## A close-up on theoretical underpinning of our restrictions

- ▶ Domestic Harrod-Balassa-Samuelson (HBS) effect following a productivity increase in tradables:  $\frac{P_N}{P_T}$ .

- ▶ What about  $TOT$  and  $RER$ ?

$$\begin{aligned} RER &= \frac{P_T}{SP_T^*} \cdot \frac{P/P_T}{P^*/P_T^*} \\ &= f(TOT) \cdot g\left(\frac{P_N}{P_T} / \frac{P_N^*}{P_T^*}\right) \end{aligned}$$

- ▶ Even conditional on domestic HBS effect, real appreciation ( $RER \uparrow$ ) will depend on  $TOT$ .
- ▶ Clear-cut answer only with full risk sharing.

## Implementing sign restrictions: Identification in VARs

- ▶ Structural form VAR

$$A_0 X_t = A(L) X_{t-1} + V_t \quad V_t \sim N(0, 1)$$

- ▶ Reduced form VAR

$$X_t = A_0^{-1} A(L) X_{t-1} + A_0^{-1} V_{t-1} = B(L) X_{t-1} + U_t \quad U_t \sim N(0, \Sigma)$$

- ▶ Standard identification amounts to providing enough restrictions to solve

$$\Sigma = A_0^{-1} [A_0^{-1}]'$$

- ▶ The  $j$ -th column of  $A_0^{-1}$ ,  $a_{j,0}$ , determines the impulse vector to  $j$ -th structural shock  $v_t^j$ .

## Identification with sign restrictions

- ▶ Use arbitrary (Cholesky, Eigenvalues) decomposition  $\Sigma = AA'$ .
- ▶ Any impulse vector  $a_{j,0}$  can be computed as  $a_{j,0} = Aq$ , where  $q$  is a unit-length vector (see Uhlig, 2005).
- ▶ The set of structural impulse responses for each horizon  $s$  can then be computed as follows

$$\Psi_{s,j} = \sum_{h=0}^s B_{s-h} \Psi_{h,j}, \quad s \geq 1, B_{s-h} = 0, s-h \geq p;$$
$$\Psi_0 = a_{j,0}.$$

## A Bayesian approach to VAR with sign restrictions

- ▶ VAR parameters as random variables: attribute zero prior probability to reduced-form parameter realizations for which impulse responses contravene the assumed set of restrictions.
- ▶ All the impulse responses from the same reduced-form realization that satisfy those restrictions have the same posterior probability.
- ▶ Standard diffuse prior on reduced form VAR coefficients and covariance matrix  $\Sigma$  yields Normal-Wishart reduced form posterior.
- ▶ For each draw from known posterior, draw thousands of  $q$ 's and compute implied IRF's, discarding IRF's inconsistent with sign restrictions.

## Data description

- ▶ Sample period is 1973-2004 (post Bretton Woods).
- ▶ Benchmark VAR's have 6 quarterly variables and 4 lags:
  - ▶ Relative labor productivity, manufacturing output relative to foreign and relative to GDP, PPI/CPI-services, relative consumption.
  - ▶ The sixth variable is alternated: E.g.,  $I-I^*$ , trade, NFA, international relative prices  $\frac{P}{SP^*}$ .
  - ▶ Three measures of  $\frac{P}{SP^*}$ : relative CPIs (RER), PPIs, Export deflators (TOT).
- ▶ Cross-country differentials between the US and an aggregate of 9 OECD countries: Six G7, plus Australia, Sweden and Ireland (data availability).
- ▶ Individual country's variables are aggregated with weights based on each country's GDP shares at annual purchasing power parity (PPP) values.

## Benchmark restrictions

<i>Productivity shock</i>		<i>Demand shock</i>	
Variable	Quarters	Variable	Quarters
$lp_{T,k} - lp_{T,k}^* > 0$	$k = 1, \dots, 20$	—	—
$y_{T,k} - y_{T,k}^* > 0$	$k = 1, \dots, 20$	$y_{T,k} - y_{T,k}^* > 0$	$k = 1, \dots, 20$
$y_{T,k} - Y_k > 0$	$k = 1, \dots, 20$	$y_{T,k} - Y_k > 0$	$k = 1, \dots, 20$
$p_{T,k} - p_{N,k} < 0$	$k = 5, \dots, 20$	$p_{T,k} - p_{N,k} > 0$	$k = 5, \dots, 20$

- ▶ The horizon of 20 quarters reflects the prior of persistent shocks; we check sensitivity to changing horizons to 28 and 12 quarters.
- ▶ Restrictions on relative prices imposed after 5 quarters to allow for nominal price rigidities in short-run, but unimportant.

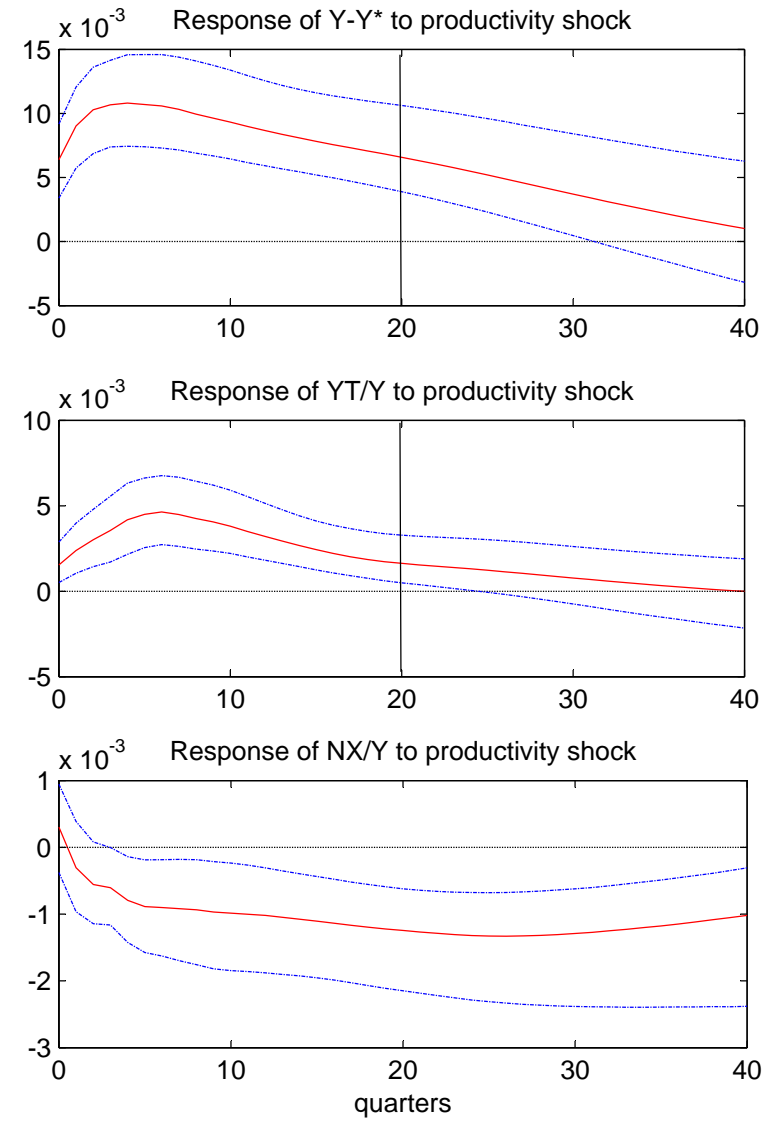
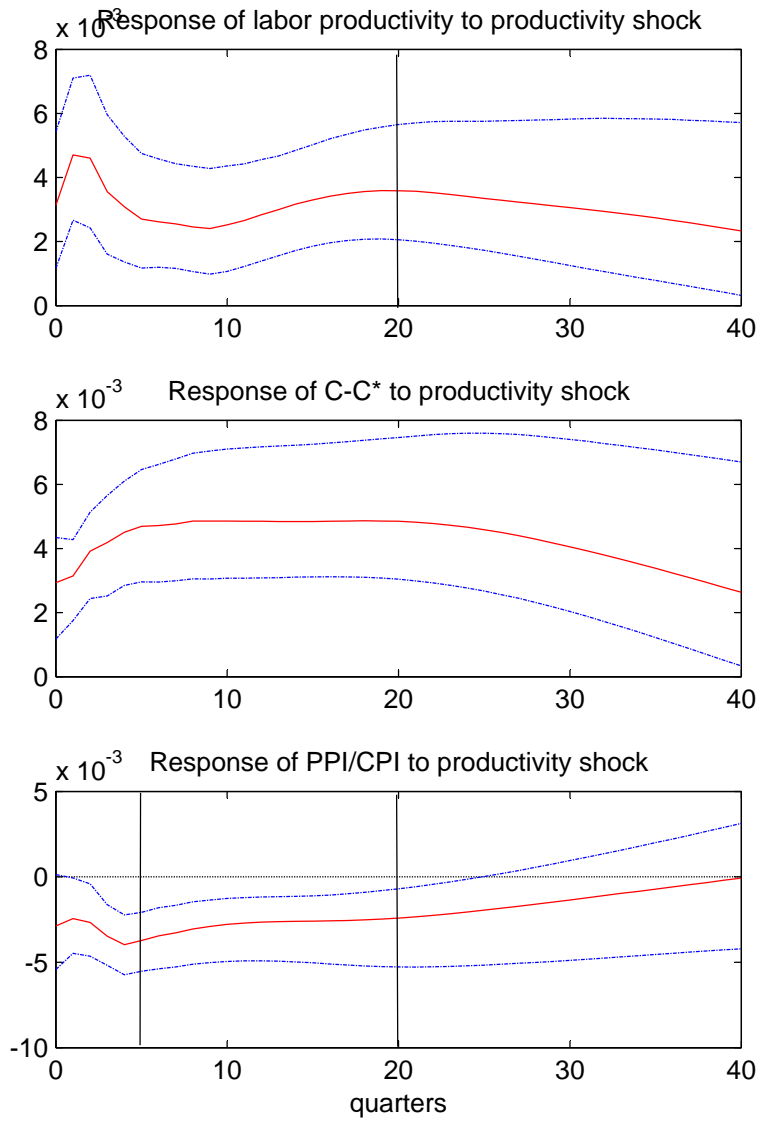
## Important statistics

- ▶ Percentage of discarded reduced form draws is typically well below 5 percent, in some case above 10%, in one case 20%.
- ▶ See Table 2 in the paper.

## Result for productivity shocks: Figure 1

- ▶ The response of restricted variables, plus consumption and net exports.

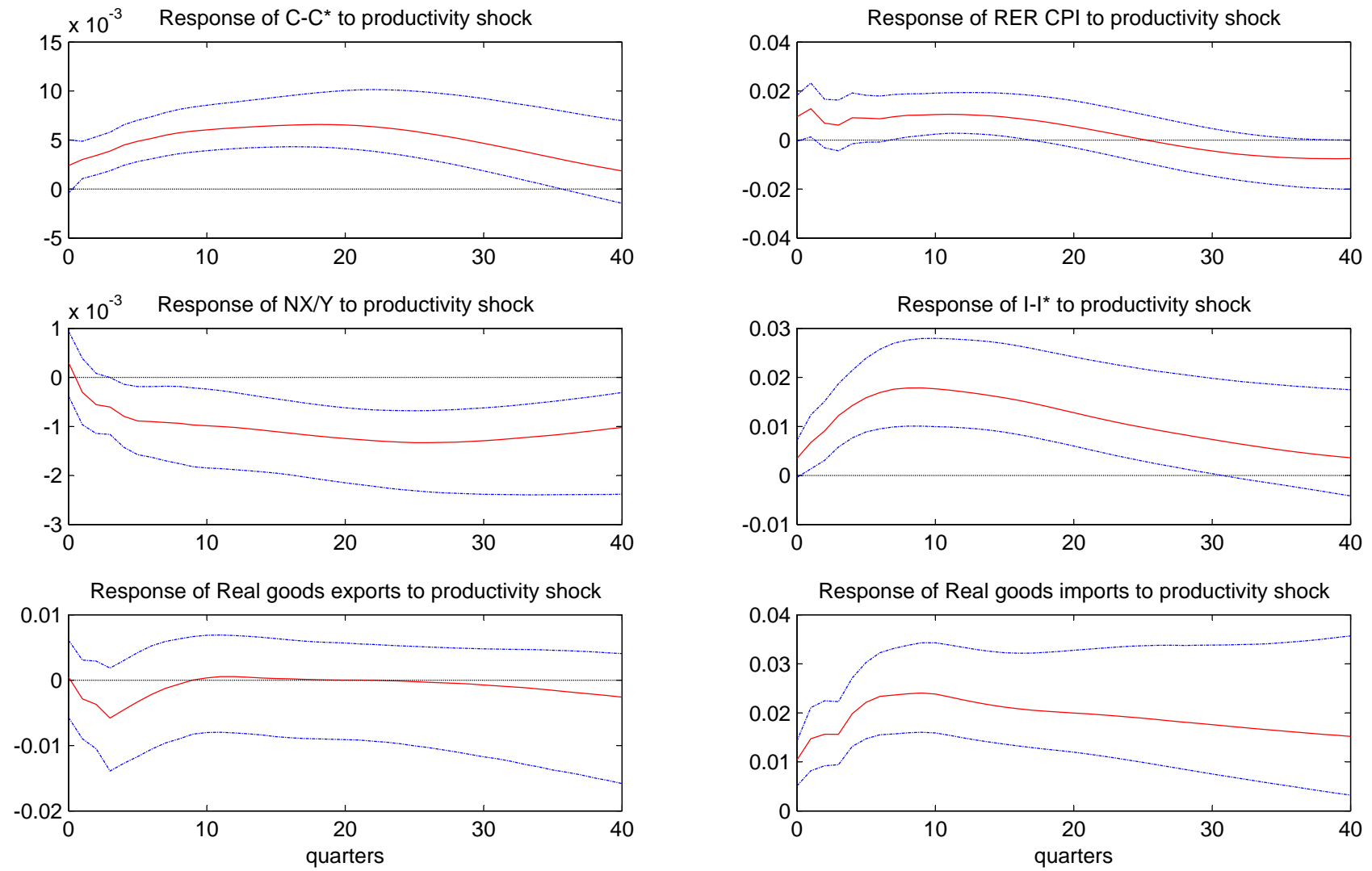
Figure 1



## Figure 2

- ▶ What drives the net export deterioration: relative absorption (C and I) and import behavior.
- ▶ Real exchange rate and consumption: the Backus Smith puzzle is confirmed conditional on productivity shocks only!

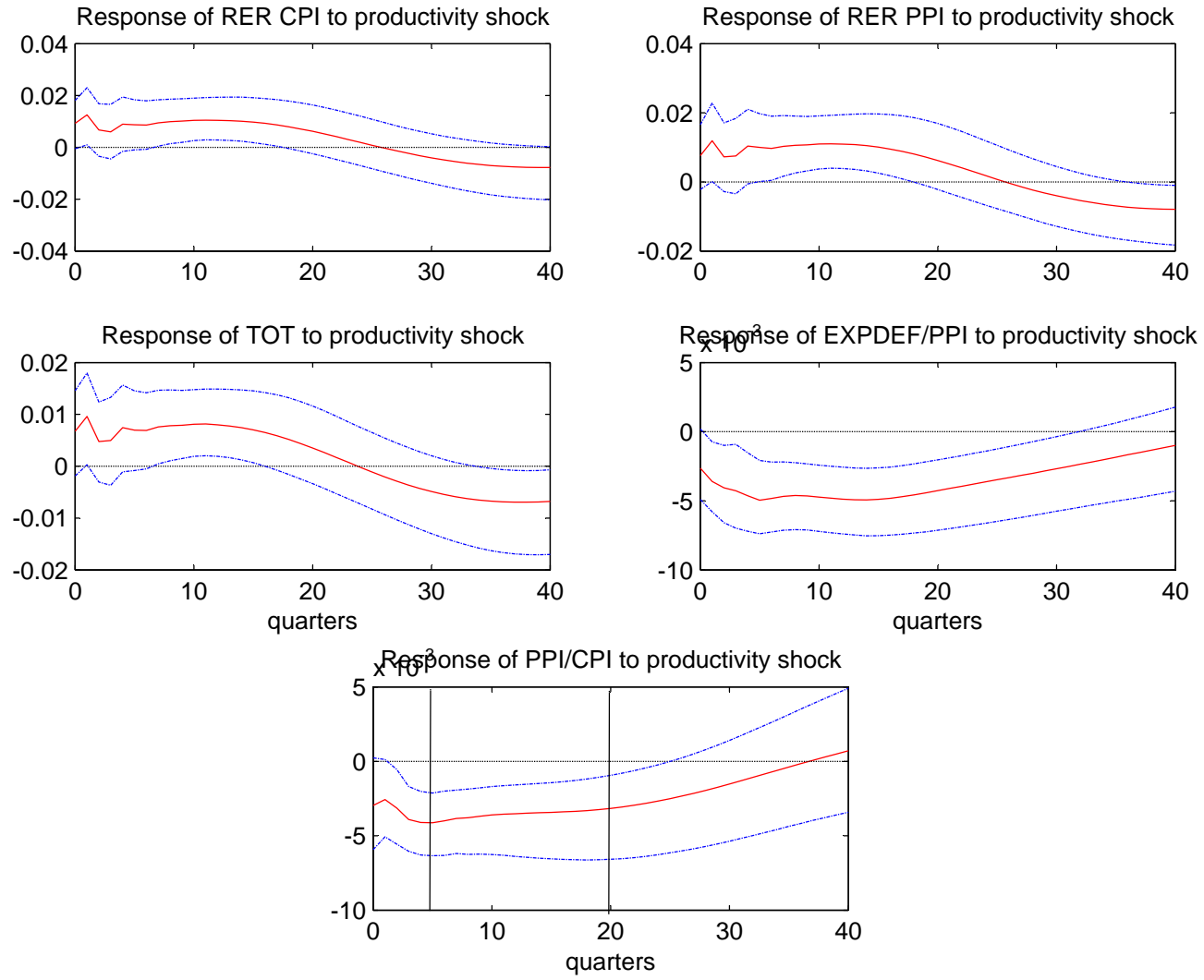
Figure 2



## Figure 3

- ▶ International relative prices: Terms of trade as driver of the Real Exchange Rate (RER).
- ▶ Export pricing: issues in imperfect pass-through, markups and costs adjustment.

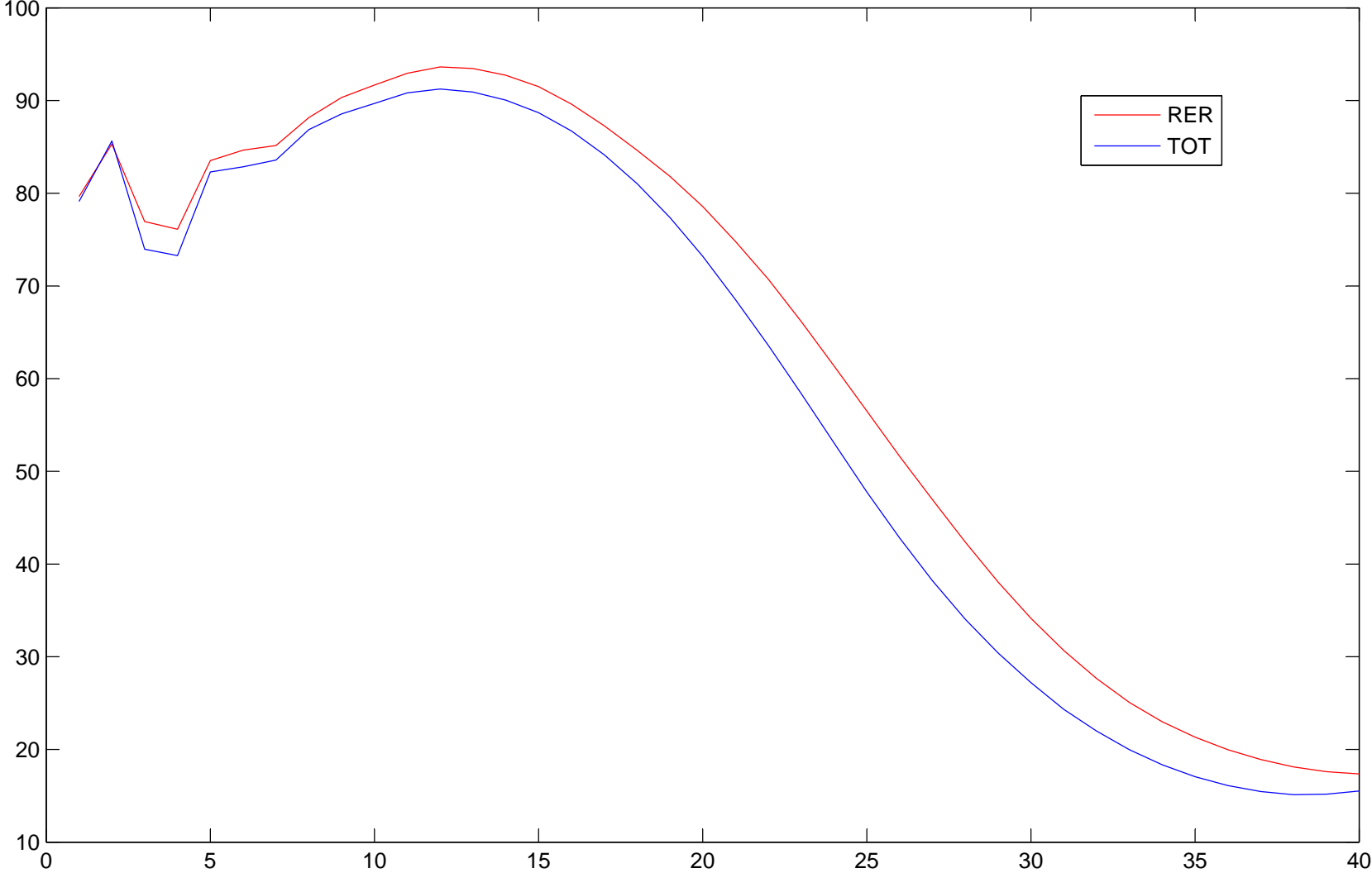
Figure 3



## Figure 4

- ▶ Probability of appreciation

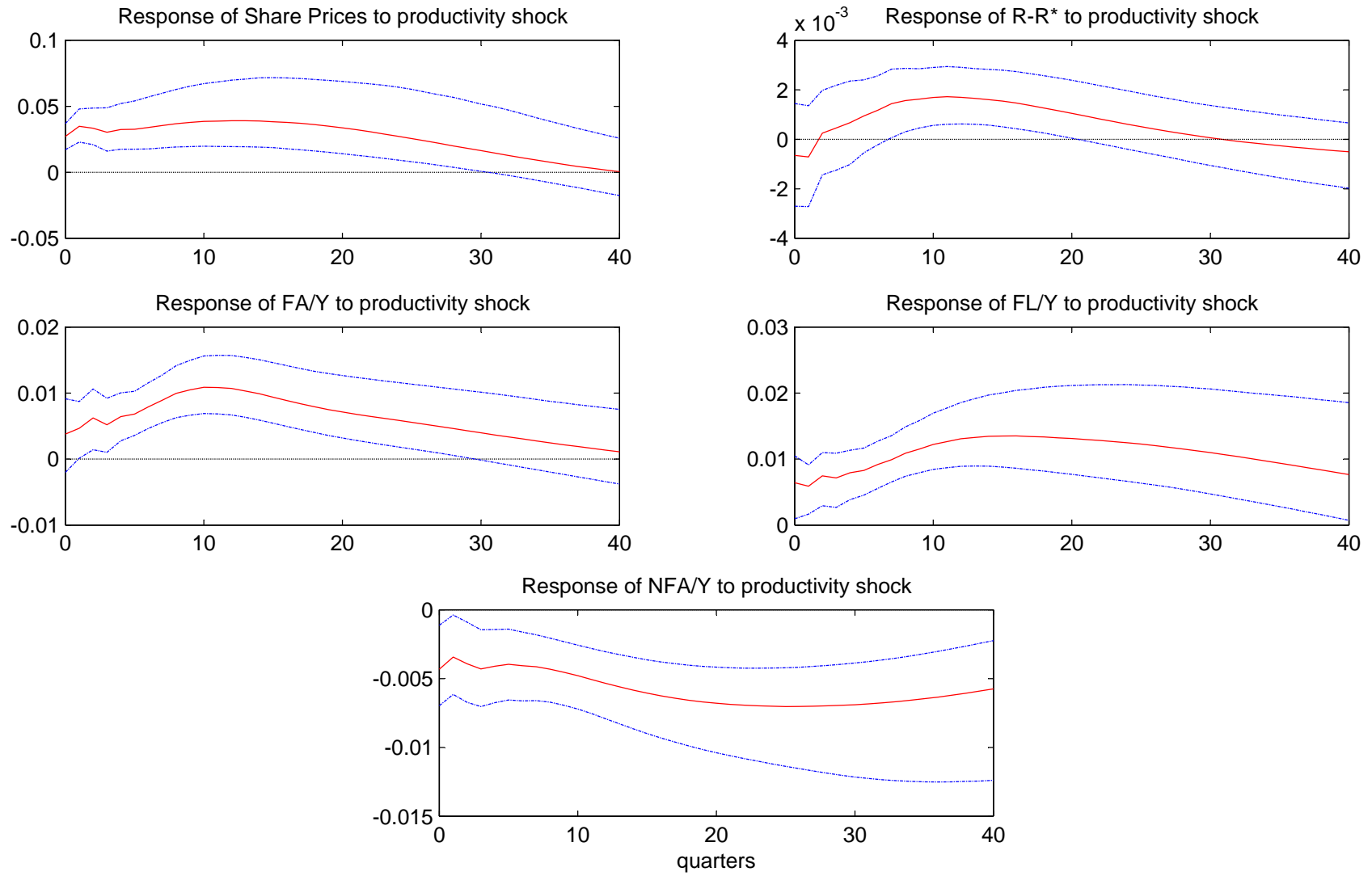
Figure 4



## Figure 5

- ▶ Financial transmission. Relative stock prices, interest differentials, foreign assets and liabilities.
- ▶ Strong stock price response.
- ▶ Intriguing portfolio dynamics: both assets and liabilities rise after the shock (despite dollar real appreciation).

Figure 5



# Demand shocks

## Figure 6-9

- ▶ Subdue effects on consumption, net trade.
- ▶ Investment and relative prices react.

Figure 6

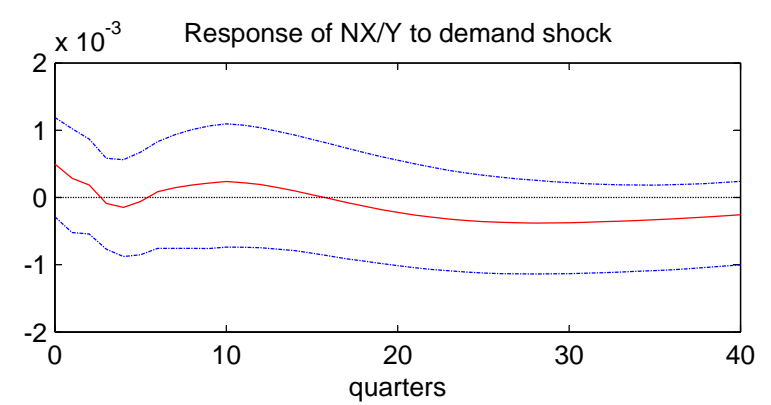
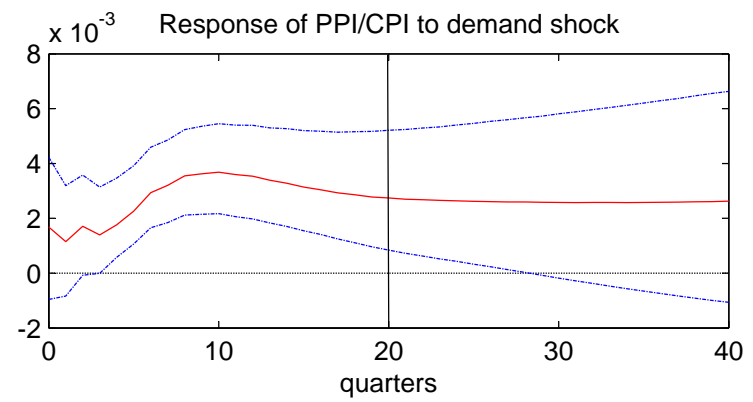
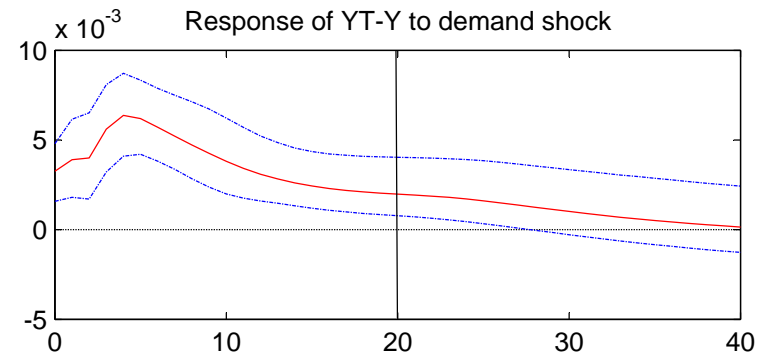
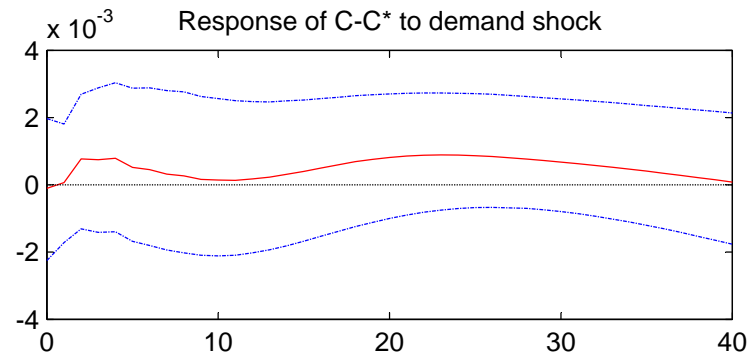
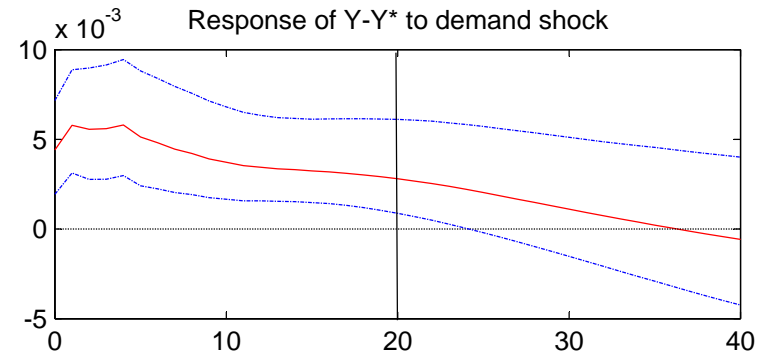
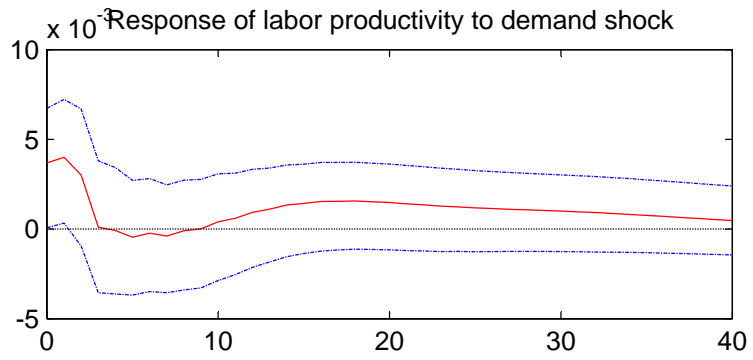


Figure 7

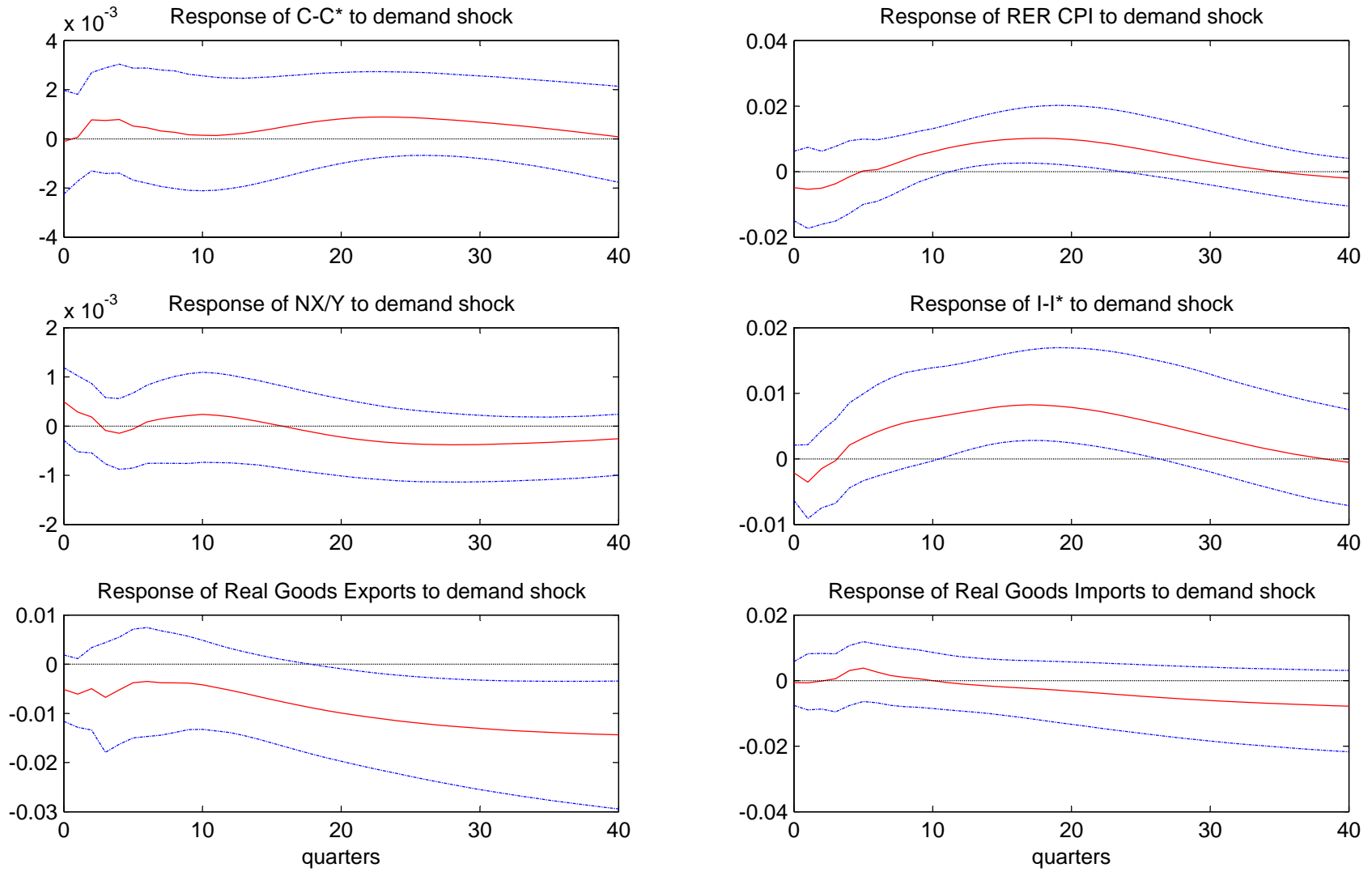


Figure 8

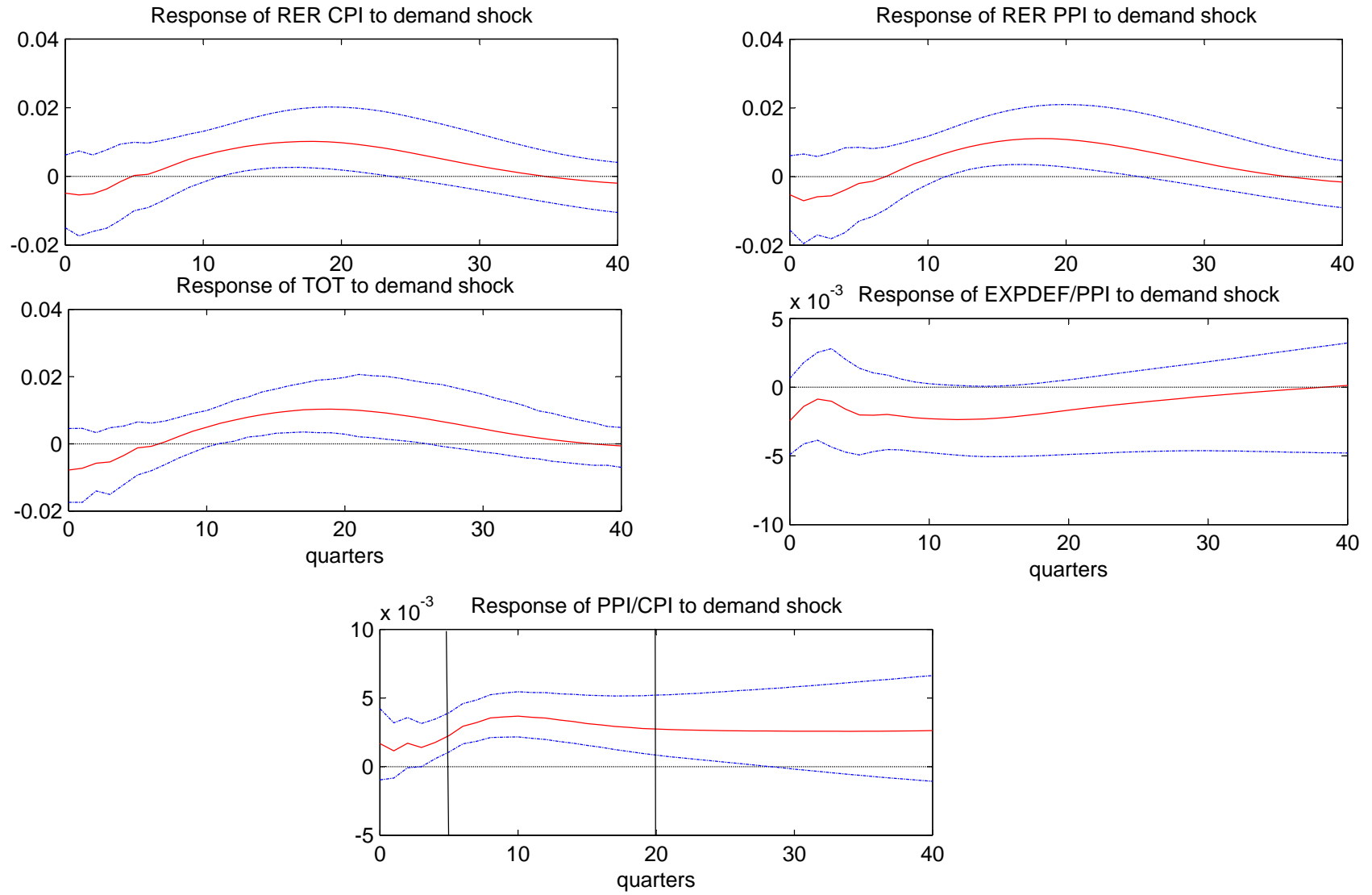
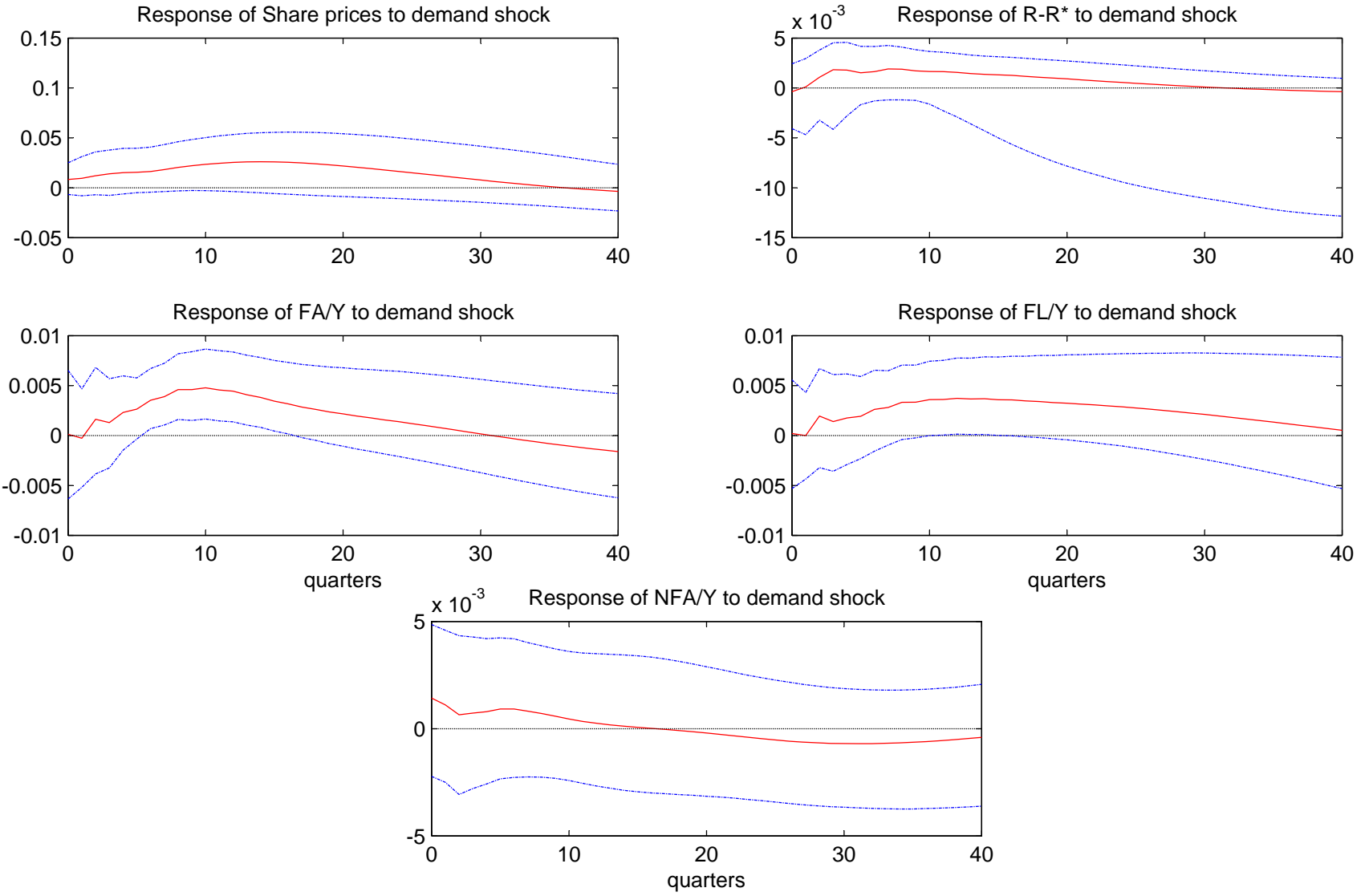


Figure 9



## Figure 2

- ▶ What drives the net export deterioration: relative absorption (C and I) and import behavior.
- ▶ Real exchange rate and consumption: the Backus Smith puzzle is confirmed conditional on productivity shocks only!

## Figure 3

- ▶ International relative prices: Terms of trade as driver of the Real Exchange Rate (RER).
- ▶ Export pricing: issues in imperfect pass-through, markups and costs adjustment.

## Figure 4

- ▶ Probability of appreciation

## Figure 5

- ▶ Financial transmission. Relative stock prices, interest differentials, foreign assets and liabilities.
- ▶ Strong stock price response.
- ▶ Intriguing portfolio dynamics: both assets and liabilities rise after the shock (despite dollar real appreciation).

## Results for demand shocks: Figure 6-9

- ▶ Subdue effects on consumption, net trade.
- ▶ Investment and relative prices react.

## 4. Sensitivity analysis

Results robust to

- ▶ Changing the time-horizon of restrictions — more or less restrictive ( $\pm 8$  quarters).
- ▶ Orthogonal productivity and demand shocks.
- ▶ Relaxing symmetry assumption and estimating 7-variable VAR with level of US productivity.
- ▶ Changing sign restrictions: impose that demand shocks raise relative consumption. Shocks have now stronger and significant effects on trade variables, but weaker effects on investment and international relative prices.
- ▶ Including different variables (e.g. alternative definitions of prices).

## Conclusions

- ▶ Cross-country transmission of US **structural** demand and supply shocks
- ▶ Sectoral demand shocks in US tradables have limited aggregate effects on absorption and net trade, yet still affect specific demand components, especially investment, and appreciate the real value of the dollar.
- ▶ Sectoral productivity shocks in US tradables have a non-trivial impact on **aggregate demand**, suggesting that an important dimension of their transmission operates via intertemporal general equilibrium effects on cross-country wealth.

## Conclusions

- ▶ The estimated wealth and aggregate demand effects of productivity shocks are at odds with a key transmission channel typically postulated by textbook open-economy models — that a higher supply of tradables must be matched by a fall in a country's terms of trade.
- ▶ Movements in the international prices are far from providing risk insurance against US productivity fluctuations — although movements in asset prices do.
- ▶ The findings in Backus and Smith [1993] that domestic consumption on average rises when the currency appreciates, emerge conditional on identified productivity shocks only.