Financial Frictions and Trade Dynamics

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Abstract

This paper demonstrates theoretically that a financial shock can have highly persistent effects on international trade. Motivation is taken from the aftermath of the dramatic trade collapse in 2008-9, which despite a substantial recovery, has left a persistently slower growth rate in trade. We find conditions under which a transitory financial shock significantly reduces the investment by firms in entering the export market, and that this can have long-lasting effects on the range of goods exported and hence overall trade. Important to our mechanism are endogenous capital structure decisions by firms in response to the financial shock, and firm entry investment that requires traded goods. This mechanism provides an example of how firm dynamics can serve as a potent propagation mechanism, generating very long-lasting effects of transitory macroeconomic shocks.

JEL classification:
Keywords: export dynamics, financial frictions, capital restructuring, extensive margin of trade

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1. Introduction

While the level of international goods trade largely has recovered from the dramatic collapse in 2008-9, there appears to be a longer run impact in the form of a persistently slower growth rate in trade compared to the trend before the crisis. As seen in Table 1, the average annual growth rate in US exports for 2012-14 was less than a third of the average annual growth rate for the five years preceding the crisis (3.1% versus 10.1%). This paper will study the role that extensive margin dynamics can play as a mechanism translating a transitory financial shock into a longer-run decline in trade.

Previous empirical research on the trade collapse has downplayed the role of the extensive margin, finding it contributed ten percent or less of the fall in trade in 2009 (see Behrens et al. 2013, and Bricongne et al. 2012). Column two of Table 1 confirms this impression, where the fall during 2009 for two measures of extensive margin, the number of goods-country combinations with positive exports and the number of exporters, respectively, are a tenth and a quarter of the fall in export value. However, Table 1 also considers a data set extended to more recent years, and column four shows that the shortfall in growth rate (comparing post-crisis to pre-crisis averages) in the extensive margin is up to one-half of the magnitude of the shortfall in export growth. We conclude that, while firm dynamics and changes in the extensive margin may move modestly in the short run, they appear to be persistent, and in the medium to long run these persistent effects in the extensive margin are a significant component of the fall in overall exports.

We draw additional empirical motivation from an empirical vector autoregression, identifying the dynamic effects of financial shocks on the margins of trade in recent historical data. Using multiple measures of trade and of the financial shock, the impulse response point estimates indicate a sharp downturn in trade, followed by a rapid partial recovery, but with a longer-term shortfall in trade relative to the original level. Impulse responses for the extensive margin indicate a similar downturn and lingering effect.

This paper will develop a two-country dynamic stochastic general equilibrium (DSGE) model capable of generating the dynamic pattern of trade volume and the extensive margin of trade found in our VAR estimation. It will offer an explanation of how these responses are related to each other, in particular, how the persistent effect on the stock of exporting firms can act as a propagation mechanism for trade volume.

There are two parts to the mechanism driving our result. The first is that shocks to costs of financing working capital lead firms to alter their capital structure from debt to more expensive equity financing. Evidence for such capital restructuring during the financial crisis has been provided by Jermann and Quadrini (2012), and Bergin et al. (2018) has shown it has important implications for firm entry. An adverse financial shock takes the usual form of a tightening of the collateral constraint for borrowing working capital during a period, which reduces the scale of firm production. Since equity is used as collateral, the shock creates an incentive for firms to reallocate firm financing away from intertemporal debt toward equity financing. Because equity is a more costly form of firm financing, this capital structure reallocation raises the effective cost of financing the sunk investment cost of entering the export market, and hence deters potential entrants.

This part of the mechanism thus addresses the problem in past research that a transitory shock affecting short run profits alone does not sufficiently reduce the overall present value of the stream of all future profits in order to have a significant effect on the level of firm entry. By translating this short-run financing shock to raise instead the effective sunk cost, the shock is able to significantly discourage new entry. Due to the fairly slow dynamics in the stock of firms, such a fall in new entry can have long-lasting effects on the number of exporters. A drop in the number of home export varieties available to foreign consumers, relative to the number of foreign domestic varieties, reduces demand for home exports in our model, leading to a long-lasting drop in export volume.

The second key part of the mechanism is that entry investment includes a substantial share of traded goods. The literature has long recognized that capital goods represent a substantial portion of trade flows, and that the volatility of investment helps explain the high volatility in trade flows, including in the recent financial crisis. (See Boileau 1999, Eaton and Kortum 2001, Engel and Wang 2011, and Alessandria et al. 2010, Aslam et al. 2017, and Bussiere et al. 2013.)

In the context of our model, including entry investment in the trade volume allows the change in extensive margin to contribute to trade dynamics in two ways. First, it adds to the initial fall in trade on impact of the shock. This fact is something that was appreciated in past work noted above studying the initial trade collapse. But a second effect, novel to our work, is that it also can have a powerful impact on the persistence of trade dynamics through a vicious circle. A drop in the extensive margin of trade lowering the number of varieties of imported goods available for investment raises the cost of investment, which lowers entry in future periods, which in turn raises the cost of future investment, etc. This persistent drop in the extensive margin of trade then translates into a persistent effect on trade volume.

Results from model simulation imply a large impact effect on trade, which partly dies away quickly, but leaves a persistent component that dies away very slowly. Simulations show this persistence in trade volume is related to an extensive margin that gradually worsens and is quite persistent. They also show the worsening price index of imports and hence for investment noted above. Experiments confirm that both parts of the mechanism, capital restructuring to raise entry cost, and entry costs in units of traded goods, are necessary for our model to generate theoretical impulse responses that look like the empirical responses, in terms of impact effect and persistence. A calibration exercise indicates that this mechanism potentially could explain a substantial share of the persistent effect on trade observed in our empirical VAR.

More broadly, this paper makes a useful contribution to the theoretical literature on firm dynamics. This literature has demonstrated special interest in the question of how firm entry dynamics can be a new source of propagation for macroeconomic shocks. (See Ghironi and Melitz (2005), and Bilbiie, Ghironi and Melitz (2012).) The mechanism in our model provides an example of how firm dynamics at the extensive margin of trade can serve as a highly potent propagation mechanism, generating very long-lasting effects of transitory financial shocks. Our finding that export firm entry can have strong implications for explaining dynamics of gross trade volume differs from Alessandria and Choi (2007), who study net trade and find exporter entry does not have strong implications for net exports.

Our model is broadly consistent with findings in Paravisini et al. (2015), which argues that the financial crisis involves shocks to working capital, but not sunk entry costs, and that these shocks directly impact the intensive rather than extensive margin. Our model is consistent with their overall conclusion, in that the type of financial shock used in our model impacts directly the working capital needed for production. However, our model is based on the idea that a shock to short term working capital costs can have strong indirect implications for the financing of firm sunk entry costs through endogenous changes in firm capital structure.[1]

[1] While Paravisini et al. (2015) do not find evidence in firm-level data for a direct effect of financial shocks on the extensive margin of trade, this result is conditional on the use of instruments to control for indirect effects on the extensive margin coming from, as they state, changes in the level in export demand, and changes in input costs. They explicitly say that their result does not reject potential explanations where: "a deterioration in credit conditions lowers the equilibrium size and profitability of each export flow, which, in turn, may reduce the probability of entering new markets— as we find when the period of analysis is extended to two years (Table 8, Panel 5)." (p353) Consequently, the empirical evidence of Paravisini et al. (2015) does not bear on the mechanism we propose, since we do not specify a direct effect of credit shock on entry, but rather that the credit shock affects entry indirectly through the

The remainder of this paper is structured as follows. Section 2 documents some new stylized facts regarding the extensive margin of trade during the financial crisis. Section 3 explains the mechanics of the DSGE model. Section 4 calibrates the model, interprets simulation results, and conducts sensitivity analyses to identify key channels of the mechanism. Section 5 concludes.

2. Empirical Motivation

We characterize the dynamic responses of the margins of trade to a financial shock by estimating a 7-variable vector autoregression model. A VAR is useful in that it can control for other shocks, such as shocks to monetary policy. It also characterizes dynamics in terms of impulse responses that are directly comparable to those produced by our theoretical DSGE model.

The VAR includes monthly 6-digit HS disaggregate U.S. export and import flow data with 238 trade partners running from 2002:1 to 2016:11 from USA Trade Online provided by the U.S. Census Bureau. This is used to measure trade flows, and permits computation of the extensive margin of trade as the number of different categories traded with a given country in a month. This sample period includes the recent crisis and recovery. Given the short time span, we procured export and import data at a monthly frequency in order to maximize the level of statistical significance. The VAR model is estimated with variables in the following order: the logarithm of industrial production, the logarithm of CPI, the federal funds rate, the 3-month interbank lending rate, the logarithm of the extensive margin of trade, the logarithm of total trade, and the logarithm of S&P500 index. For robustness, we will also estimate VARs for exports and imports separately, in place of the trade variable.

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channels of a rise in input costs for the investment good used for entry, a reduction in expected future export sales and profits, and through capital restructuring.

The strategy for identification of the financial shock closely follows that in Bergin et al. (2018). The interbank lending rate is used as a measure of tightness of financial conditions over time as in Chor and Manova (2012), as it is a broad measure of financial liquidity in the economy. We represent an exogenous financial shock as an innovation to the lending rate orthogonal to contemporaneous movements in other macroeconomic variables, including the federal funds rate. These variables are included to help disentangle the effects on the lending rate due to monetary policy from the effects of an exogenous financial shock. We follow Eichenbaum and Evans (1995) and Bernanke and Mihov (1998) to assume that output and consumer prices are not contemporaneously affected by monetary policy shocks, and thus specify a VAR ordering federal funds rate after industrial production and CPI. To examine how financial shock affect the extensive margin of trade, total trade and stock prices, we follow Bergin and Corsetti (2008) to put the extensive margin of trade after the variables representing shocks discussed above, which allow the data to speak as to whether this variable responds in the initial period of shocks or with a lag. We order stock prices last to allow for the possibility that stock prices respond quickly to new information.[2]

The impulse responses are reported in Fig. 1, along with two-standard error bands. These show that the lending rate has negative and significant impacts on the extensive margin of trade and total trade. The effect on trade is a sharp downturn that reaches a peak 8 to 9 months after the shock, followed by a rapid recovery two years after the shock. However, the level of trade does not fully return to the original level, with a small but persistent shortfall. The impulse response for the extensive margin is very similar, with a sharp downturn reaching a peak at 3 months, followed by a rapid

[2] A well-known disadvantage of using a Cholesky decomposition on the reduced-form residuals is that results can be sensitive to the ordering of variables, calling into question the validity of the restrictions used for identification. In addition, ordering restrictions typically are not derived from a theoretical model. Robustness checks reported in section A of a Supplementary Online Appendix show that our conclusions are robust to alternative orderings.

recovery which leaves a small but very persistent shortfall compared to the original level. These impulse responses are consistent with a highly persistent effect on trade, in that the point estimates of the impulse responses do no fully return to the starting point, even when the horizon of the impulse responses is doubled to 120 months. (However, wide confidence bands preclude claims of statistical significance in the long run.)

Figs. 2 and 3 estimate the impacts of financial shock on exports and imports separately. The impulse responses of the extensive margins of exports and imports are both very persistent, however, the significance of impacts on the extensive margin of imports is longer-lasting than that on the extensive margin of exports.

For robustness, we also consider VARs that replace innovations in the interbank rate with an innovation in the Chicago Fed National Financial Conditions Index as an indicator of the financial shock. The results shown in Appendix Fig. A1 to A3 are very similar to our benchmark model. However, the impacts of financial shock on the extensive margin of trade and total trade are even somewhat more persistent than the benchmark.[3] Because we focus on the responses of trade flows, Appendix Fig. A4 shows the impulse responses of VARs when including the real effective exchange rate in the model. Our benchmark results are robust, and the financial shock has no significant effect on the real effective exchange rate.

3. Model

[3] The Appendix also reports results for a panel VAR exercise, in which we redefine the measure of extensive margin to track the number of products rather than the combination of products and country, so that the country dimension is available for use for cross-sectional information. The cross sectional information does not narrow the confidence bands for the variables of interest, trade and the extensive margin. See Appendix Fig. 5. Only when we reduce the number of estimated parameters in the VAR by reducing the number of variables to 3, are we able to find a statistically significant negative long run effect of the shock on the extensive margin of trade. This specification also redefines the shock by interacting the Libor rate with a dummy indicating the crisis period after 2008. See Appendix Fig. 6.

The theoretical model combines financial frictions as specified in Jermann and Quadrini (2012), with export firm dynamics as developed in Ghironi and Melitz (2005), though the latter is modified to facilitate compatibility with the specification of financial frictions. For example, we introduce an up-front sunk cost of export entry, to facilitate study of external financing of export entry, including equity issuance. We abstract from the domestic entry condition and sunk costs of domestic firm creation, assuming there is a fixed mass of domestic firms.[4] We abstract from firm productivity heterogeneity, assuming homogenous firms.[5] Finally, export sales begin in the initial period of entry rather than with a lag, which simplifies the model greatly by implying all firms, both new exporters and incumbents, face the same financial constraint defined over a firm's working capital.

The theoretical model considers two symmetric countries, Home and Foreign. In each country there are five sectors: (1) a perfectly competitive final goods sector whose goods will be consumed domestically, (2) a perfectly competitive investment goods sector whose goods will be used for export market entry investment, (3) a monopolistically competitive intermediate goods sector where some producers are exporters and the rest are non-exporters, (4) a representative investor who finances domestic intermediate firms through equity purchases, and (5) a representative worker who supplies labor to domestic intermediate firms and purchases bonds from these firms.

4 Given that we need a sunk cost of exporting, we did not want to also model domestic entry, as the presence of two sunk costs could introduce complex issues of option value of paying the domestic sunk in case it becomes optional under some future shock to pay the sunk export entry cost. This option value could greatly complicate the solution method, for reasons that have little bearing on the export entry decision we wish to focus on. Our specification of a constant mass of domestic firms while focusing on export entry follows that in Bergin and Lin (2012) and Ruhl (2008).

5 We are not unique in studying firm entry when firms are symmetric; see for example Bilbiie, Ghironi and Melitz (2007, 2012) and Bergin and Corsetti (2008). In general it is possible to determine the number of exporting firms, even if one cannot identify which of the identical firms is doing the exporting. In the absence of heterogeneity, this identification does not affect the equilibrium. Given the size of overall home country export revenue, only so many home firms can enter before the fraction allocated to each firm is small enough to just barely justify a given entry cost.

The intermediate firms are financially constrained as they may default on their borrowing for wage payments. To smooth production, the intermediates may change their capital structure through equity and bond issuance as described in Jermann and Quadrini (2012). Non-exporters may choose to become exporters after paying a sunk entry cost. For simplicity we assume that for a given country the total mass of firms in the intermediate goods sector is constant, fixed at a mass of unity, but that the number of these firms that engage in export activity varies endogenously. For simplicity, we assume balanced trade.[6]

Below we describe the economy in the Home country; the economy in the Foreign country is analogous. All foreign variables are indicated by a superscript '*'. For a given country, we denote exporters and non-exporters with a subscript 'x' or 'nx' respectively. Prices are in common currency. As our focus is on real variables, the model abstracts from money and nominal exchange rates.

3.1 Timeline

The timeline of the economy is shown in Table 2. Each period starts with four aggregate state variables: the technology shocks (A_t, A_t^*), and the financial shocks (ξ_t, ξ_t^*). We will describe the financial shocks (ξ_t) in more detail in the next section.

There is a unit mass of firms in the intermediate goods sector, with fraction n_{xt-1}

[6] Perri and Quadrini (2016) introduce international asset trade in equities in a two country model with financial shocks and capital restructuring. However, our model differs in introducing nontraded goods, including some goods which are traded in some states and nontraded in others, which prevents us from using the standard modeling of equity trade used in Perri and Quadrini (2016). Further, introducing international financial integration in our model would not confer the benefit it does in their model, whereby it endogenously transmits financial shocks internationally, to make the tightness of the financial constraint co-move perfectly across countries. This is because collateral in our model is specified in terms of equity rather than capital, and the financial shock enters directly in the firm Euler equation.

that are exporters, and fraction $1-n_{xt-1}$ that are non-exporters at the end of period $t-1$. In period t, after paying a sunk entry cost, ne_{xt} non-exporters enter the export market, so the mass of exporters becomes $n_{xt-1}+ne_{xt}$, and the mass of non-exporters are $n_{nxt}^{begin}=1-\left(n_{xt-1}+ne_{xt}\right)$, where n_{nxt}^{begin} represents the non-exporter number at the beginning of period t. Following Bergin et al. (2018), we assume that new exporters hire labor, produce goods and issue corporate bonds in the initial period of entry. As in Bergin et al. (2018), this specification preserves the property that all firms, both incumbents and new entrants, are homogeneous and face the same enforcement constraint. New exporters differ from incumbent exporters in that they have a matured debt position like their non-exporter counterparts, since new exporters existed as non-exporters in the preceding period. New exporters also differ from incumbent exporters in that they must pay a sunk entry cost.

At this point in time, all firms make production and financial decisions. They hire labor and make wage payments before revenue realization, issue corporate bonds and equities and produce goods. The household receives wage income and bond repayment, and the investor receives equity returns from the ne_{nxt-1}^{end} surviving non-exporters and the n_{xt-1} surviving exporters; in the mean time they make financial investment over the n_{nxt}^{begin} non-exporters and the $n_{xt-1}+ne_{xt}$ exporters.

At the end of period t, after all markets have cleared, an exogenous death shock applies to the firms with a probability of λ. So now there are $n_{xt}=\left(1-\lambda\right)\left(n_{xt-1}+ne_{xt}\right)$ surviving exporters and $n_{nxt}^{end}=\left(1-\lambda\right)n_{nxt}^{begin}$ surviving non-exporters, each of which will enter period $t+1$ with a matured debt repayment b_{xt} or b_{nxt} respectively. To maintain the assumption of a unit mass of firms, after the death shock at t a mass of $1-n_{xt}-n_{nxt}^{end}$, that is, λ firms are born into the domestic market as non-exporters automatically without incurring any additional cost.[7]

So the dynamics of exporters and non-exporters in the home country is as follows:

$$n_{xt}=(1-\lambda)(n_{xt-1}+ne_{xt}) \tag{1}$$

$$n_{nxt}^{begin}=1-(n_{xt-1}+ne_{xt}) \tag{2}$$

$$n_{nxt}^{end}=(1-\lambda)n_{nxt}^{begin} \tag{3}$$

3.2 Final goods sector: Consumption and Investment

3.2.1 Consumption

The overall consumption goods index (C_t) is a CES aggregator of home and foreign varieties:

$$C_t \equiv \left[\int_0^{n_{xt-1}+ne_{xt}} c_{dxit}^{\frac{\sigma-1}{\sigma}}di+\int_{n_{xt-1}+ne_{xt}}^{1} c_{nxit}^{\frac{\sigma-1}{\sigma}}di+\int_0^{n_{xt-1}^{*}+ne_{xt}^{*}} c_{fxit}^{\frac{\sigma-1}{\sigma}}di\right]^{\frac{\sigma}{\sigma-1}},$$

where c_{dxit} denotes the varieties produced by the home exporter while consumed domestically by the home consumers, representing fraction $n_{xt-1}+ne_{xt}$ of all home varieties. Likewise c_{nxit} is the goods produced by domestic non-exporter nx_{it}, representing fraction $1-(n_{xt-1}+ne_{xt})$ of home varieties. The variable c_{fxit} denotes the varieties produced by the foreign exporter while consumed by the home country,

[7] We assume that death shocks apply to both exporters and nonexporters, since we do not want the decision of whether to become an exporter to be driven by an exogenous and arbitrary distinction that exporters are at greater risk of death shocks. Our specification of death shocks and a constant mass of domestic firms follows Bergin and Lin (2012) and Ruhl (2008). In our context, it is assumed that newly born non-exporting firms inherit the debt position of the dying non-exporting firms they replace.

representing fraction $n^*_{xt-1} + ne^*_{xt}$ of all foreign varieties. For reference, we can write this overall consumption index in terms of sub-aggregates:

$$C_t = \left[C_{Ht}^{\frac{\sigma-1}{\sigma}} + C_{Ft}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}},$$

where C_{Ht} is a CES aggregator of all home varieties,

$$C_{Ht} \equiv \left[\int_0^{n_{xt-1}+ne_{xt}} c_{dxit}^{\frac{\sigma-1}{\sigma}} di + \int_{n_{xt-1}+ne_{xt}}^1 c_{nxit}^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}},$$

and $C_{\mathrm{F}t}$ is a CES aggregator of imported foreign varieties,

$$C_{Ft} \equiv \left[\int_0^{n^*_{xt-1}+ne^*_{xt}} c_{fxit}^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}} = \left(n^*_{xt-1} + ne^*_{xt} \right)^{\frac{\sigma}{\sigma-1}} c_{fxit} .$$

where the second equalities are from the symmetric equilibrium as shocks in the economy are at the aggregate level and common to all firms of the same type.

The corresponding consumer price indices are thus given by:

$$P_t = \left[P_{Ht}^{1-\sigma} + P_{Ft}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{4}$$

where

$$P_{Ht} \equiv \left[\int_0^{n_{xt-1}+ne_{xt}} p_{\mathrm{d}xit}^{1-\sigma} di + \int_{1-\left(n_{xt-1}+ne_{xt}\right)}^1 p_{nxit}^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}, \tag{5}$$

or equivalently $P_{Ht}^{1-\sigma} \equiv \left(n_{xt-1} + ne_{xt} \right) p_{\mathrm{d}xit}^{1-\sigma} + \left(1 - n_{xt-1} - ne_{xt} \right) p_{nxit}^{1-\sigma}$,

and

$$P_{Ft} \equiv \left[\int_0^{n^*_{xt-1}+ne^*_{xt}} p_{fxit}^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} = \left(n^*_{xt-1} + ne^*_{xt} \right)^{\frac{1}{1-\sigma}} p_{fxit} \tag{6}$$

for homogeneous firms. Here, P_t is the domestic aggregate consumer price level, P_{Ht} is the price level of the home composite, P_{Ft} is the price of the imported foreign composite, and p_{hxit}, p_{nxit} and p_{fxit} are the prices (faced by home consumers) of individual varieties produced by home exporers, home non-exporters and foreign exporters.

The implied relative demand functions for home country are

$$C_{Ht} = \left(\frac{P_{Ht}}{P_t} \right)^{-\sigma} C_t \tag{7}$$

$$C_{Ft} = \left(\frac{P_{Ft}}{P_t} \right)^{-\sigma} C_t \tag{8}$$

$$c_{nxit} = \left(\frac{p_{nxit}}{P_{Ht}} \right)^{-\sigma} C_{Ht} \tag{9}$$

$$c_{dxit} = \left(\frac{p_{dxit}}{P_{Ht}} \right)^{-\sigma} C_{Ht} \tag{10}$$

$$c_{fxit} = \left(\frac{p_{fxit}}{P_{Ft}} \right)^{-\sigma} C_{Ft} = \left(n^*_{xt-1} + ne^*_{xt} \right)^{\frac{\sigma}{1-\sigma}} C_{Ft} \tag{11}$$

Analogous conditions apply to the foreign country.

3.2.2 Investment

In period t, each of the ne_{xt} new exporters must pay an entry cost, K_t^E, to enter the export market. So the total investment expenditure on entry in Home country is given by

$$I_t \equiv ne_{xt} K_t^E . \tag{12}$$

Analogous to the aggregate consumption index above C_t, we assume the production of investment good for entry is a CES aggregator of home and foreign varieties, given by

$$I_t = \left[\theta^{\frac{1}{\phi}} I_{Ht}^{\frac{\phi-1}{\phi}} + (1-\theta)^{\frac{1}{\phi}} I_{Ft}^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}},$$

where $1-\theta$ is the degree of bias to imported foreign goods, reflecting the dependence of home firms on local inputs when entering foreign market. Here, I_{Ht} is a CES aggregator of all home varieties,

$$I_{Ht} \equiv \left[\int_0^{n_{xt-1}+ne_{xt}} i_{dxit}^{\frac{\sigma-1}{\sigma}} di + \int_{n_{xt-1}+ne_{xt}}^{1} i_{nxit}^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}},$$

and I_{Ft} is a CES aggregator of imported foreign varieties,

$$I_{Ft} \equiv \left[\int_0^{n_{xt-1}^*+ne_{xt}^*} i_{fxit}^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}} = \left(n_{xt-1}^* + ne_{xt}^* \right)^{\frac{\phi}{\phi-1}} i_{fxit} .$$

The corresponding investment price index is thus given by

$$P_{It} = \left[\theta P_{Ht}^{1-\phi} + (1-\theta) P_{Ft}^{1-\phi} \right]^{\frac{1}{1-\phi}} . \tag{13}$$

The implied relative demand functions for home country are

$$I_{Ht} = \theta \left(\frac{P_{Ht}}{P_{It}} \right)^{-\phi} I_t \tag{14}$$

$$I_{Ft} = (1-\theta) \left(\frac{P_{Ft}}{P_{It}} \right)^{-\phi} I_t \tag{15}$$

$$i_{nxit} = \left(\frac{p_{nxit}}{P_{Ht}} \right)^{-\phi} I_{Ht} \tag{16}$$

$$i_{dxit} = \left(\frac{p_{dxit}}{P_{Ht}} \right)^{-\phi} I_{Ht} \tag{17}$$

$$i_{fxit} = \left(\frac{p_{fxit}}{P_{Ft}} \right)^{-\phi} I_{Ft} = \left(n_{xt-1}^* + ne_{xt}^* \right)^{\frac{\phi}{1-\phi}} I_{Ft} \tag{18}$$

Analogous conditions apply to the foreign country.

3.2 Worker preferences and optimization

The representative worker derives utility from consuming the basket of final goods (C_{wt}), and disutility from labor supply (L_t) in each period, and maximizes expected lifetime utility,

$$\max\ E_0 \sum_{t=0}^{\infty} \beta^t U(C_{wt}, L_t), \qquad with \qquad U(C_{wt}, L_t) = \frac{C_{wt}^{1-\rho}}{1-\rho} - \kappa \frac{L_t^{1+\varphi}}{1+\varphi},$$

where $\rho > 0$ is the worker's degree of risk aversion, $\beta \in (0,1)$ is the worker's discount factor, and κ is the relative weight of labor in the utility function.

The worker receives income from providing labor services (L_t) at the real wage rate (w_t), and holding matured corporate bonds of the (n_{xt-1}) domestic exporters (b_{xit-1}) and of the ne_{nxt-1}^{end} non-exporters (b_{nxit-1}), respectively. The worker then purchases consumption (C_{wt}), and updates its corporate bond investment to the ($n_{xt-1} + ne_{xt}$) domestic exporters and n_{nxt}^{begin} domestic non-exporters with a price at $\frac{1}{R_t}$. Note that, workers are indifferent to the bonds issued by non-exporters or exporters as these two types of bonds bear identical risks and identical prices.

The period budget constraint may thus be written as

$$C_{w,t} + \frac{(n_{xt-1} + ne_{xt}) b_{xt}}{R_t} + \frac{n_{nxt}^{begin} b_{nxt}}{R_t} \leq w_t \mathrm{L}_t + n_{xt-1} b_{xt-1} + n_{nxt-1}^{end} b_{nxt-1} \ .$$

From the constraint, we see that worker receives financial income from the n_{xt-1} surviving exporters and n_{nxt-1}^{end} surviving non-exporters from last period, but purchases corporate bonds from the n_{xt-1} surviving exporters, the ne_{xt} new exporters and the n_{nxt}^{begin} non-exporters.

The worker maximizes his expected lifetime utility subject to the budget constraint, leading to the following first-order conditions:

$$U_{C_{wt}} w_t + U_{Lt} = 0 \tag{19}$$

$$\beta(1-\lambda) E_t \left[U_{C_{wt+1}} R_t \right] = U_{C_{wt}} \tag{20}$$

where Eq. (19) is the labor-consumption tradeoff condition, and Eq. (20) is the Euler equation for holding exporter and non-exporter bonds. As household is indifferent between the bonds issued by exporter and non-exporter, Eq. (20) applies to both types of home firms.

3.3 Investor preferences and optimization

The representative investor derives utility from consuming the basket of final goods (C_{It}) in each period, and maximizes his expected lifetime utility:

$$\max\ E_0 \sum_{t=0}^{\infty} \beta_I^t U(C_{It}), \qquad with \qquad U(C_{I,t}) = \frac{C_{It}^{1-\rho_I}}{1-\rho_I},$$

where $\rho_I > 0$ is the investor's degree of risk aversion, and $\beta_I \in (0,1)$ is the investor's discount factor.

The investor makes equity investment in domestic intermediate firms. He purchases equities of the n_{xt-1} surviving exporters, the ne_{xt} new exporters and the n_{nxt}^{begin} non-exporters, and receives incomes from last period equity investment on the n_{xt-1} surviving exporters and the n_{nxt-1}^{end} surviving non-exporters. The period budget constraint may thus be written as:

$$C_{It} + (n_{xt-1} + ne_{xt}) q_{xt} s_{xt} + n_{nxt}^{begin} q_{nxt} s_{nxt} \leq n_{xt-1} s_{xt-1} (q_{xt} + d_{xt}) + n_{nxt-1}^{end} (q_{nxt} + d_{nxt}) \tag{21}$$

where s_{xt} and s_{nxt} are the stock shares purchased from exporters and non-exporters respectively, q_{xt}, q_{nxt}, are the market stock prices, and d_{xt} and d_{nxt} are the dividends received from owning shares issued by domestic exporters and non-exporters respectively, all in units of final goods. As intermediate firms are fully owned by domestic investor, $s_{xt} = s_{nxt} = 1$ in equilibrium.

The optimization implies the following first-order conditions:

$$\beta_I (1-\lambda) E_t \left[U_{C_{It+1}} \left(q_{xt+1} + d_{xt+1} \right) \right] = U_{C_{It}} q_{xt} \tag{22}$$

$$\beta_I (1-\lambda) E_t \left[U_{C_{It+1}} \left(q_{nxt+1} + d_{nxt+1} \right) \right] = U_{C_{It}} q_{nxt} \tag{23}$$

where Eqs. (22-23) are the Euler equations for holding shares issued by domestic exporters and non-exporters.

As in Perri and Quadrini (2016), we assume that the investor is less patient than worker, $\beta_I < \beta$. Because firms are owned by the investor, the higher discounting rate of investor implies that in equilibrium firms prefer borrowing from the worker since bond financing is cheaper than equity financing.

3.4 Intermediate goods sector

3.4.1 Enforcement constraint

Each intermediate firm issues one-period corporate bonds (denoted by b_{xit} for exporters, or b_{nxit} for non-exporters) or adjusts their dividend payouts (denoted by d_{xit}, or d_{nxit}) to maximize their firm values. As the investor (equity holder) is less patient than the worker (debt holder), firms prefer debt financing to equity financing (in steady state) because the cost of external financing through bond issuance is lower than the cost through equity issuance.

In addition to the inter-period corporate bonds, each firm also borrows an intra-period loan at the amount of $w_t l_{xit}$ or $w_t l_{nxit}$ as labor market requires working capital being paid before the realization of revenue. The intra-period loan is repaid at the end of the period and there is no interest. As firms may default on the intra-period loan repayments, their borrowing is restricted by the firm's end-of-period equity value perceived by the credit market:

$$\xi_t E_t(m_{t+1} V_{xit+1}(b_{xit})) \geq w_t l_{xit} \tag{24}$$

$$\xi_t E_t(m_{t+1} V_{nxit+1}(b_{nxit})) \geq w_t l_{nxit} \tag{25}$$

where $m_{t+1} = \beta_I (1-\lambda) \frac{U_{CI,t+1}}{U_{CI,t}}$ is the discount factor as the firms are essentially owned by the investor through equity purchases, and $E_t(m_{t+1} V_{xit+1})$ (or $E_t(m_{t+1} V_{nxit+1})$) is the firm's end-of-period equity value.[8] The lenders are willing to lend only if the perceived liquidation value of the equity asset ($\xi_t E_t(m_{t+1} V_{xit+1})$ or $\xi_t E_t(m_{t+1} V_{nxit+1})$) in case of default is sufficient to cover the loaned amount ($w_t l_{xit}$ or $w_t l_{nxit}$). Note that, the liquidation value of equity asset is determined not only by the firm's end-of-period equity value but also by the liquidity of the credit market, captured by the stochastic variable ξ_t and $\xi_t < 1$ due to liquidation loss. When the credit market condition worsens (ξ_t falls), lenders might have difficulty in liquidating the firm asset and consequently impose tighter constraints on firm borrowing.

3.4.2 Incumbents' production and pricing

[8] The idea with financially constrained working capital needs is not new, and can be widely seen in literature, such as in Jermann and Quadrini (2009, 2012). The collateral constraint is not derived from an optimal credit contract. Instead, it may come from the limited enforcement that prevents lenders from collecting more than a certain fraction of the firm's collateral asset value.

The variety (y_{nxit}) produced by non-exporters will be used domestically for consumption (c_{nxit}) and for entry investment (i_{nxit}). The resource constraint for non-exporters is thus given by:

$$y_{nxit} = c_{nxit} + i_{nxit} . \tag{26}$$

The variety (y_{xit}) produced by exporters will serve two markets for two purposes, the domestic market (y_{dxit}) for consumption (c_{dxit}) and for entry investment (i_{dxit}), and the foreign market (y^*_{hxit}) for consumption (c^*_{hxit}) and for entry investment (i^*_{hxit}). When shipping abroad, only a fraction $1-\eta \in [0,1]$ of the exports will arrive at the destination. The resource constraint for exporters is thus given by:

$$y_{xit} = y_{dxit} + y^*_{hxit} . \tag{27}$$

where

$$y_{dxit} = c_{dxit} + i_{dxit} . \tag{28}$$

$$y^*_{hxit} = \frac{c^*_{hxit} + i^*_{hxit}}{1-\eta} . \tag{29}$$

Each firm produces a unique variety, requiring only one factor, labor. The production functions are thus:

$$y_{xit} = A l_{xit} , \tag{30}$$

$$y_{nxit} = A l_{nxit} , \tag{31}$$

where A is the aggregate productivity common to all firms, and l_{xit} (or l_{nxit}) is the input of labor by exporter (or non-exporter) i.

Firm dividends are given by:

$$d_{xit} = \pi_{dxit} + \pi^*_{hxit} - \left(b_{xit-1} - \frac{b_{xit}}{R_t} \right), \qquad (32)$$

$$d_{nxit} = \pi_{nxit} - \left(b_{nxit-1} - \frac{b_{nxit}}{R_t} \right), \qquad (33)$$

where the operation profits π_{dxit}, π^*_{hxit}, π_{nxit} are defined as:

$$\pi_{dxit} = \frac{p_{dxit}}{P_t} y_{hxit} - w_t \frac{y_{dxit}}{A} \quad , \qquad (34)$$

$$\pi^*_{hxit} = \frac{p^*_{hxit}}{P_t} y^*_{hxit} \left(1 - \eta\right) - w_t l^*_{hxit} \quad , \qquad (35)$$

$$\pi_{nxit} = \frac{p_{nxit}}{P_t} y_{nxit} - w_t l_{nxit} \,. \qquad (36)$$

The value functions of the firms, representing the beginning of period firm value before dividends are paid, are thus,

$$V_{xit}\left(b_{xit-1}\right) = \max_{p_{dxut}, p^*_{hxit}, b_{xit}} \{ d_{xit} + E_t (m_{t+1} V_{xit+1}\left(b_{xit}\right)) \} \,, \qquad (37)$$

$$V_{nxit}\left(b_{nxit-1}\right) = \max_{p_{nxit}, b_{nxit}} \{ d_{nxit} + E_t (m_{t+1} V_{nxit+1}\left(b_{nxit}\right)) \} \,. \qquad (38)$$

The last term in brackets is the end of period firm value, which is also the measure of equity prices: $q_{xit} = E_t\left(m_{t+1}V_{xit+1}\left(b_{xit}\right)\right)$ and $q_{nxit} = E_t(m_{t+1}V_{nxit+1}\left(b_{nxit}\right))$. Exporter (non-exporter) i chooses the price levels sold in home and in foreign countries, p_{dxit}, p^*_{hxit} (p_{nxit}), and its issue of debt, b_{xit} (b_{nxit}), to maximize its firm value, Eq. (37) (Eq.(38)), subject to the enforcement constraint, Eq. (24) (Eq. (25)), the resource constraint, Eq. (27-29) (Eq. (26)), the production function, Eq. (30) (Eq. (31)), the dividend equation, Eq. (32) (Eq. (33)), and the demand for individual varieties, Eqs. (10-11) and (17-18) (Eqs. (9) and (16)).

The optimization implies the following pricing rules and the multiplier associated with the enforcement constraint:

$$\frac{p_{dxit}}{P_t} = \frac{\sigma}{\sigma-1}\frac{w_t}{A}\left(1+\mu_{xit}\right), \tag{39}$$

$$\frac{p^*_{hxit}}{P_t} = \frac{\sigma}{\sigma-1}\frac{w_t}{\left(1-\eta\right)A}\left(1+\mu_{xit}\right) \quad , \tag{40}$$

$$\frac{p_{nxit}}{P_t} = \frac{\sigma}{\sigma-1}\frac{w_t}{A}\left(1+\mu_{nxit}\right), \tag{41}$$

$$\mu_{xit} = \frac{\frac{1}{R_t} - E_t m_{t+1}}{\xi_t E_t m_{t+1}}, \tag{42}$$

$$\mu_{nxit} = \mu_{xit}, \tag{43}$$

where μ_{nxit} and μ_{xit} are the Lagrange multipliers associated with the enforcement constraint for non-exporters and exporters, respectively. As the investor is indifferent between the bonds issued by exporters and non-exporters, the two multipliers are identical. The multiplier is the shadow price of the intra-period loan on firm value and measures the relative cost of bond financing ($1/R_t$) to equity financing ($E_t m_{t+1}$) for a financially constrained firm adjusted by the financial market condition. When a firm increases its bond issuance, it raises dividend payout today but simultaneously suffers an opportunity cost of tightening financial constraint due to falling equity value.

The enforcement constraint, Eqs. (24-25), shows that a firm can relax its constraint by reducing its bond issuance today. The benefit from bond reduction is two-fold. First, according to the firm value Eqs. (37-38), a one unit drop of debt issuance today would increase the firm's end-of-period value by an amount of $E_t m_{t+1}$. Second, the rise in end-of-period value would increase the firm's borrowing capacity on working capital by an amount of $\xi_t E_t m_{t+1}$.

However, there is also a cost of bond issuance reduction as it reduces the firm's cash flow and hence reduces the firm's beginning-of-period value by an amount of $\frac{1}{R_t}$.

To what degree the enforcement constraint would be relaxed relies on the direct benefit and cost of debt reduction on firm value ($\frac{1}{R_t} - E_t m_{t+1}$) and the associated contribution to working capital finance ($\xi_t E_t m_{t+1}$).

The presence of the enforcement constraint adds a wedge term, $1+\mu_{xt}$ (or $1+\mu_{dt}$), to a typical pricing rule, as shown in Eqs. (39-41). The wedge term represents the credit channel introduced by the financing constraint. As shown in Eq. (42), a worsening financing condition (a fall in ξ_t) is associated with a rising μ_{xt} (or μ_{nxt}), which implies a rising price markup according to Eqs. (39-41), holding all else constant. In other words, an adverse financial shock lowers liquidation value of a firm and makes its enforcement constraint tighter, thus a firm sets a higher relative price (relative to the overall price index, P).

3.4.3 New exporters' production and pricing

As we stated in Section 3.1, among the $1-n_{xt-1}$ non-exporters at the beginning of period t, ne_{xt} will become new exporters, so these new exporters have a matured debt position the same as their non-exporter counterparts. To enter the export market, these new exporters must pay a sunk entry cost K_t^E, and then they face enforcement constraints, make production and financing decisions like their incumbent exporter counterparts.

For a marginal non-exporter who decides to become exporters, his/her firm value is as follows:

$$V_{nxit}\left(b_{nxit-1}\right)=\max_{p_{dxit}^{new},p_{xit}^{*new},b_{xit}^{new}}\begin{Bmatrix} d_{nxit}+E_t(m_{t+1}V_{nxit+1}\left(b_{nxit}\right)) \\ d_{xit}^{new}+E_t(m_{t+1}V_{xit+1}\left(b_{xit}^{new}\right)) \end{Bmatrix}$$

where the retained earnings d_{xit}^{new} is given by:

$$d_{xit}^{new}=\pi_{nxit}+\pi_{hxit}^{*new}-b_{nxit-1}+\frac{b_{xit}^{new}}{R_t}-\frac{P_{It}}{P_t}K_t^E. \qquad (44)$$

with that $\pi_{hxit}^{*new}=\frac{p_{hxit}^{*new}}{P_t}y_{hxit}^{*new}\left(1-\eta\right)-w_t l_{hxit}^{*new}$.[9]

The marginal firm will be indifferent between the choices of being exporter and being non-exporter, implying that:

$$d_{nxit}+E_t(m_{t+1}V_{nxit+1}\left(b_{nxit}\right))=\pi_{nxit}+\pi_{hxit}^{*new}-b_{nxit-1}+\frac{b_{xit}^{new}}{R_t}-\frac{P_{It}}{P_t}K_t^E+E_t\left(m_{t+1}V_{xit+1}\left(b_{xit}^{new}\right)\right)$$

After a few steps of transformation, we have the free entry condition as follows:

$$\frac{P_{It}}{P_t}K_t^E=E_t(m_{t+1}\left(\pi_{hxit+1}^{*new}+\frac{P_{It+1}}{P_{t+1}}K_{t+1}^E\right))+\left(\frac{1}{R_t}-E_t m_{t+1}\right)\left(b_{xit}^{new}-b_{nxit}\right) \qquad (45)$$

The value of the new exporter is thus given by:

$$V_{it}^{new}\left(b_{nxit-1}\right)=d_{xit}^{new}+E_t\left(m_{t+1}V_{xit+1}\left(b_{xit}^{new}\right)\right). \qquad (46)$$

We allow for the possibility of a congestion externality associated with export firm entry[10]:

[9] The model implicitly assumes that the debt of exiting non-exporters is inherited by newly born non-exporters. But equation (44) implies that the additional debt of exiting exporters relative to non-exporters disappears. The online appendix describes an alternative specification where the extra debt of exporters is passed exogenously on to newly entering exporters. As shown in the appendix, our results are almost the same as for the benchmark specification.

[10] See also Bergin and Lin (2012) and Lewis (2009) for discussions of this model feature. Our functional specification of entry costs more closely resembles that in Lewis (2009) in specifying the rise in entry cost as a function of the number of new entrants, motivated in terms of an imperfectly elastic supply of a factor specific to product entry such as advertising. Bergin and Lin (2012) also allows for the possibility of a congestion externality in entry but specifying the rise in entry cost as a function of total number of active firms. Their specification is in line with Berentsen and Waller (2009), which was motivated using a matching externality found in Rocheteau and Wright (2005) and common in monetary search models.

$$K_t^E = \bar{K}^E \left(\frac{ne_{xt}}{ne_{xt-1}} \right)^{\tau}. \tag{47}$$

Here, $\bar{K}^E$ is the steady state level of sunk entry costs, and ne_{xt} describes the number of new exporters who compete with each other in entering the export market. This functional specification of entry costs has been motivated in terms of an imperfectly elastic supply of a factor specific to product entry such as advertising.

We now turn to the financing and pricing/production decision of the new exporters. Just as for the existing exporters, the new exporters maximize the beginning-of-period firm value (Eq. 46, in this case) subject to the retained earnings equation, (Eq. 44), the enforcement constraint facing exporters, (Eq. 24), and the demand for individual varieties, Eqs. (10-11) and (17-18). Because the enforcement constraint here is not affected by the initial bond position, the first order conditions are the same as for an existing exporter (Eqs. 39-42). We thus conclude that the choice variables of the new exporters are the same as for the incumbents: $b_{xit}^{new} = b_{xit}$, $p_{dxit} = p_{dxit}^{new}$, $\mu_{xit} = \mu_{xit}^{new}$. From the demand equations for individual varieties, that is, Eqs. (10-11) and (17-18), we then have that market demand for the goods of new exporters is identical to that of exporters, and hence $y_{xit}^{new} = y_{xit}$, and $l_{xit}^{new} = l_{xit}$. That is, new exporters and existing exporters make identical decisions on production and financing.

3.5 Equilibrium

Shocks are common to all firms from a given country; thus, this study solves the symmetric equilibrium in which firms in the same sector from a given country behave identically. As firms of the same type hire the same amount of labor in production and labor is immobile across countries, the market clearing condition for labor is thus given by:

$$L_t = \left(1-\left(n_{xt-1}+ne_{xt}\right)\right)l_{nxt} + \left(n_{xt-1}+ne_{xt}\right)l_{xt}\,. \tag{48}$$

Overall consumption combines that of both the investor and worker:

$$C_t = C_{It} + C_{wt}\,. \tag{49}$$

Balanced trade requires:

$$\left(n_{xt-1}+ne_{xt}\right)p^*_{hxit}y^*_{hxit} = \left(n^*_{xt-1}+ne^*_{xt}\right)p_{fxit}y_{fxit} \tag{50}$$

For reference, GDP will be defined:

$$GDP_t = C_t + \frac{P_{It}}{P_t}I_t\,.$$

The financial shock is log-normally distributed as follows:

$$\log\xi_t - \log\overline{\xi} = \rho_\xi(\log\xi_{t-1} - \log\overline{\xi}) + \varepsilon_{\xi,t} \tag{51}$$

where $\varepsilon_{\xi,t}$ represents financial innovations, which are i.i.d. random variables with homoscedastic variances. We don't allow spillovers of shocks across borders.

Equilibrium is a sequence of the following 100 endogenous variables: n_{xt}, ne_{xt}, $n^{end}_{nxt}, n^{begin}_{nxt}$, P_t, P_{Ht}, P_{Ft}, p_{dxit}, p_{nxit}, p_{fxit}, $C_t, C_{Ht}, C_{Ft}, c_{nxit}, c_{dxit}, c_{fxit}$ $I_t, K^E_t, I_{Ht}, I_{Ft}, P_{It}, i_{fxit}$, $i_{nxit}, i_{dxit}, C_{wt}, w_t, L_t, R_t, C_{It}, q_{xt}, q_{nxt}, d_{xt}, d_{nxt}, V_{xt}, l_{xt}, V_{nxt}, l_{nxt}, y_{xt}, y_{nxt}, y_{dxt}, y_{fxt}, \pi_{dxt}$, $\pi_{fxt}, \pi_{nxt}, b_{xt}, b_{nxt}, \mu_{xt}, \mu_{nxt}$, V^{new}_{xt}, d^{new}_{xt}, and their foreign counterparts. The 100 equilibrium conditions are Eqs. (1-49) with their foreign counterparts, the balance trade condition Eq. (50), and choice of the home consumption bundle as the numeraire: $P_t = 1$, summarized in Appendix 1.

4 Quantitative analysis

To analyze the full response paths of firm entry, equity prices and other key macroeconomic variables in response to financial shocks, we log-linearize the system around the unique deterministic steady state. We calibrate parameters and numerically solve the log-linearized model for the dynamic responses to exogenous shocks using the method of generalized Schur decomposition.

4.1 Parameter values

Table 3 lists the parameters in the benchmark setting. The two economies are symmetric in terms of parameter values. We set $\beta = 0.995$ and $\beta_I = 0.978$ to capture an annual bond return of 2% and an annual stock return of 8%. The risk aversion of the worker and the investor are set at $\rho = \rho_I = 2$ (Arellano, Bai and Kehoe, 2012). The exogenous death shock probability is set at $\lambda = 0.025$ to match the 10% annual job destruction rate in the U.S. data as documented in the literature (for instance, in Bernard et al. (2010)). We follow Ghironi and Metliz (2005), Bernard et al. (2003) and Bilbiie, Ghironi and Melitz (2012) in setting the elasticity of substitution among all varieties, both domestic and imported, to $\sigma = 3.8$. The same calibration is used for the aggregation of goods for use in investment: $\phi = 3.8$.

The relative utility weight of labor is set at $\kappa = 3.409$ and the inverse of Frisch labor supply elasticity is set at ψ =0.5 to capture an elasticity of 2, which is used in Arellano, Bai and Kehoe (2012) and is in the range commonly estimated in micro- and macroeconomic work as reported by Rogerson and Wallenius (2009).

Sunk entry costs and iceberg costs are set to imply jointly a steady state where 21% of firms export (from Ghironi and Melitz, 2005) and exports represent 18% of GDP, taken from author calculations as the average for OECD counties in the Comtrade data base. This implies $\overline{K}^E = 1.5$ and $\eta = 0.014$. The entry adjustment cost curvature parameter is calibrated at $\tau = 4.2$ as in Bergin and Lin (2012). Given limited evidence on the share of imports in export entry investment expenditure, we will consider the full range of values in sensitivity analysis in Section 4.3.1; the benchmark version will specify international market entry cost takes the form of all imported goods, that is, $\theta = 0$.

As our focus is on the impact of financial shocks on trade persistence, we fix the technology shock at its mean level, that is, $\overline{A} = 1$ without loss of generality. A period is identified as a quarter. The mean and the persistence of financial shock are set at $\overline{\xi} = 0.1634$, and $\rho_{\xi} = 0.9703$, respectively, taken from the calibration of financial shocks estimated in Jermann and Quadrini (2012) for US quarterly data 1984:I–2010:II. For purposes of simulation, $\sigma_{\xi} = 0.05$ in order to replicate the drop in real US GDP during the 2007-9 financial crisis.

4.2 Impulse responses for the benchmark model

We follow Perri and Quadrini (2016) in studying the effects of a global financial shock, impacting the exogenous financial innovation term of both home and foreign countries.[11] Impulse responses for the benchmark model specification are reported in Fig. 4. The magnitude of the shock is set to replicate the approximately 5% fall in US GDP following the 2007-9 financial crisis. Falling collateral value due to the worsening credit makes it harder for firms to finance working capital to hire workers for

[11] Although the model of Perri and Quadrini (2016) introduces financial integration which links the Lagrange multipliers on the collateral constraint of firms in both counties, they nevertheless need to assume financial shocks that are exogenously perfectly correlated across countries in order to generate international co-movement in financial flows.

production. As a result, labor demand falls, lowering wages and employment, as seen in the figure. Since workers invest in corporate bonds, the drop in their income also raises firms' financing cost through bond issuance. As market demand for individual varieties falls, firms' production and sales drop as well. Although the falling wage to a certain degree compensates firms' market stance in terms of reducing their production cost, firms expect less profit from worse aggregate economy, which is reflected in falling equity values, reported in the figure as an average over all home firms. All these variables return fairly quickly to their long run steady states as the shock dissipates.[12]

The figure shows a pronounced fall in exports in the initial periods, larger in magnitude than the fall in GDP. The ratio of the change in exports to that in GDP is 3.0, which is quite close to the ratio of 3.8 observed for U.S. data during the financial crisis. This is followed by a rapid recovery, with half of the drop reversed in one year. However, after the initial partial recovery, the improvement in trade levels off, leaving a highly persistent shortfall relative to the initial value of trade before the shock. This behavior is similar to that observed in the empirical VAR above. To understand the model's ability to generate this particular combination of short run and long run dynamics, we must first explain the dynamics of firm financing and firm entry, which we turn to next.

Important to our argument, firms respond to the worsening credit market with a strategy of capital restructuring. They reduce bond issuance and postpone dividend payouts today, as observed in the figure. This moderates the fall in equity value and hence helps ease the tightening financial constraint. Given that firms are switching from

[12] In principle, when comparing model predictions to data, it is preferable to use data-consistent variable definitions of model variables, which do not adjust price indexes for availability of new products. See Ghironi and Melitz (2005). While the theoretical impulse responses reported in the main text are utility-consistent definitions from the model section, the corresponding impulse responses for data-consistent definitions are extremely similar, and our conclusions are unaffected. See Supplementary Online Appendix E for details of variable definitions and results.

previously cheaper bond financing to relatively more expensive equity financing, this capital restructuring increases the effective entry cost in the export entry condition faced by potential non-exporters who are otherwise willing to become exporters. This leads to the substantial fall in entry to the export market observed in Fig. 4, which is consistent with what was observed in the empirical VAR for the extensive margin of trade. Previous work in Bergin et al. (2018) has shown that a transitory fall in expected future firm profits is not sufficient to generate the large fall in firm entry observed during the financial crises, as it has too small effect on the total present discounted value of all future firm profits in the entry condition, Eq. (45). Our model reproduces the large fall in firm entry instead by explaining how the shock affects the effective sunk entry cost, which also appears in the entry condition.

A prominent feature observed in the empirical impulse responses in section 2 was a gradual but persistent fall in the extensive margin. This persistence is consistent with what we see in Fig. 4. While persistence arises in part from the congestion externality noted above, it also arises from the fact that the investment price index rises progressively over time, as seen in the figure. In the benchmark model the investment price index, which is the same as the import price index, rises due to the fall in the number of traded varieties available as imports, akin to a love of variety effect. We thus see a vicious circle in which a fall in export entry in both countries resulting from the global financial shock makes the cost of entry higher, which further reduces entry for future periods, which raises the entry cost further, etc. The figure demonstrates that this mechanism can be a powerful propagation channel.

These dynamics of the extensive margin of trade now help us understand the dynamics of total exports in the model. First, the short run fall in trade in the periods after the shock is particularly steep in part due to the dramatic fall in investment demand for imports coming from the dramatic fall in firm entry investment. This reflects the common mechanism in intertemporal models that investment, due to its volatility and greater concentration in traded goods, tends to be a prominent source of trade dynamics.[13] In the present model, investment takes the form of firm entry costs. In addition, as the number of imported varieties shrinks relative to domestic varieties in the overall consumption index, given that our elasticity of substitution between all varieties is the same regardless of country of origin, a fall in extensive margin translates into a nearly proportionate fall in trade as a share of consumption expenditure. For both these reasons, the fall in investment and consumption demand for imports, the fall in extensive margin contributes to the short run fall in trade.

Second, the fact that the extensive margin remains below its steady state value for a very long time explains the very persistent effect on trade in the long run. Again, the fact that firm entry remains below its steady state for a long time means there is a prolonged shortfall in investment demand for imports and progressively rising investment price. And again, the fact the number of firms remains below steady state for a very protracted time means the share of import varieties in the overall consumption bundle remains low, so trade remains low as a share of overall consumption.

While the benchmark experiment focuses on a global shock impacting both countries symmetrically, Fig. 5 reports dynamics for a shock hitting just the home country. The persistence in exports is even more extreme in this case, with almost no tendency for the long run effect to dissipate. However, the magnitude of the effect in the initial periods now is smaller than in the benchmark case and smaller than the change in home GDP in percentage terms. The reason is that the fall in the variety of home exports affects the price index of foreign rather than home investment. Further the shock does not lead to a fall in foreign GDP or foreign export entry, as the fall in

[13] See Boileau (1999), Eaton and Kortum (2001), Engel and Wang 2011, and Alessandria et al. (2010).

wages is able to compensate for the loss of variety in the foreign investment price index. This example illustrates that goods market linkages are not enough to strongly transmit a financial shock, and more complex international financial linkages would be required.[14] Given that international transmission is a challenging current research question in its own right and not the purpose of this study, we will continue to focus on a symmetric global shock in the subsequent experiments.

4.3 Sensitivity Analysis

4.3.1 Share of imports in investment goods

As there is no clear evidence to use in calibrating the share of imports in new firm entry investment, θ, it is appropriate to conduct sensitivity analysis for this parameter. Fig. 6 reports impulse responses for a version of the model that makes the opposite assumption to that in our benchmark economy, assuming no imported goods in the investment goods bundle ($\theta = 1$). The fall in exports is smaller in magnitude than in the benchmark model, no more volatile than GDP, and the degree of persistence appears to be less, though exports are still somewhat more persistent than GDP. These export dynamics reflect the smaller magnitudes and persistence in the extensive margin, and the fact that the investment price index now falls, given that it does not include import prices.

One way to quantify the persistence in exports is to look at the impulse response value at the ten year mark after the shock, given that we are now about ten years after the financial crisis. We take this value as a ratio to the maximum (in absolute value)

[14] Supplementary Online Appendix D reports results for an extension of the model that includes an internationally traded bond. Results indicate that a home financial shock has very similar effects on trade volume as in the benchmark model. Some international transmission takes place, as the home financial shock lowers foreign as well as home output, and generates a home current account deficit as home agents try to borrow from the foreign country.

impulse response value. As a gauge, the empirical VARs in section 2 imply a persistence ratio of either 0.16 or 0.22 for overall trade, depending on which of the definitions of the shock is used. The benchmark model implies a very generous degree of persistence, with a ratio of 0.45 of the impact effect lasting 10 years. The model of Fig. 6 with no imports in investment implies a persistence ratio of 0.15, which is a bit shy of the range implied by the empirical VARs.

To fill in the picture for the middle range, Fig. 7a plots the persistence ratio for versions of the model that calibrate the import share θ for value in between 0 and 1. The figure shows that to achieve the degree of persistence in the empirical VAR the model requires a modest share of imports in the investment bundle ($1-\theta$) of 60% at the upper range, down to as little as 20%. While there is no clear evidence regarding the empirically plausible value for this parameter, Cavallari (2013) chooses a 0.6 ($\theta = 0.4$) as a plausible value for the share of imports in domestic entry investment. This calibration would easily allow our model to replicate the degree of persistence in export responses to a financial shock observed in the empirical VAR. We conclude that the presence of imports in the investment bundle is important for generating the high degree of persistence observed in data, but that the share of imports need not be unreasonably high to achieve the minimum objective.

To illustrate this point, Fig. 7b plots impulse responses for the model (using $\theta = 0.4$) and the empirical VAR together at a common quarterly frequency. The standard deviation of the shock in the model was calibrated so that the maximum impact in absolute value of the simulation matches that of the empirical VAR, rather than to match the particular magnitude following the 2008 crisis.[15] We note that while the model impulse response shows a great deal of persistence, it fails to replicate the hump

[15] The empirical VAR uses all fluctuations in the Libor rate to help identify financial shocks, not just the large shock of the 2008 crisis.

shape dynamics seen in the early periods of the empirical impulse response.

While persistence is fairly robust to a lower import content of entry investment, the impact volatility of exports is more sensitive. Fig 7c. reports the ratio of the maximum effect on exports to that in GDP, showing that it falls fairly rapidly from the value of 3 in the benchmark calibration $\theta = 0$, to levels around 1.5 for a value of $\theta = 0.4$. Recall that the empirical VAR implied a ratio of 3.8.

4.3.2 Export goods in investment bundle

While our benchmark model specifies investment goods as a bundle biased toward home imports, one might also conjecture that the investment bundle for entry into a foreign market could alternatively be biased toward foreign imports, that is, home exported goods that the firm takes with them to the foreign destination. In principle, given that our model and shock is symmetric, our mechanism of rising import and export prices should work equally well for this specification.

To implement this idea, suppose production of investment goods for entry needs all home produced varieties, but different weights are given to the goods produced by non-exporters and by exporters, given by

$$I_t = I_{Ht} \equiv \left[\alpha_{dx}^{\frac{1}{\phi}} \int_0^{n_{xt-1}+ne_{xt}} i_{dxit}^{\frac{\phi-1}{\phi}} di + \left(1-\alpha_{dx}\right)^{\frac{1}{\phi}} \int_{n_{xt-1}+ne_{xt}}^1 i_{nxit}^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}},$$

where α_{dx} is the degree of bias to exporter produced goods. The corresponding investment price index is then given by

$$P_{It} = \left[\alpha_{dx} \left(n_{xt-1} + ne_{xt} \right) p_{dx}^{1-\phi} + \left(1-\alpha_{dx}\right) \left[1 - \left(n_{xt-1} + ne_{xt} \right) \right] p_{nx}^{1-\phi} \right]^{\frac{1}{1-\phi}}, \tag{52}$$

and the implied relative demand functions for home country are

$$i_{nxit} = \left(1-\alpha_{dx}\right) \left(\frac{p_{nxit}}{P_{It}} \right)^{-\phi} I_{Ht} \tag{53}$$

$$i_{dxit} = \alpha_{dx} \left(\frac{p_{dxit}}{P_{It}} \right)^{-\phi} I_{Ht} \tag{54}$$

Analogous conditions apply to the foreign country.

Fig. 8 reports the impulse responses where more weight is assigned to goods produced by home exporters with $\alpha_{dx} = 0.75$ and $\alpha_{nx} = 0.25$ (cases with high shares of exports proved numerically difficult to solve). Exports fall more on impact than does GDP, and exports show a greater degree of persistence, but these features are somewhat weaker than in the case of entry costs in units of imported goods. The persistence ratio reported above takes the value 0.28, less than in the benchmark case, but sufficient to match that of the empirical VARs.

4.3.3 Role of capital restructuring and congestion externality

To confirm the importance of capital restructuring to our result, we simulate a case where no intertemporal bonds are traded, and firm financing is by equity issue only. This means that firms do not respond to the financial shock by decreasing reliance on bond financing, and thus do not raise the cost of financing export entry. Fig. 9 shows that our result completely disappears in the absence of capital restructuring.[16] Firm entry now rises upon the shock rather than falling. This leads to a substantial rise in trade, as consumers have access to a wider range of imported goods varieties. This result demonstrates that capital restructuring is an absolutely essential part of our explanation for the persistent fall in trade.

Next, we investigate the role of entry cost curvature, representing a congestion externality, summarized in the parameter τ. Fig. 10 reports impulse responses for exports for a variety of values for this parameter. The main effect is that a higher value

[16] A slightly different calibration of parameters is needed in this case in order to ensure the existence of a steady state.

of τ amplifies the fall in trade in the initial period. This is because the fall in new firm entry, ne_x leads to a progressively larger fall in entry cost, K^E. So even if a higher τ mutes the fall in ne_x, the even greater amplification of the fall in K^E leads to a larger fall in investment expenditure, which is the product of the two, $ne_x \times K^E$. The larger fall in investment expenditure then leads to a larger fall in trade. In any case, trade falls for all values of τ, and the figure shows that this parameter does not diminish the degree of long-run persistence in the effect of the shock on exports.

Finally, we note that our persistence result is not necessarily specific to a financial shock; other shocks that lead to a change in the extensive margin of exporters will initiate the story described above, leading to persistent effects on trade variables. While our model only includes financial shocks, extensions that include productivity and taste shocks show similar persistence in effects on exports and trade share. (See the Supplementary Online Appendix C for details.)

5. Conclusions

Recent experience has shown that a transitory financial shock can lead to lingering, persistent effects on international trade. This paper argues that this phenomenon may be understood in part in terms of persistent dynamics in the extensive margin of trade, arising from the decision of firm to enter the export market. Empirical evidence indicates that while the extensive margin played a small role in the dramatic initial effects of the financial shock on trade volume, it is quantitatively a greater part of the long run effect observed in data and our empirical VARs. One key element to our explanation is an endogenous capital structure decision by firms in response to the financial shock. As firms shift from cheaper bond financing toward more expensive equity financing in order to relax the collateral constraint for short-term borrowing, it raises the cost of long term financing for export entry investment. A reduction in the extensive margin translates to a lower volume of trade, as imported varieties represent a smaller share of the varieties available to consumers. This interacts with a second key element, a bias in the composition of entry investment expenditure toward imported goods. A reduction in imported varieties raises the investment price index, further raising entry cost and reducing the extensive margin in future periods.

A calibration exercise indicates that this mechanism potentially could account for a substantial share of the persistent component of the fall in trade volume observed in the wake of the financial crisis. Even reasonable shares of imports in the investment goods bundle imply a high degree of persistence of the shock on the extensive margin. This finding does not gainsay the potential role of other economic or even political factors in generating persistence. But it does suggest that the extensive margin, viewed as peripheral with regard to the dramatic trade collapse in 2007-9, warrants greater attention with regards to the persistent effects of this crisis on trade.

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Table 1. Average annual growth rates for U.S. exports

	(1) 2003-7	(2) 2009	(3) 2012-14	(4) (3) - (1)
Exports	10.1%	-19.8%	3.1%	-7.0%
Extensive margin (good-country)	2.5%	-2.3%	0.1%	-2.4%
Number of exporters	3.6%	-4.6%	0.2%	-3.4%

Source: annual data from the U.S. Census Bureau and author computations.[1]

[1] Annual exports is measured by adding up export value across all HS-level export goods. The extensive margin of exports is measured as the number of variety exported in HS disaggregated data. The same category of goods but exported to different counties are counted as different varieties. Data on HS-level U.S. exports are from Schott's International Economics Resource Page, which were purchased from the U.S. Census Bureau. Data on the number of exporters are from Profile of U.S. Importing and Exporting Companies provided by the U.S. Census Bureau.

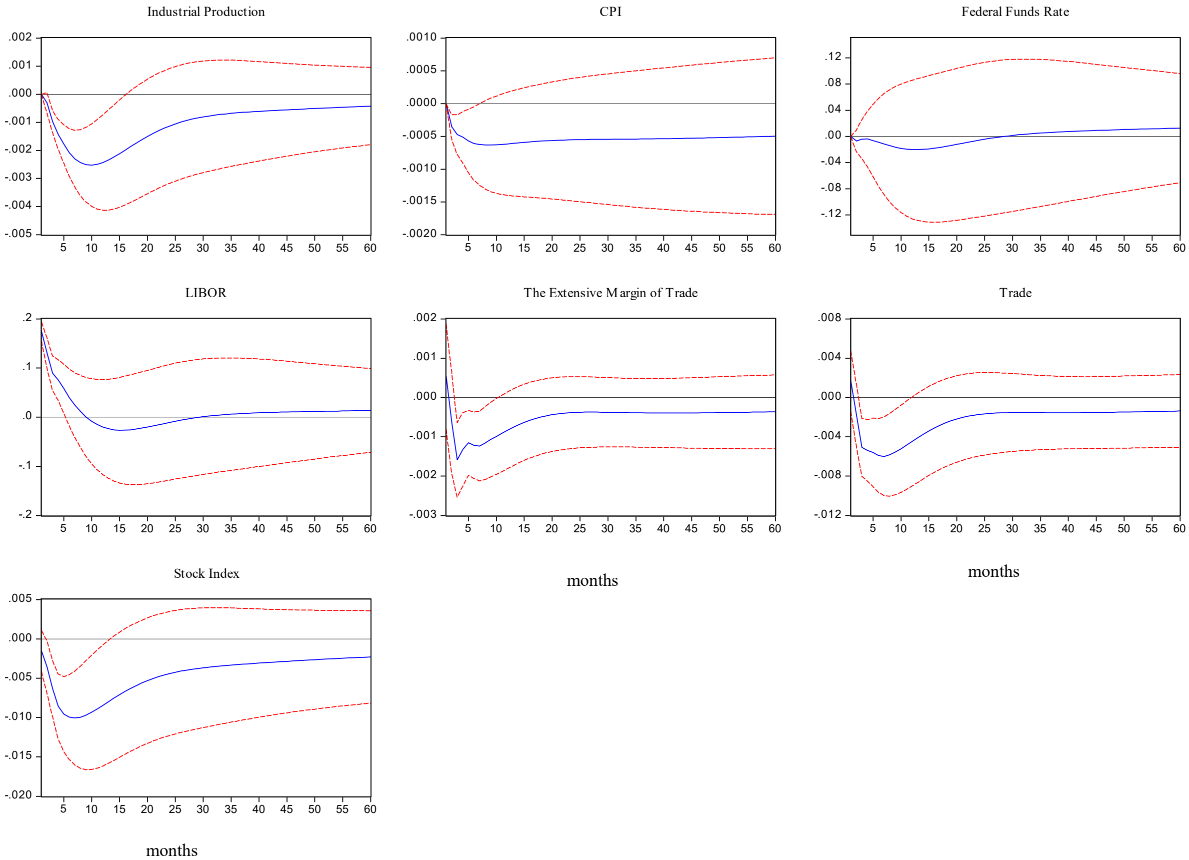
Table 2 Timeline for Home Country

<table>
<tr><th>Beginning of t</th><th>Before death shock</th><th>Death shock</th><th>Beginning of $t+1$</th></tr>
<tr>
<td rowspan="5">(1) Four shock variables: technology shocks (A_t, A_t^*); financial shocks (ξ_t, ξ_t^*)
(2) n_{xt-1} surviving exporters; $1-n_{xt-1}$ non-exporters among which: n_{nxt-1}^{end} survived, $1-n_{xt-1}-n_{nxt-1}^{end}$ newborns</td>
<td>n_{xt-1} Incumbent exporters: (1) wage payments made through intra-period loan; (2) financing choice (bond and equity issuance) and revenue realization</td>
<td rowspan="2">(1) Mass of exporters before death shock: $n_{xt-1}+ne_{xt}$
(2) Mass of exporters after death shock: $n_{xt}=(1-\lambda)(n_{xt-1}+ne_{xt})$</td>
<td rowspan="5">(1) $1-(n_{xt}+n_{nxt}^{end})$ newborns as non-exporters
(2) Repeating the whole process</td>
</tr>
<tr>
<td>ne_{xt} non-exporters becoming exporters: (1) make production and financing decisions as exporters; (2) a matured debt position as exporters</td>
</tr>
<tr>
<td>$n_{nxt}^{begin}=1-(n_{xt-1}+ne_{xt})$ non-exporters: make production and financing decisions</td>
<td>(3) Mass of non-exporters before death shock: $n_{nxt}^{begin}=1-(n_{xt-1}+ne_{xt})$;
(4) Mass of non-exporters after death shock: $n_{nxt}^{end}=(1-\lambda)n_{nxt}^{begin}$</td>
</tr>
<tr>
<td>Worker: Consumption and bond investment;</td>
<td rowspan="2">(5) Mass of all surviving firms: $n_{xt}+n_{nxt}^{end}<1$</td>
</tr>
<tr>
<td>Investor: Consumption and equity investment;</td>
</tr>
</table>

Table 3 Parameterization

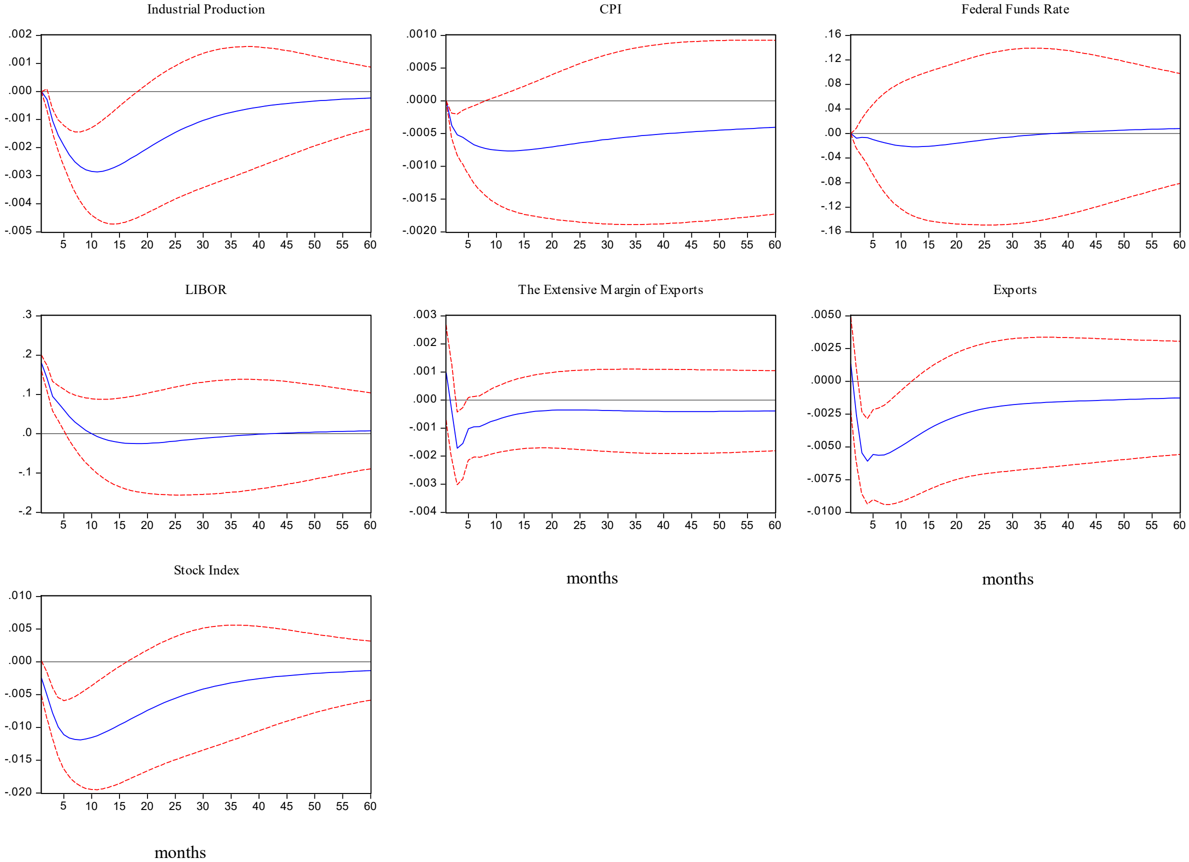
Description	
Worker Relative risk aversion	$\rho = 2$
Investor Relative risk aversion	$\rho_I = 2$
Worker discount factor	$\beta = 0.995$
Investor discount factor	$\beta_I = 0.978$
Substitution elasticity in the consumption bundle	$\sigma = 3.8$
Substitution elasticity in the investment bundle	$\phi = 3.8$
Probability of death shock	$\lambda = 0.025$
Entry costs	$K^E = 1.5$
Congestion Externality in Entry	$\tau = 4.2$
Weight of labor disutility in utility function	$\kappa = 3.409$
Inverse of labor supply elasticity	$\psi = 0.5$
Iceberg trade cost	$\eta = 0.014$
Enforcement parameter	$\bar{\xi} = 0.1634$
Persistence: financing shock	$\rho_\xi = 0.97$

Fig. 1. Impulse Responses to Innovation in Interbank Rate : Trade



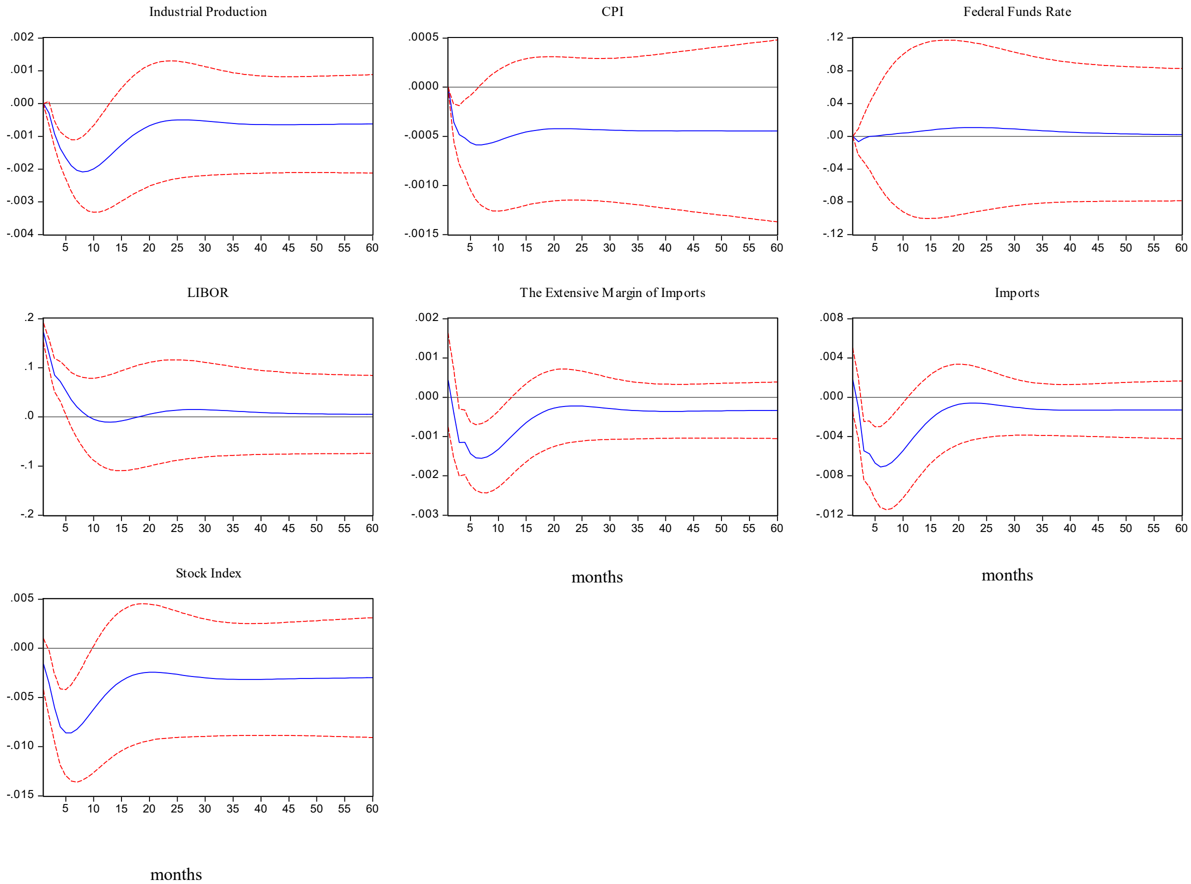
Note: Data are at monthly frequency, based on 6-digit HS disaggregate U.S. export and import flows, running from 2002:1 to 2016:11

Fig. 2. Impulse Responses to Innovation in Interbank Rate: Exports



Note: Data are at monthly frequency, based on 6-digit HS disaggregate U.S. export flows, running from 2002:1 to 2016:11

Fig. 3. Impulse Responses to Innovation in Interbank Rate: Imports



Note: Data are at monthly frequency, based on 6-digit HS disaggregate U.S. import flows, running from 2002:1 to 2016:11.

Fig. 4. Impulse responses for benchmark theoretical model

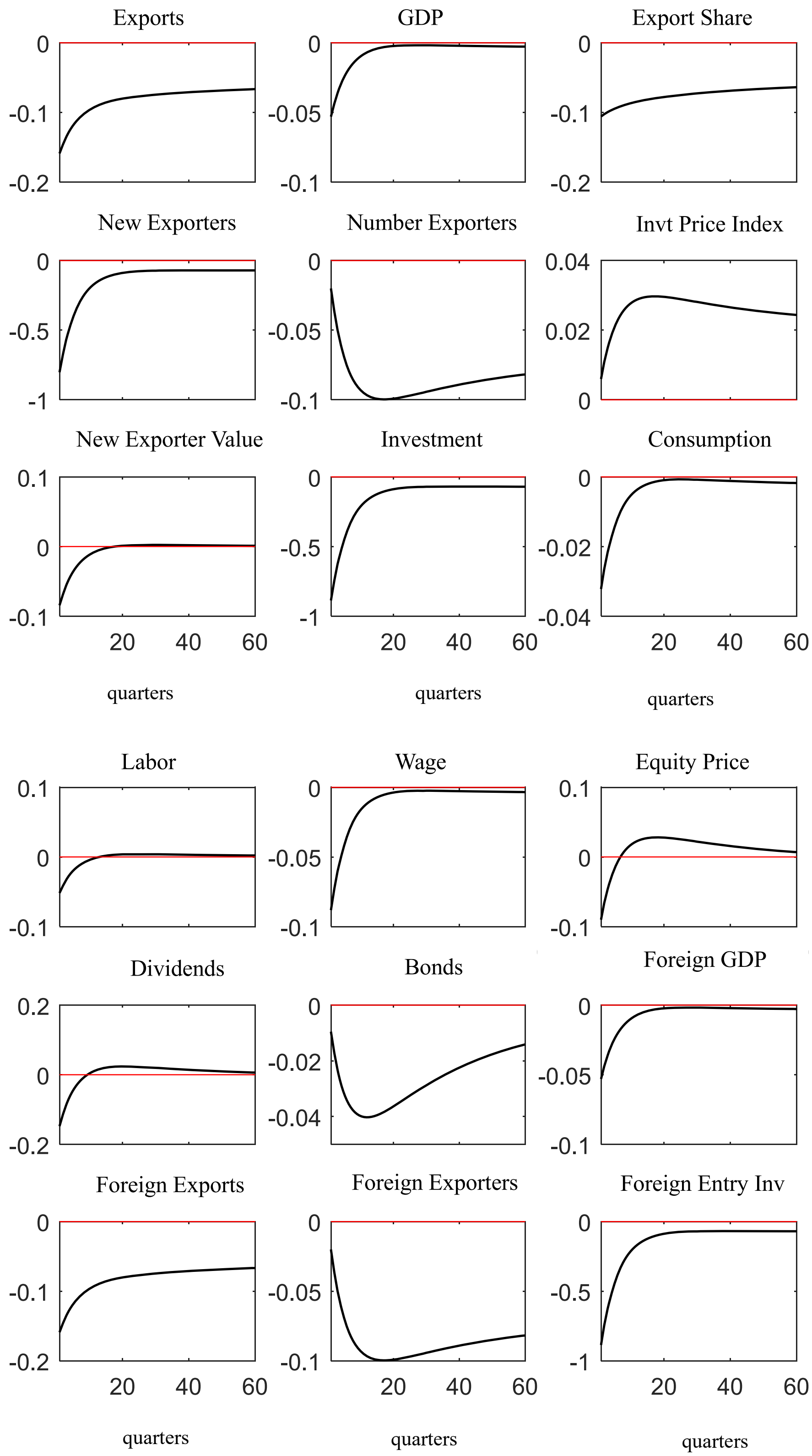


Fig. 5. Impulse responses for benchmark theoretical model, home country shock

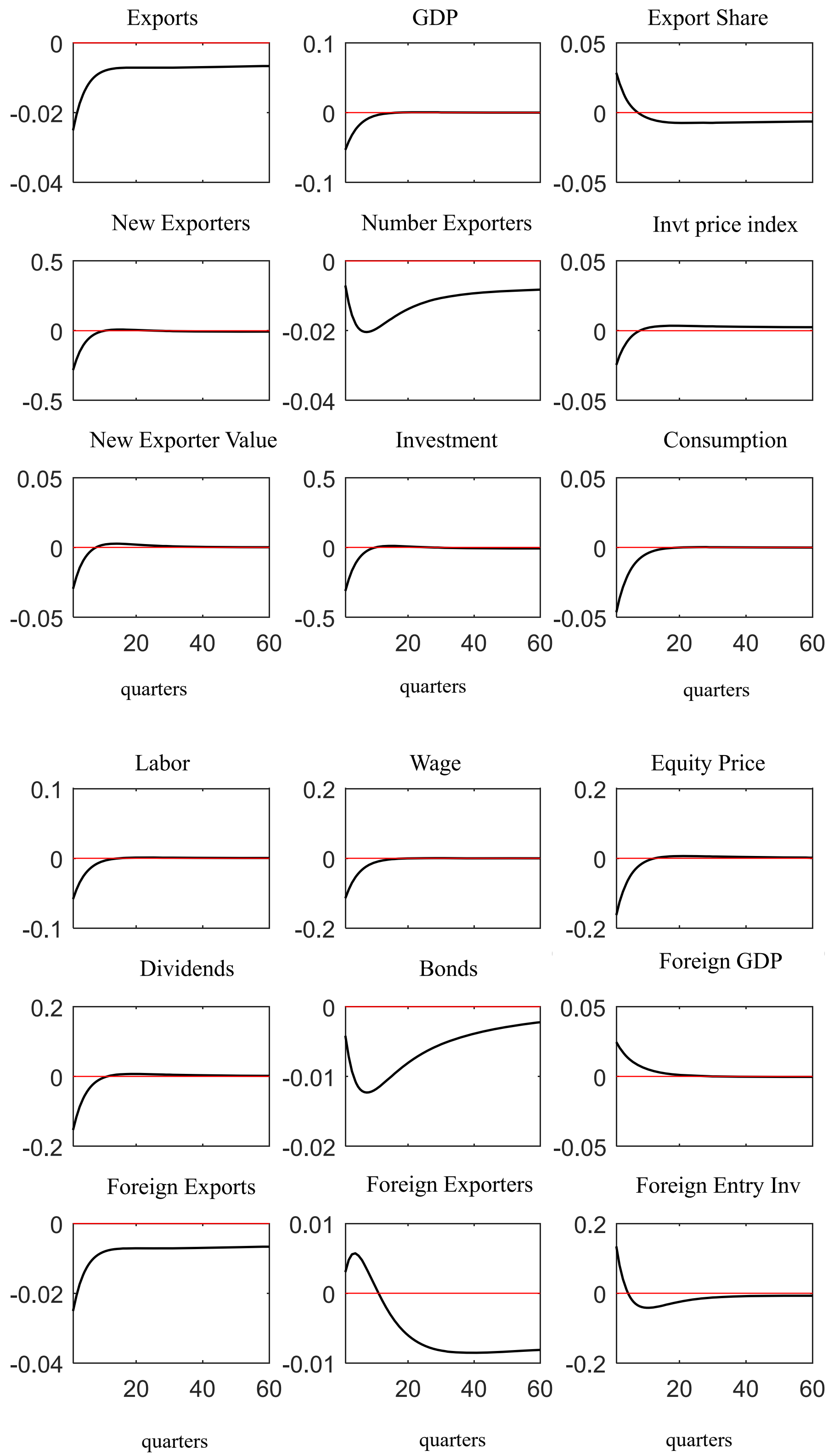


Fig. 6. Impulse responses for model with no imported goods in investment

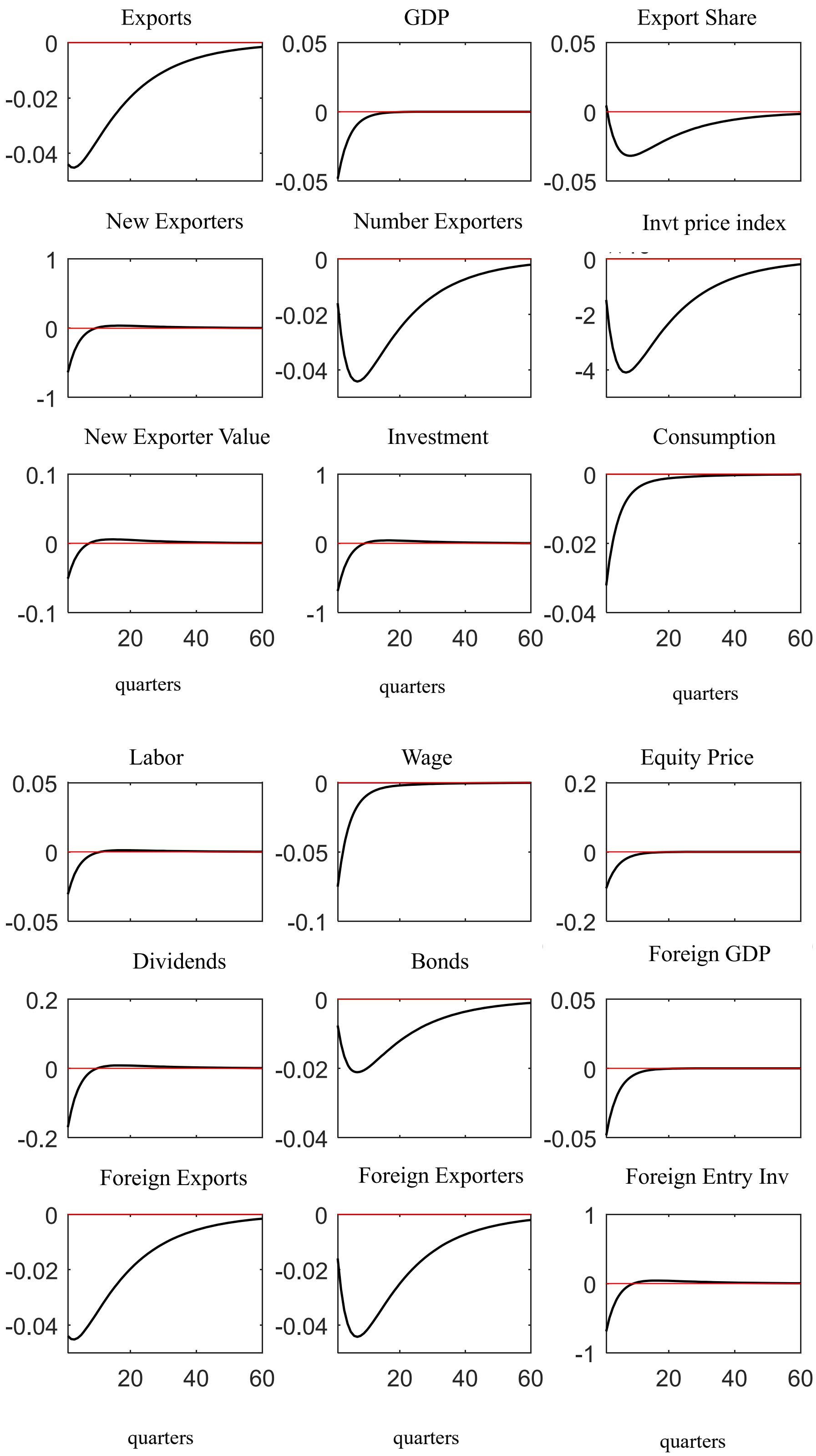
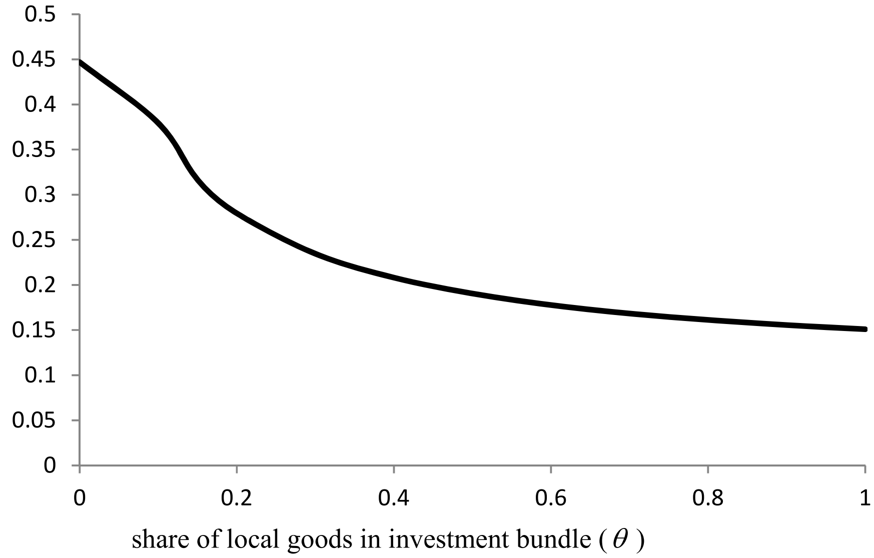
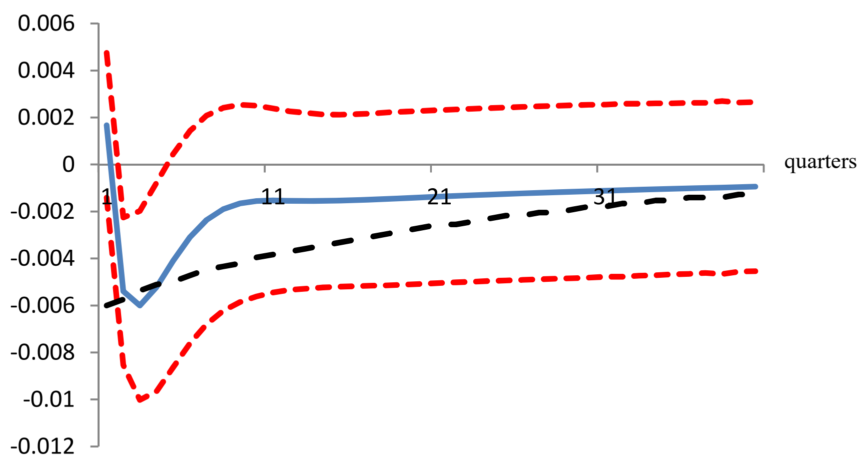


Fig. 7a. How persistence of exports dynamics varies for lower shares of trade in entry cost*



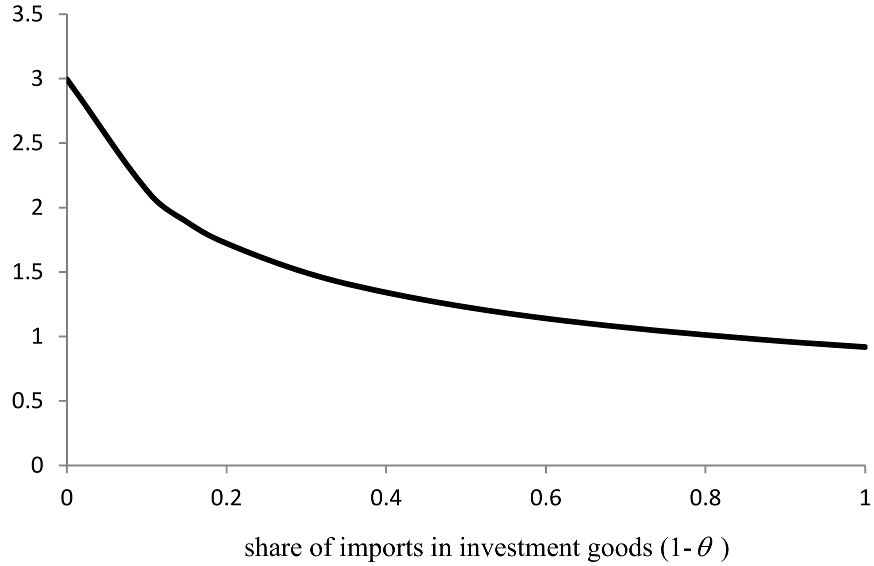
* The metric of persistence is the value of the impulse response for exports in year 10 divided by the maximum impulse response.

Fig. 7b. Impulse responses for extensive margin of trade, empirical VAR and model simulation



** Solid (blue) line is VAR impulse response, with two standard error confidence bands (dashed red). Black (large dash) line is model simulation.

Fig. 7c. How volatility of exports varies for lower shares of trade in entry cost**



** The metric for volatility is the ratio of impulse response value in period 1 (the maximum effect) for exports divided by that for GDP.

Fig. 8. Impulse responses for model with exported goods in entry investment

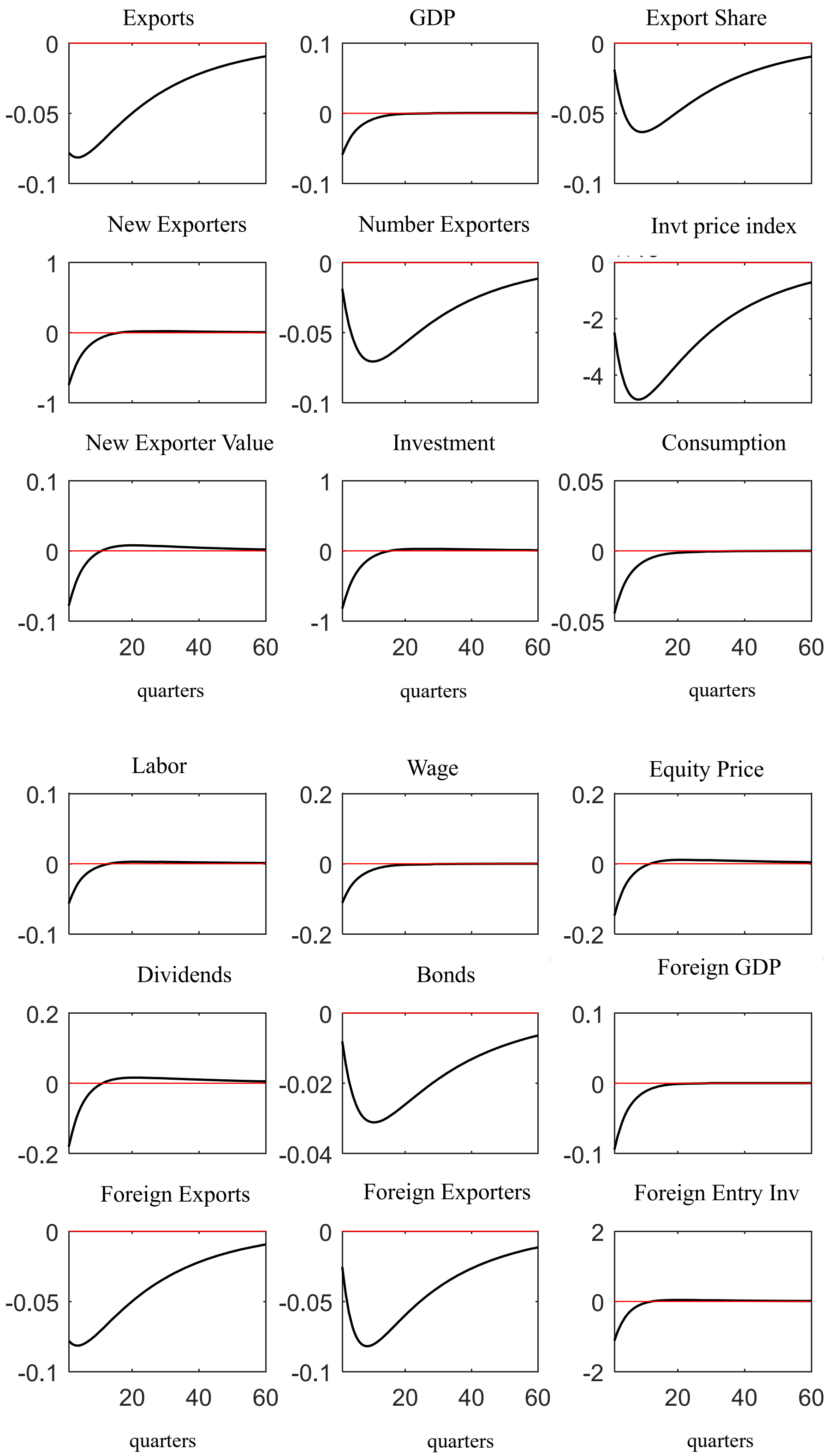


Fig. 9. Impulse responses for model with no bonds

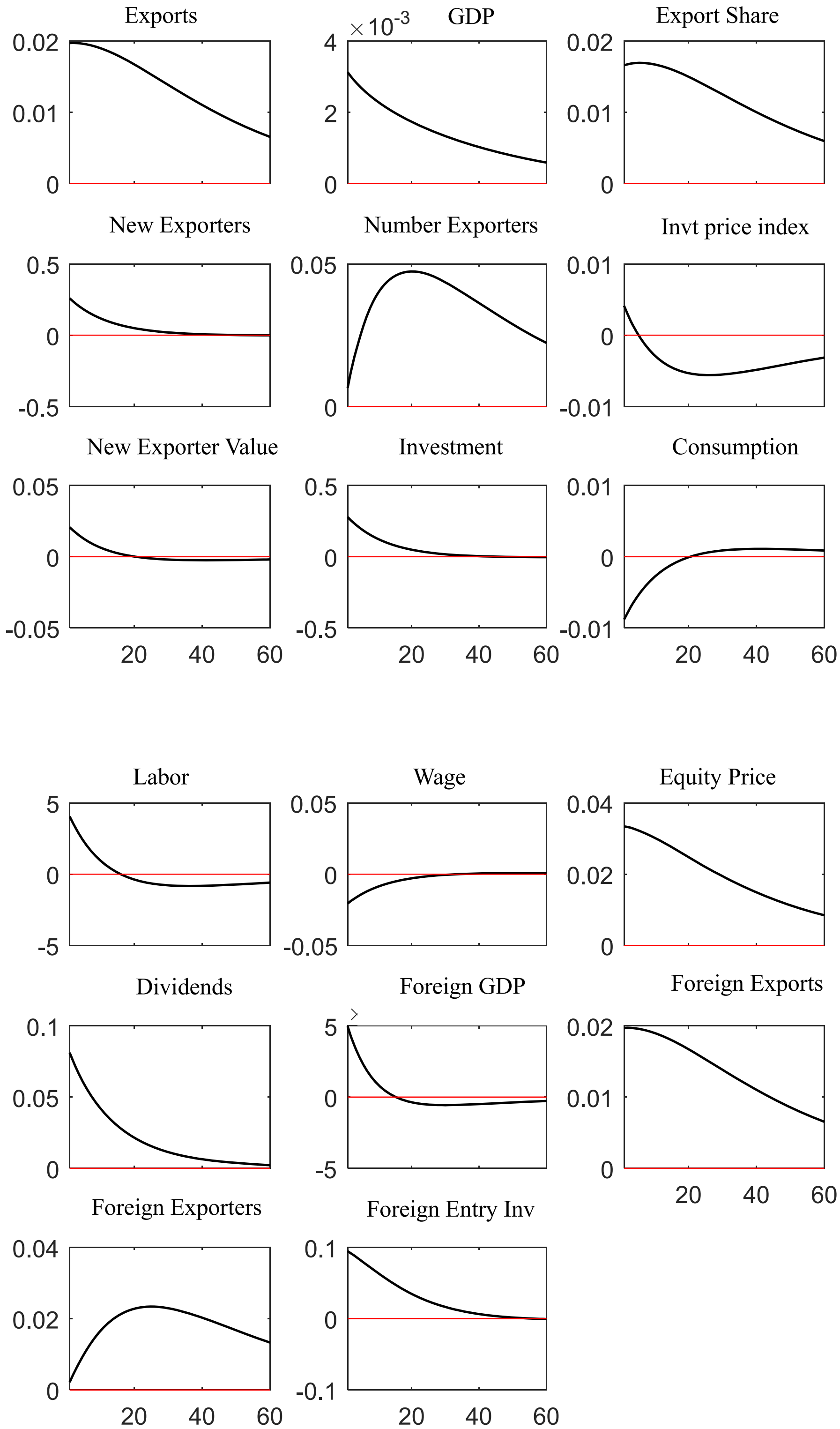
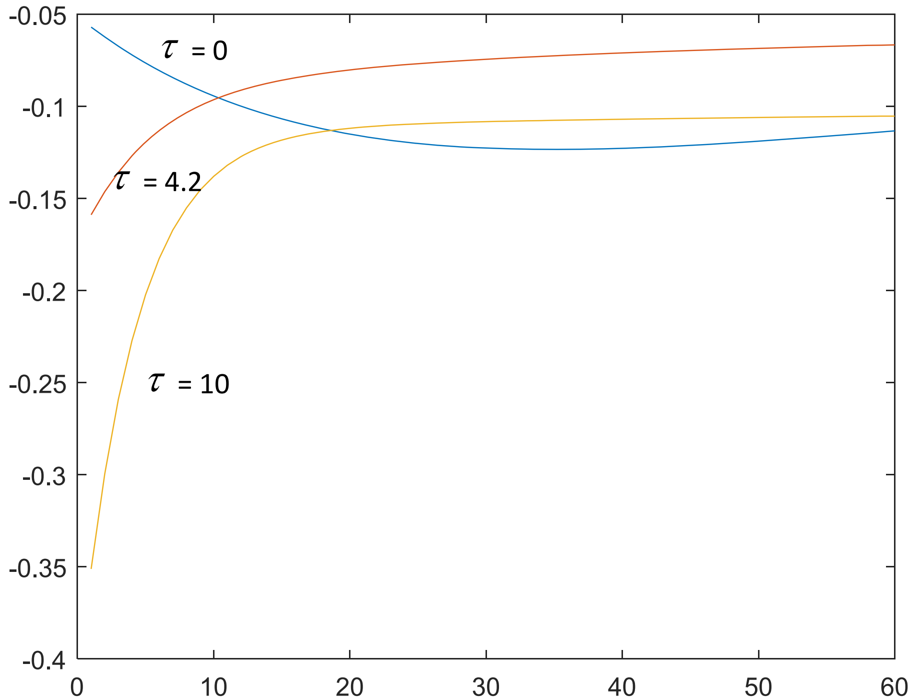


Fig. 10. Export impulse response for various parameterizations of congestion externality



6. Appendix Table: Equilibrium Conditions

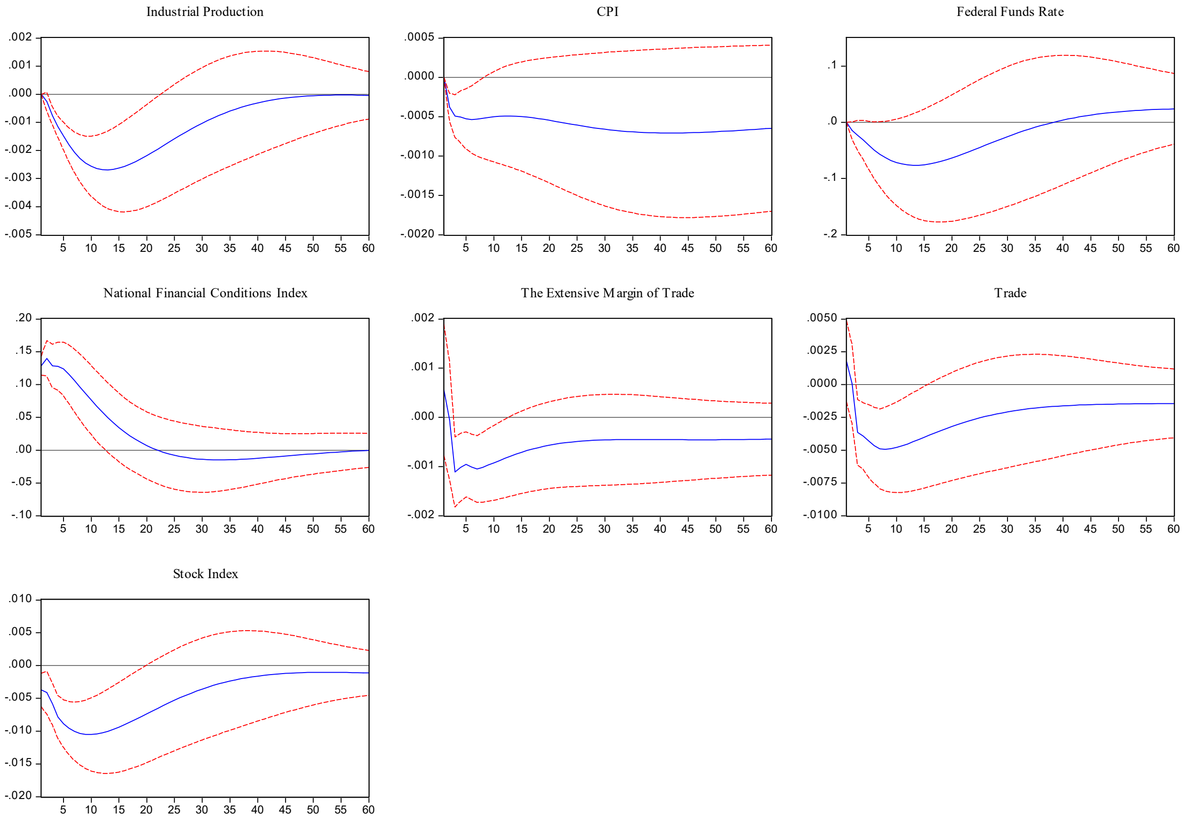
	Benchmark Economy: New Entrants Entry Simultaneously With Production
Firm Dynamics	(1) $n_{xt} = (1-\lambda)(n_{xt-1} + ne_{xt})$ (2) $n_{nxt}^{begin} = 1-(n_{xt-1} + ne_{xt})$ (3) $n_{nxt}^{end} = (1-\lambda)n_{nxt}^{begin}$
Demand and CPI	(4) $P_t = \left[P_{Ht}^{1-\sigma} + P_{Ft}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$ (5) $P_{Ht} \equiv \left[\int_0^{n_{xt-1}+ne_{xt}} p_{\mathrm{d}xit}^{1-\sigma} di + \int_{1-(n_{xt-1}+ne_{xt})}^{1} p_{nxit}^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}$ (6) $P_{Ft} \equiv \left[\int_0^{n_{xt-1}^*+ne_{xt}^*} p_{fxit}^{1-\sigma} di\right]^{\frac{1}{1-\sigma}} = \left(n_{xt-1}^* + ne_{xt}^*\right)^{\frac{1}{1-\sigma}} p_{fxit}$ (7) $C_{Ht} = \left(\frac{P_{Ht}}{P_t}\right)^{-\sigma} C_t$ (8) $C_{Ft} = \left(\frac{P_{Ft}}{P_t}\right)^{-\sigma} C_t$ (9) $c_{nxit} = \left(\frac{p_{nxit}}{P_{Ht}}\right)^{-\sigma} C_{Ht}$ (10) $c_{dxit} = \left(\frac{p_{dxit}}{P_{Ht}}\right)^{-\sigma} C_{Ht}$ (11) $c_{fxit} = \left(\frac{p_{fxit}}{P_{Ft}}\right)^{-\sigma} C_{Ft} = \left(n_{xt-1}^* + ne_{xt}^*\right)^{\frac{\sigma}{1-\sigma}} C_{Ft}$
Entry Investment	(12) $I_t = ne_{xt} K_t^E$ (13) $P_{It} = \left[\theta P_{Ht}^{1-\phi} + (1-\theta) P_{Ft}^{1-\phi}\right]^{\frac{1}{1-\phi}}$

	(14) $I_{Ht}=\theta\left(\frac{P_{Ht}}{P_{It}}\right)^{-\phi}I_t$ (15) $I_{Ft}=(1-\theta)\left(\frac{P_{Ft}}{P_{It}}\right)^{-\phi}I_t$ (16) $i_{nxit}=\left(\frac{p_{nxit}}{P_{Ht}}\right)^{-\phi}I_{Ht}$ (17) $i_{dxit}=\left(\frac{p_{dxit}}{P_{Ht}}\right)^{-\phi}I_{Ht}$ (18) $i_{fxit}=\left(\frac{p_{fxit}}{P_{Ft}}\right)^{-\phi}I_{Ft}=\left(n^*_{xt-1}+ne^*_{xt}\right)^{\frac{\phi}{1-\phi}}I_{Ft}$
Worker	(19) $U_{C_{wt}}w_t+U_{Lt}=0$ (20) $\beta(1-\lambda)E_t\left[U_{C_{wt+1}}R_t\right]=U_{C_{wt}}$
Investor	(21) $C_{It}+\left(n_{xt-1}+ne_{xt}\right)q_{xt}s_{xt}+n^{begin}_{nxt}q_{nxt}s_{nxt}\le n_{xt-1}s_{xt-1}\left(q_{xt}+d_{xt}\right)+n^{end}_{nxt-1}\left(q_{nxt}+d_{nxt}\right)$ (22) $\beta_I(1-\lambda)E_t\left[U_{C_{It+1}}\left(q_{xt+1}+d_{xt+1}\right)\right]=U_{C_{It}}q_{xt}$ (23) $\beta_I(1-\lambda)E_t\left[U_{C_{It+1}}\left(q_{nxt+1}+d_{nxt+1}\right)\right]=U_{C_{It}}q_{nxt}$
Financial Constraint	(24) $\xi_tE_t(m_{t+1}V_{xit+1}(b_{xit}))\ge w_tl_{xit}$ (25) $\xi_tE_t(m_{t+1}V_{nxit+1}(b_{nxit}))\ge w_tl_{nxit}$
Incumbents	(26) $y_{nxit}=c_{nxit}+i_{nxit}$ (27) $y_{xit}=y_{dxit}+y^*_{hxit}$ (28) $y_{dxit}=c_{dxit}+i_{dxit}$ (29) $y^*_{hxit}=\frac{c^*_{hxit}+i^*_{hxit}}{1-\eta}$

	(30) $y_{xit} = A_t l_{xit}$, (31) $y_{nxit} = A_t l_{nxit}$, (32) $d_{xit} = \pi_{dxit} + \pi^*_{hxit} - \left(b_{xit-1} - \frac{b_{xit}}{R_t} \right)$ (33) $d_{nxit} = \pi_{nxit} - \left(b_{nxit-1} - \frac{b_{nxit}}{R_t} \right)$ (34) $\pi_{dxit} = \frac{p_{dxit}}{P_t} y_{hxit} - w_t \frac{y_{dxit}}{A_t}$ (35) $\pi^*_{hxit} = \frac{p^*_{hxit}}{P_t} y^*_{hxit} (1-\eta) - w_t l^*_{hxit}$ (36) $\pi_{nxit} = \frac{p_{nxit}}{P_t} y_{nxit} - w_t l_{nxit}$ (37) $V_{xit}(b_{xit-1}) = \max_{p_{dxit}, p^*_{hxit}, b_{xit}} \{d_{xit} + E_t(m_{t+1} V_{xit+1}(b_{xit}))\}$ (38) $V_{nxit}(b_{nxit-1}) = \max_{p_{nxit}, b_{nxit}} \{d_{nxit} + E_t(m_{t+1} V_{nxit+1}(b_{nxit}))\}$. (39) $\frac{p_{dxit}}{P_t} = \frac{\sigma}{\sigma-1} \frac{w_t}{A_t}(1+\mu_{xit})$ (40) $\frac{p^*_{hxit}}{P_t} = \frac{\sigma}{\sigma-1} \frac{w_t}{(1-\eta) A_t}(1+\mu_{xit})$ (41) $\frac{p_{nxit}}{P_t} = \frac{\sigma}{\sigma-1} \frac{w_t}{A_t}(1+\mu_{nxit})$ (42) $\mu_{xit} = \frac{\frac{1}{R_t} - E_t m_{t+1}}{\xi_t E_t m_{t+1}}$ (43) $\mu_{nxit} = \mu_{xit}$

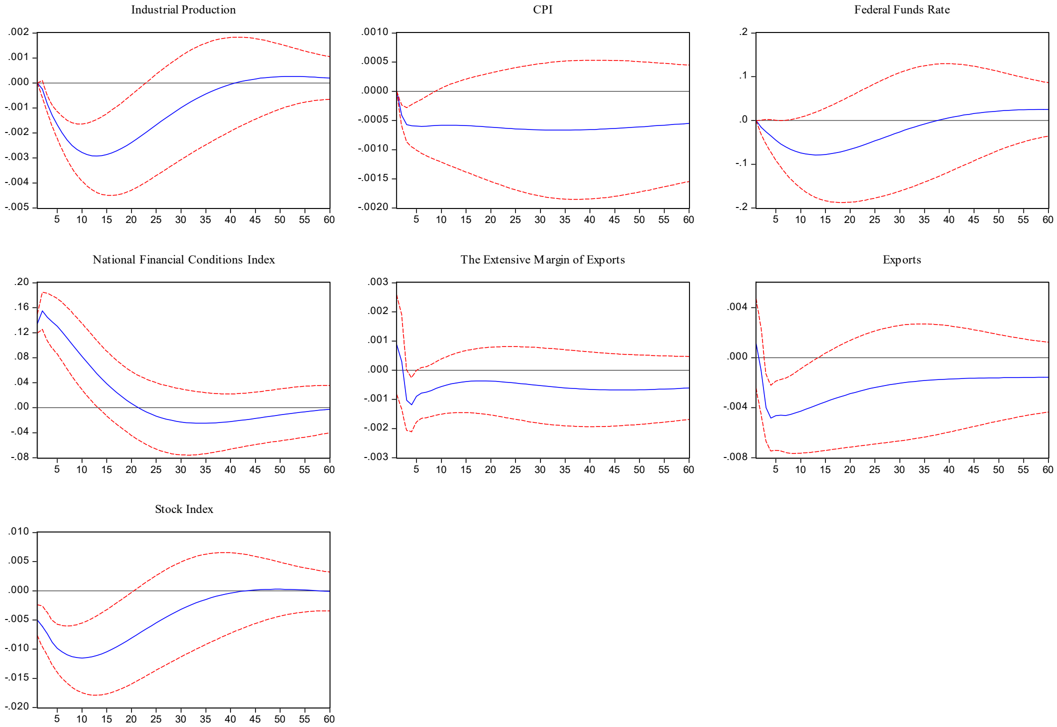
New Entrants	(44) $d_{xit}^{new} = \pi_{nxit} + \pi_{hxit}^{*new} - b_{nxit-1} + \frac{b_{xit}^{new}}{R_t} - \frac{P_{It}}{P_t} K_t^E$ $\pi_{hxit}^{*new} = \frac{p_{hxit}^{*new}}{P_t} y_{hxit}^{*new} (1-\eta) - w_t l_{hxit}^{*new}$ (45) $\frac{P_{It}}{P_t} K_t^E = E_t(m_{t+1}\left(\pi_{hxit+1}^{*new} + \frac{P_{It+1}}{P_{t+1}} K_{t+1}^E\right)) + \left(\frac{1}{R_t} - E_t m_{t+1}\right)\left(b_{xit}^{new} - b_{nxit}\right)$ (46) $V_{it}^{new}\left(b_{nxit-1}\right) = d_{xit}^{new} + E_t\left(m_{t+1} V_{xit+1}\left(b_{xit}^{new}\right)\right)$ (47) $K_t^E = \bar{K}^E \left(\frac{ne_{xt}}{ne_{xt-1}}\right)^{\tau}$
Market Clearing	(48) $L_t = \left(1 - \left(n_{xt-1} + ne_{xt}\right)\right) l_{nxt} + \left(n_{xt-1} + ne_{xt}\right) l_{xt}$ (49) $C_t = C_{It} + C_{wt}$
Balanced Trade	(50) $\left(n_{xt-1} + ne_{xt}\right) p_{hxit}^* y_{hxit}^* = \left(n_{xt-1}^* + ne_{xt}^*\right) p_{fxit} y_{fxit}$
Normalization	(51) $P_t = 1$

Appendix Fig. 1 Impulse Responses to National Financial Conditions Index: Trade



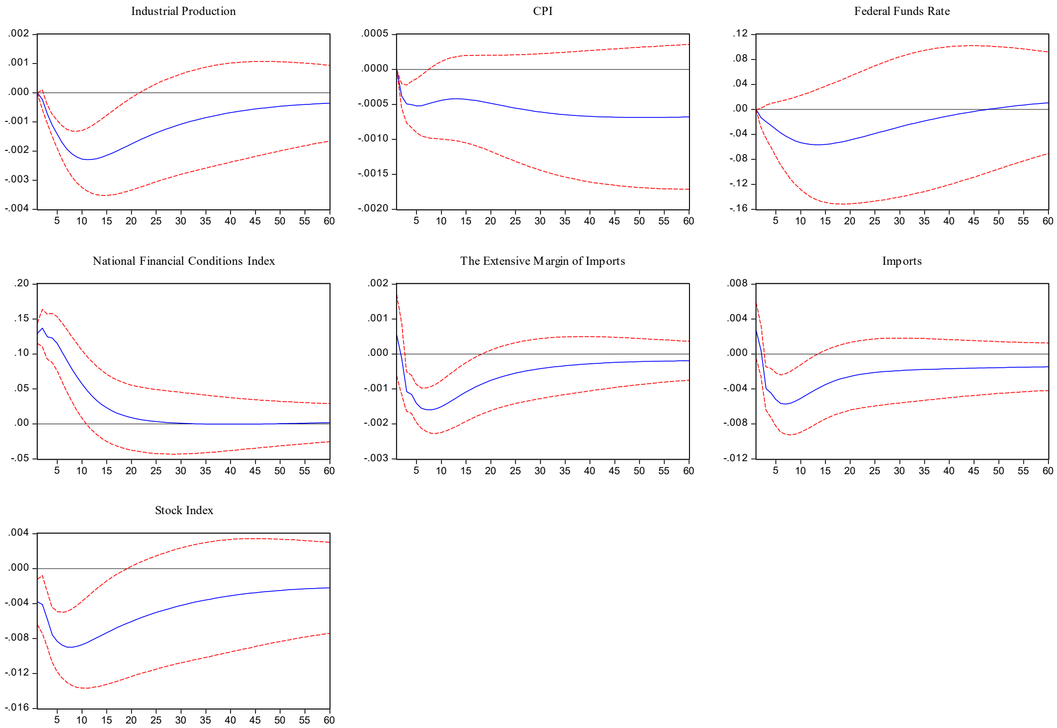
Note: Data are at monthly frequency, based on 6-digit HS disaggregate U.S. export and import flows, running from 2002:1 to 2016:11.

Appendix Fig. 2 Impulse Responses to National Financial Conditions Index: Exports



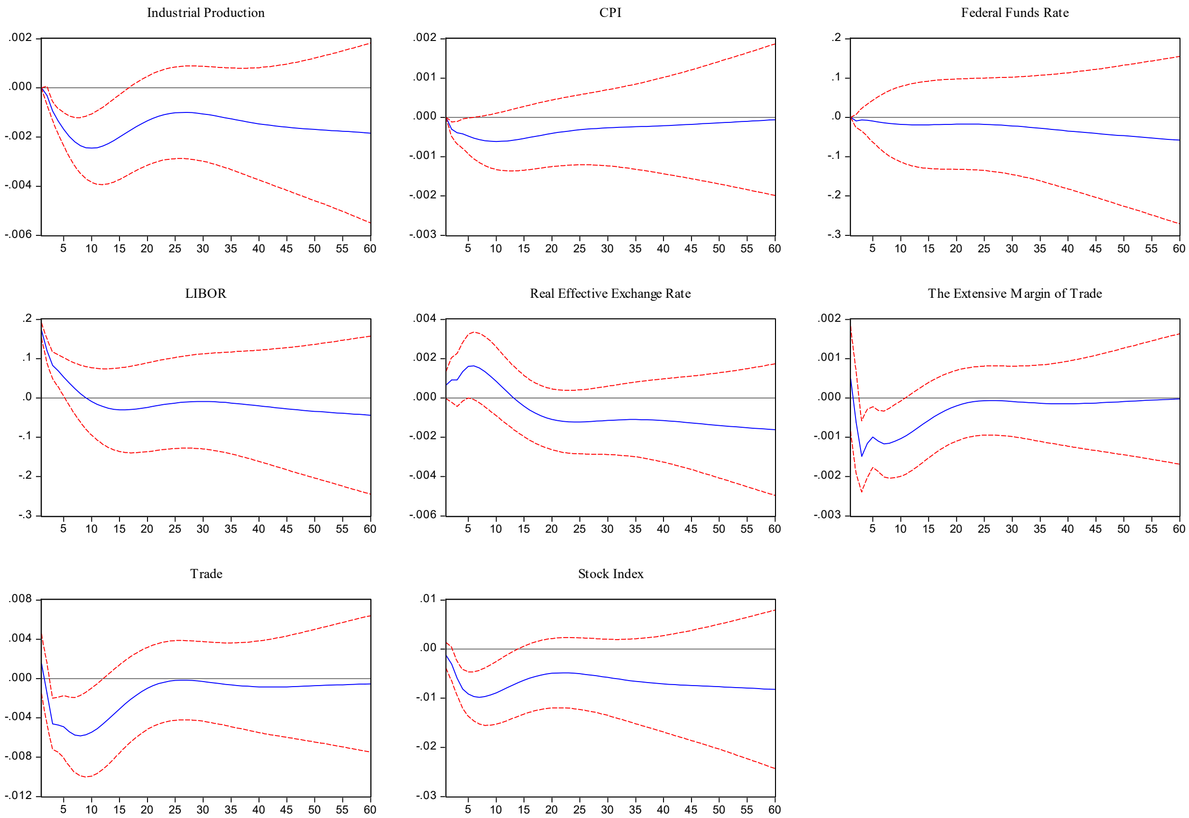
Note: Data are at monthly frequency, based on 6-digit HS disaggregate U.S. export flows, running from 2002:1 to 2016:11.

Appendix Fig. 3 Impulse Responses to National Financial Conditions Index: Imports



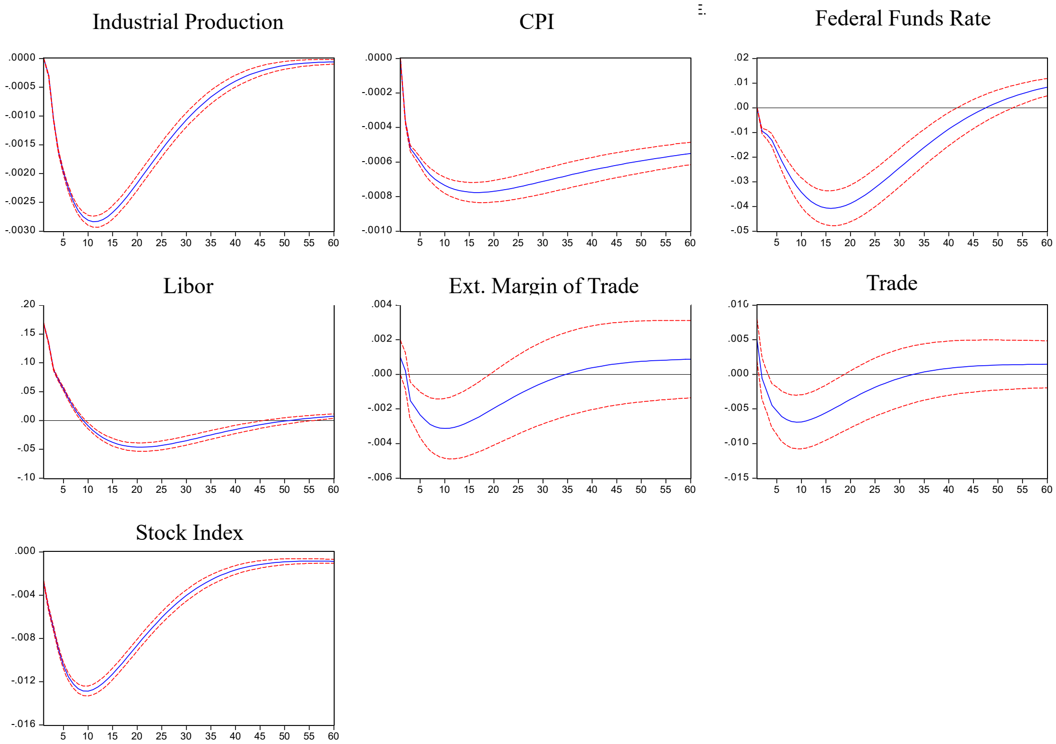
Note: Data are at monthly frequency, based on 6-digit HS disaggregate U.S. import flows, running from 2002:1 to 2016:11

Appendix Fig. 4 Impulse Responses to Interbank Rate: Real Effective Exchange Rate Included in the VAR



Note: We order the real effective exchange rate after monetary policy and the interbank rate, indicating that the real effective exchange rate responds contemporaneously to the shock. Our results are robust to alternative orderings.

Appendix Fig. 5 Panel VAR with 7 Variables



Appendix Fig. 6 Panel VAR with 3 Variables