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# Financial Shocks, Supply-chain Relationships and the Great Trade Collapse[*]

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## Abstract

The collapse in trade relative to GDP during 2008-09 was unusually large historically and puzzling relative to the predictions of canonical two-country models. In a calibrated dynamic general equilibrium two-country model where firms must build supply chain relationships in order to sell their product, we show that a tightening of credit can cause a sizable fall in the trade-GDP ratio (44 percent of the observed value) while productivity shocks cannot. The key mechanism underlying the sharper fall in trade relative to GDP involves an endogenous reallocation of scarce resources from international to domestic supply-chains, that are acquired and maintained at lower cost. JEL Codes: E32; F41; F44, Keywords: Credit Shocks, News Shocks, Supply Chains, Relationship Capital, Trade Collapse

# 1  Introduction

World trade displayed an unusually large collapse during the Great Recession of 2008-2009 even after accounting for the unusually large recession experienced by the world. In the US, total trade as measured by the sum of real exports and imports fell to about 13% below trend while output fell 2.8% below trend. In this paper, we focus on the behaviour of the trade to GDP ratio in what follows in order to highlight the severity of the trade collapse during the Great Recession. Figure 1 reports the percentage deviation from trend for this ratio, calculated using the Hodrick-Prescott filter over the post-war period. The trade to GDP ratio fell to a trough that was $10.3\%$ below trend, which is unprecedented in recent decades (the average trough in the trade-GDP ratio for all US recessions since 1947 is 6.5%).
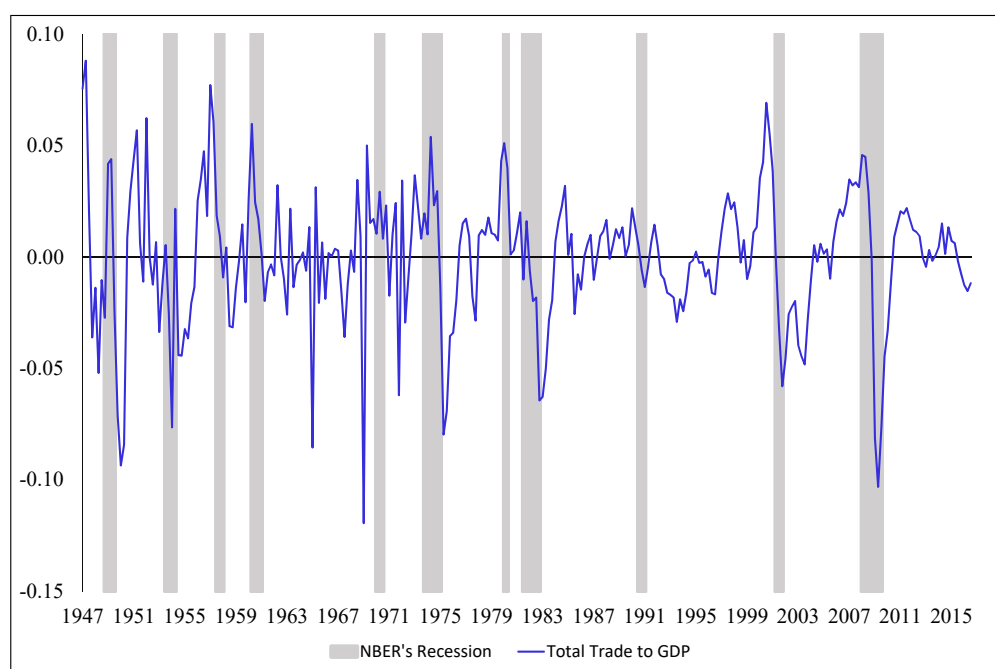


Figure 1: Trade to GDP ratio over time

*Note*: Quarterly trade and GDP data is detrended using the HP-filter with smoothing parameter of 1600.
*Source*: U.S. Bureau of Economic Analysis

Interestingly, this unusually large collapse in trade is difficult to reconcile with the quantitative predictions of canonical two-country business cycle models calibrated to the U.S., in that trade fell

much more than would be predicted by the fall in overall economic activity or domestic absorption. Levchenko et al. (2010) shows that the "trade wedge" between the actual data and the canonical model's prediction is extremely large during the recent collapse period.

In order to offer further insight into the unusually large drop in the trade-GDP ratio, we build a quantitative dynamic general equilibrium model in which an aggregate shock that tightens credit, reduces demand for both domestic and foreign intermediate goods, however, an endogenous reallocation of marketing inputs towards the domestic market by intermediate producers causes cross-border trade to fall more than within-border trade and thus, more than GDP. Our model involves a world with trading frictions in which producers cannot sell directly to the end user. Instead, they must deal with other firms which are part of the distribution network of the economy, whom we call middlemen. Both producers and middlemen incur expenses in building long term supply chain relationships that allow produced goods to be sold to the eventual user. Below, we discuss details of our modeling strategy while also highlighting the related quantitative models.

We explore the trade collapse in a two-country real business cycle model where firms must spend resources in order to build a stock of supply-chain relationships (i.e., relationships where firms are the customers of other firms) to sell their product. As an example, think of firms that operate in the wholesale market as opposed to the retail market. Producers must convince these wholesale firms to carry their products and spend substantial amount of resources to do so.[1] Some examples of occupations that fall into this category of activity, taken from the Occupation Employment Statistics are: marketing managers; sales managers; advertising and promotions managers; parts salespersons; advertising sales agents; sales representatives, wholesale and manufacturing.[2]

In our two-country framework which builds on and modifies Drozd and Nosal (2012), intermediate good firms wish to sell their product in both countries and therefore must accumulate a stock of relationship capital on both sides of the border.[3] A key feature of the accumulation process is

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[1]Since Levchenko et al. (2010) provides evidence that the trade collapse was concentrated in intermediate good sectors, we model trade as occurring solely in intermediate goods that are combined together to produce the final good using a standard CES technology.

[2]Related models with this form of trading friction can be found in Gourio and Rudanko (2014); Drozd et al. (2014). See also Antràs and Costinot (2011).

[3]Drozd and Nosal (2012) discuss the importance of enduring producer-supplier relationships, the costs of switch-

an efficiency parameter that governs the relative ease of building new supply-chain relationships in any market. In our analysis, it is always more expensive to add relationships in the foreign market as compared to the domestic market, perhaps due to language or cultural barriers or an additional information burden. In response to a fall in demand for their product driven by tightening credit availability to wholesalers in both markets, firms choose to invest less in maintaining and building relationship capital which in turn means less sales and production overall. Moreover, due to the differentially higher cost of building relationships in the foreign market, firms choose to reallocate a greater share of the shrunken marketing resources away from the foreign market and towards the domestic market.[4] As a result, relationship capital falls more in the foreign market than in the domestic market and these disruptions in international supply-chains, in turn, imply that cross-border trade shrinks more than domestic trade.

The fall in wholesalers' demand for the firm's product is driven by a credit shock that reduces their ability to borrow in both countries. The wholesale sector firms are modeled as agents of a middleman who spends resources to get matched with both home country and foreign producers. The middleman's agents are a proxy for the substantial amount of resources spent by the economy in matching buyers and sellers. For example, in 2008, value added by the private wholesale trade sector in the U.S. was 6 percent of GDP. It fell by 5 percent from this level during the recession and slowly recovered to the same level over the next few years. We have in mind the idea that tighter credit conditions for the wholesale sector led to the exit of firms, the closing of some locations, the abandonment by firms of some product lines and the firing of staff during the great recession, all of which would impede the ability of producers to sell their product. In the model, the middleman must pay matching costs in advance of payments so there is a need for working capital. Given an enforceability problem, lenders limit the amount of working capital loans available to the middleman. In turn, it limits their ability to form new supply chain relationships which limits

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ing and the implications of this form of friction for breaking the law of one price in two-country business cycle models. Gourio and Rudanko (2014) provides additional motivation and evidence.

[4]Eaton et al. (2014) models and quantifies these types of search costs and studies their impact on export dynamics. Arkolakis (2010) studies exporter's entry and exit dynamics using market penetration costs that are convex, ie., firms have to pay higher costs to reach additional customers.

the amount of goods that can be purchased from producers. A shock that exogenously tightens the enforceability constraint, causes the middleman to reduce the amount of resources spent on matching with producers, which in turn reduces the number of newly formed matches for a given amount of marketing expenditure by producers. As a result, there is a decline in the amount of relationship capital. The reallocation of marketing resources exacerbates the trade collapse while mitigating the fall in domestic sales so that trade falls much more than GDP. Figure 2 presents data on the number of employees in US wholesale trade in deviations from trend. The approximately 3.62% fall in employees relative to trend during the Great Recession is consistent with the model mechanism described above.
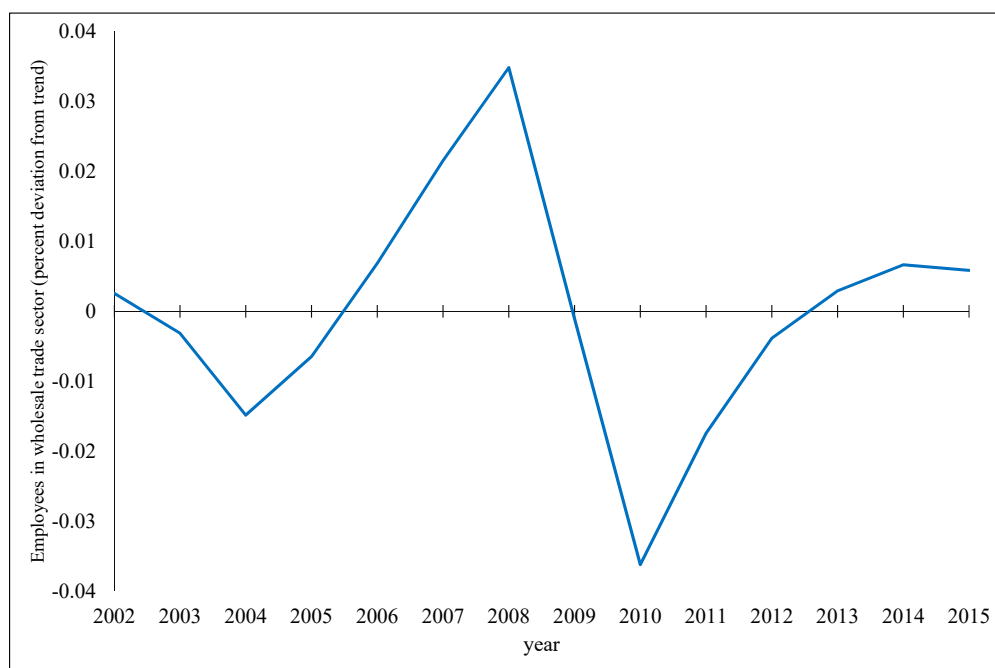


Figure 2: % Employees in Wholesale Trade Sector, Deviation from Trend

*Note*: The trend is calculated using HP-filter with smoothing parameter of 6.25.
*Source*: Occupational Employment Statistics (OES) Survey.

While there is no direct data that separates out the value added by marketing departments of firms, we can use employment data to get a sense of the magnitudes involved. Using data from the Occupational Employment Statistics collected by the Bureau of Labor Statistic, we can get a measure of the relative size of the marketing sector expenditure on employees to total expenditure

on employees using the occupations mentioned above. Between 2008 and 2009, the relative wage bill of these occupations to total wage bill of all occupations fell by $2\%$ indicating a decline in marketing expenses of the economy relative to the overall decline of the whole economy which is consistent with the mechanism outlined here.

We now provide more details about the shock that drives the trade collapse in our model. The severity of the financial crisis accompanying the Great Recession, makes financial shocks a natural candidate cause of the downturn in economic activity. Dynamic general equilibrium models with this feature can be found in Gilchrist and Zakrajšek (2012), Gunn and Johri (2013), Jermann and Quadrini (2012), Kalemli-Ozcan et al. (2013), Kollmann et al. (2011), and Kollmann (2013) among others.[5] To illustrate the co-movement between aggregate short term credit market activity and the trade collapse, we plot in Figure 3 the percentage deviations from trend of our measure of credit shocks ( discussed later), non-financial commercial paper outstanding and the trade-GDP ratio for the period 2005-2014. As seen in Figure 3, these series fall about $30\%$ while the trade-GDP ratio falls $10\%$ percent below trend. Note also that the measures of credit lag the trade-GDP ratio by one quarter. This is confirmed by the fact that the one quarter ahead correlation between non financial commercial paper and the trade-GDP ratio rises to 0.78 while the contemporaneous correlation is only 0.31.[6] Our interpretation of this lead-lag pattern is that the turmoil in financial markets towards the end of 2008 epitomized by the collapse of Lehmann Brothers acted as a news shock which created expectations of tighter credit conditions in the near future. We explore the quantitative implications of this interpretation by augmenting our shock process to allow for one quarter ahead news shocks.

Following the two-country business cycle literature, we parametrize the model to assess its quantitative ability to generate movements in the trade-GDP ratio in response to plausibly sized credit shocks. Our credit shock is chosen to deliver the observed $3.62\%$ decline in wholesale sector employment discussed above. In response, a calibrated version of the model successfully generates

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[5]The importance of binding leverage constraints in the international transmission of shocks is explored in Devereux and Yetman (2010).

[6]In Appendix Figure A1, we report another often used measure of the health of the financial system, the spread between Libor and US T-bill rate. Once again, the rise in the spread is accompanied with a fall in the trade-GDP ratio.
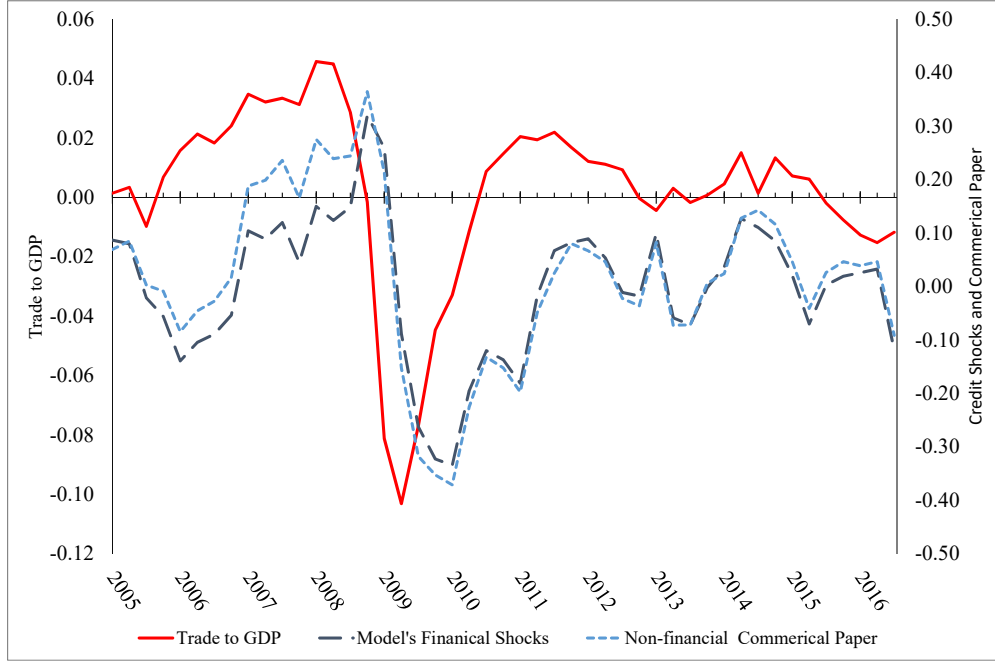
Figure 3: % Deviation from Trend: Trade to GDP Ratio and Credit Measures

*Note*: The trend is calculated using HP-filter with smoothing parameter of 1600.
*Source*: U.S. Bureau of Economic Analysis and Board of Governors of the Federal Reserve System (US).

a 4.5% fall in the trade-GDP ratio below steady state levels while being consistent with a number of stylized facts of that episode.[7] In section 3, we show the impact of both contemporaneous and news shocks on model variables which differ mainly in the timing of the trade collapse. In response a news shock that causes expected declines in the ability of firms to borrow next period, in our model, the middleman immediately cuts back on the number of agents sent out into the matching market. This leads to an immediate decline in trade even though credit has yet to decline.

Contrary to our approach, some empirical studies focus on tightening credit conditions that are worse for the financing of exports and imports relative to the rest of the economy. For example, Amiti and Weinstein (2011) and Chor and Manova (2012) provide evidence that tighter conditions in trade specific finance may have played a role in the trade collapse. They argue that exporters are more reliant on trade credit than domestic producers and therefore suggest that difficulty in

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[7]In order to generate the entire observed collapse in the trade-GDP ratio of 10%, the model requires a 17.6% fall in credit. By comparison non-financial commercial paper fell 37% below trend.

obtaining trade credit may have been responsible for the unusually large fall in international trade. Levchenko et al. (2010), on the other hand, casts doubt on the trade-credit story, finding that more trade-credit intensive sectors did not display larger trade collapses. Influenced by these mixed findings and by the economy wide scope of the credit collapse, our model does not rely on a differentiated drop in credit to importers or exporters relative to domestic trade. Given the perceived imminent implosion of global financial markets around the collapse of Lehman Brothers and the almost complete freezing up of inter-bank credit flows, we find it more natural to focus on financial shocks that symmetrically affect all trade, whether domestic or international and look for an endogenous mechanism to cause a disproportionate fall in cross-border trade.[8] To the extent that trade credit fell more than other forms of credit during the financial crisis, this mechanism would further contribute to the mechanism explored in our paper.

Our paper complements the short existing business cycle literature which offers alternative explanations for the trade collapse. For example, Alessandria et al. (2010b) provides evidence and a general equilibrium model in which the inventory cycle plays an important role in generating a trade collapse in response to an exogenous rise in the interest rate paid by firms. Alessandria et al. (2010a) provides more detail on modeling the inventory cycle. Novy and Taylor (2014) uses an inventory cycle model to generate trade fluctuations driven by uncertainty shocks. In addition, our model contributes to the short list of open economy business cycle models with news shocks such as Beaudry et al. (2011), Durdu et al. (2013), Jaimovich and Rebelo (2008), and Kamber et al. (2017). Our news shocks differ from these in that fluctuations are driven by financial news shocks whereas most models in this literature contain TFP news shocks (see Beaudry and Portier (2014) for a literature review and Schmitt-Grohé and Uribe (2012) for an estimated model with news shocks to several processes.). An exception in which a news shock to bank balance sheets can cause a recession can be found in Gunn and Johri (2015). News shocks in a model with financial enforceability constraints can also be found in Gortz and Tsoukalas (Forthcoming). Our model with relationship capital is an example of the few two-country models with forms of intangible

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[8]Given the global nature of the financial crisis, we model the two countries in a symmetric way, so that both receive the same financial shock.

capital. Another example in a monetary model can be found in Johri and Lahiri (2008) where firms' accumulation of organizational capital helps to explain the dynamics of real exchange rates.

The rest of the paper proceeds as follows. Section 2 describes the model. Section 3 provides our quantitative results and also outlines different variants of the model that highlight the importance of various model elements in delivering the trade collapse and shows the sensitivity of the quantitative model to several key parameters. Section 4 concludes.

# 2  Model

Our model consists of two ex-ante symmetric countries, home and foreign, each of which has a stand-in household that supplies labor and capital to competitive firms in exchange for wage and rental payments. Since we are interested in studying the impact of credit shocks in the wholesale market, final goods production is delegated to the household in each country and as such they own a CES technology for converting intermediate goods into final goods for consumption and investment purposes. Both countries are subject to productivity shocks and credit shocks which are the only sources of uncertainty.[9] A large number of identical firms, of unit measure, produce country-specific tradable intermediate goods which are called the domestic good ($d$) and the foreign good ($f$). There is a product market friction that makes sales between the households and the tradable good firms non-trivial. A middleman who intermediates between the household and producers must incur expenses in order to match with producers of both countries.[10] Time is discrete and has an infinite horizon. An asterisk denotes variables in the foreign country. In what follows, we develop various agent's problems from the domestic country's perspective, while the foreign country agent's problems are only discussed where necessary.

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[9]Productivity shocks are included in the model for calibration of certain parameters. They cannot, by themselves, generate a trade collapse in a recession in either our model or in Drozd and Nosal (2012).

[10]The middleman can be thought of as wholesalers or distributors who have a lower cost of matching with producers. Previous work with middlemen in an international context can be found in Ahn et al. (2011) and Bai et al. (2017).

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## 2.1 The Household

In each period, the household maximizes expected discounted lifetime utility by using their income to purchase units of the domestic and foreign good ($d_t$ and $f_t$ respectively) which are in turn converted into the final consumption-investment good using an in-house technology. In addition, households borrow using units of a non-state contingent, one-period, internationally traded bond, $D_{t+1}$ which must be repaid the next period. Income is obtained by choosing hours worked, $N_t$, renting out capital held, $K_{t-1}$, to firms taking prices as given. Lifetime expected discounted utility is given by:

$$\sum_{t=0}^{\infty} \beta^t E_t \left\{ \frac{\left( C_t^{\psi}(1-N_t)^{1-\psi} \right)^{1-\sigma}}{(1-\sigma)} \right\}. \tag{1}$$

In period $t$, the budget constraint of the household is given by

$$w_t N_t + r_t K_{t-1} + Q_t D_{t+1} + \Pi_t^M + \Pi_t^F \geq P_{d,t} d_t + P_{f,t} f_t + D_t. \tag{2}$$

where all prices are expressed in term of the domestic final good.

$P_d$ and $P_f$ refer to the price of the domestic and foreign good charged by the middleman. The household receives labor income at wage rate, $w_t$ and capital rental income at the rate, $r_t$. Additionally, as owners of all firms, the household receives lump-sum transfers of profits from the middleman, $\Pi^M$, and firms, $\Pi^F$. The household also makes within period loans to the middleman to cover their matching cost. Following Jermann and Quadrini (2012), we assume the loan does not pay out any interest and is returned at the end of the period, therefore we omit notation for it here. The household can smooth consumption by using the international bond where $Q_t$ is the price of the bond and $D_{t+1}$ is the amount of bonds the household can buy or sell. Our notation implies that $D_t$ is a loan that must be returned in period $t$.

After the household purchases the domestic and foreign intermediate goods from the middle-

man, it uses the following technology to combine $d_t$ and $f_t$ into the final good, $G_t$.

$$G_t = \left( \omega d_t^{\frac{(\gamma-1)}{\gamma}} + (1-\omega) f_t^{\frac{(\gamma-1)}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \quad \gamma > 0 \quad \text{and} \quad 1 > \omega > 0, \tag{3}$$

where $\gamma$ determines the long-run trade elasticity, and $\omega$ determines the home bias. In turn, $G$ is allocated between investment, $I_t$, and consumption, $C_t$.

$$G_t = C_t + I_t. \tag{4}$$

Physical capital, $K_{t-1}$, follows a standard law of motion,

$$K_t = (1 - \delta_K) K_{t-1} + I_t, \quad 0 < \delta_K < 1. \tag{5}$$

The foreign household is identical except for the bond price, which is written as $Q_t/e_t$ since the bond is traded in units of home country's final good. Here $e_t$ denotes the real exchange rate in term of the consumption in the home country.

## 2.2 Intermediate Producer's Problem

Producers in any country hire labor and capital and use a standard, constant return to scale production function to produce output for sale in both the home country and the foreign country. Since all firms in a country are the same, anticipating a symmetric equilibrium in which all firms make the same decision, we eschew firm specific notation. To simplify the problem, we first solve for the unit cost function:

$$v_d = \min_{k,n} \{ w_t n_t + r_t k_{t-1} \quad \text{s.t} \quad z_t n_t^{1-\alpha} k_{t-1}^{\alpha} = 1 \}, \tag{6}$$

where $z_t$ is an exogenous technology shock following an AR(1) process

$$\log z_t = \rho_z \log z_{t-1} + \epsilon_{z,t}, \text{where} \quad 0 < \rho_z < 1, \tag{7}$$

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and $v_d$ is also the marginal cost for the economy since the production function is constant returns to scale.

The key departure from a canonical two-country model such as Backus et al. (1992) is the requirement that firms must build relationships with the middleman before any sales can be made. These relationships are made with the agents of the middleman through a matching process that requires an input from firms which we call marketing costs. We interpret marketing in a broad sense to include sales material, brochures, expenses on trade shows and on sales staff, non transportation related distribution costs, destination-specific packaging, costs to tailor the product for the counterpart, and so forth.

Taking marginal cost, $v_d$, from the problem above, firms choose both the quantity of goods to produce and how much to spend on marketing in order to maximize their discounted profit stream:

$$\max E \sum_{t=0}^{\infty} Q_t \left\{ (q_{d,t} - v_{d,t})d_t + (e_t q_{d,t}^* - v_{d,t})d_t^* - \zeta_d v_{d,t} a_{d,t} - e_t v_{f,t} \zeta_d^* a_{d,t}^* \right\}.$$

The first term, $(q_{d,t} - v_{d,t})$, is the markup from selling one unit of the good, $d$, to the domestic middleman while the second term, $(e_t q_{d,t}^* - v_{d,t})$, represents the markup from selling to the middleman in the foreign country after adjusting for the exchange rate, each multiplied by the units sold at home and abroad respectively. The third and fourth terms measure the total marketing cost in the home and foreign country. Firms must use factors in the country where they wish to build supply-chain relationships so foreign marketing costs must be converted using the exchange rate in the fourth term. The ratio, $\frac{\zeta_d^*}{\zeta_d}$, denotes the foreign to home marketing cost differential; a ratio greater than one represents a higher cost for firms to market in the foreign country. These cost differentials can arise because of language barriers, informational frictions that are more severe in cross border trade, extra costs to maintain an office abroad, the cost to hire a foreign agent to run the marketing, and so forth.

Domestic producers maintain two lists of supply-chain relationships at home and abroad separately. Given the number of agents in the matching market (determined by the middleman, see below) and the marketing expense of producers, $\pi_{dt} h_t$ new relationships get added to the domestic

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list, $H_d$, which evolves according to:

$$H_{d,t} = (1 - \delta_h)H_{d,t-1} + \pi_{dt}h_t - \phi \left( \frac{a_{d,t}}{a_{d,t-1}} - 1 \right)^2 a_{d,t-1}, \tag{8}$$

where $\delta_H$ is an exogenous separation rate governing the loss of relationships. The adjustment cost term implies it is costly to vary marketing expenses and this is useful for calibrating the model. An analogous accumulation equation for relationships in the foreign market is :

$$H_{d,t}^* = (1 - \delta_h)H_{d,t-1}^* + \pi_{dt}^* h_t^* - \phi \left( \frac{a_{d,t}^*}{a_{d,t-1}^*} - 1 \right)^2 a_{d,t-1}^*. \tag{9}$$

The size of the list determines the amount of goods the producer can sell. Specifically, sales cannot exceed the number of supply-chain relationships with the middleman,

$$H_{d,t} \geq d_t \quad \text{and} \quad H_{d,t}^* \geq d_t^*. \tag{10}$$

The matching environment implies that producers must first match with an agent sent by a middleman, who will then deliver the new contract made to the middleman. Bargaining over prices occurs between middleman and producer, and, in equilibrium, this new contact is added to the existing list of relationships. Domestic firms have to compete with foreign firms in matching with agents, $h_t$, sent by the middleman. To simplify the problem, only the marketing expense, $a$, of a firm determines the probability of matching.[11] A producer from the home country matches with a fraction of the agents operating in the domestic market, $h_t$, which is given by $\pi_d = \frac{a_{d,t}}{\bar{a}_{d,t} + \bar{a}_{f,t}} = \frac{a_{d,t}}{\bar{a}_t}$, where $\bar{a}$ refers to market averages. Similarly, foreign producers match with agents in the domestic market with probability $\pi_f = \frac{a_{f,t}}{\bar{a}_{d,t} + \bar{a}_{f,t}} = \frac{a_{f,t}}{\bar{a}_t}$. In the foreign market, the home producer matches with a fraction of the agents, $h^*$, given by $\pi_d^* = \frac{a_{d,t}^*}{\bar{a}_{d,t}^* + \bar{a}_{f,t}^*} = \frac{a_{d,t}^*}{\bar{a}_t^*}$ while $\pi_f^* = \frac{a_{f,t}^*}{\bar{a}_{d,t}^* + \bar{a}_{f,t}^*} = \frac{a_{f,t}^*}{\bar{a}_t^*}$ is the fraction of foreign agents that match with the foreign producer. We will refer to these fractions as

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[11]Gourio and Rudanko (2014) and Shi (2016) provide an environment where firms can use price to attract customers. In our model, the relative amount of marketing expense is the sole source determining the market share.

matching market share in our discussion below.[12]

## 2.3 The Middleman

In each country, the middleman sends out agents who are responsible for acquiring supply-chain relationships with intermediate goods producers from both countries. Once agents bring contacts to the middleman, an enduring relationship begins which involves a bilateral bargaining problem that determines the price, $q_d$ or $q_f$, at which one unit of the good in question is traded.[13] We will refer to these prices as producer prices in the future. The middleman bargains over prices with all the old and new producers that they have a relationship with while also engaged in selling these acquired units of domestic and foreign goods to the household in competitive markets. The price differential between what the household pays and the producer prices allow the middleman to recover their costs and make a profit. The middleman chooses the number of agents, $h_t$, sent into the matching market after observing aggregate shocks. Random matching governs whether any individual agent will match with a home producer or a foreign producer but the law of large numbers implies that they can assess the ex-ante probability of matching with domestic good firm, $\pi_d$, and the foreign good firm, $\pi_f$. Each match leads to an exchange of one unit of the relevant good in period $t$ as well as subsequent trades in the future until separation. The middleman incurs an increasing and convex matching cost based on the number of agents used, $\chi v_{d,t} h_t^2$.[14] In order to induce borrowing, we assume that these costs must be paid in advance of any trades by taking an

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[12]While our model shares many common features with Drozd and Nosal (2012), one way it differs is that marketing expenses are not accumulated as marketing capital. We can think of this difference as coming from a marketing capital depreciation rate of unity. Since we are not thinking about advertising expenses aimed at consumers where brand loyalty is a big concern but rather about expenses on salesman etc., this difference seems appropriate. In any case, allowing for a firm's marketing input to accumulate has little impact on the result. Sensitivity to this assumption can be obtained from the authors. Our paper also differs from Drozd and Nosal (2012), without major implications, in that the adjustment cost appears on the relationship capital accumulation equation.

[13]For a theoretical model of middlemen with posted prices rather than bargaining see Johri and Leach (2002).

[14]Agents may be thought of as locations or offices instead of as merely individuals. Our specification of costs implicitly assumes that the technology used in the production of agents is the same as that of producers so we can use the same economy-wide marginal cost function. This parsimonious specification helps to calibrate the model in the absence of detailed information about the wholesale sector of the economy. We also note that specifying the matching costs in terms of the final good had little impact on the results discussed in the next section.

intra-period loan which is limited by an enforcement constraint discussed below.[15]

Taking the price at which households buy the goods (which we will refer to as customer prices), the results of the bargaining problem described below and the ex-ante probability of matching with domestic versus foreign producers as given, the middleman chooses the number of agents, $h$ to maximize the expected stream of profits given by:

$$\Pi_t^M = (p_{d,t} - q_{d,t})H_{d,t} + (p_{f,t} - q_{f,t})H_{f,t} - \chi v_{d,t}h_t^2 + EQ_{t+1}\Pi_{t+1}^M, \tag{11}$$

subject to the borrowing constraint:

$$\psi_{f,t}\left[(p_{d,t} - q_{d,t})H_{d,t} + (p_{f,t} - q_{f,t})H_{f,t}\right] \geq \chi v_{d,t}h_t^2. \tag{12}$$

Using equations (9) and (10), and the quadratic formula, the optimal $h$ is

$$h = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \tag{13}$$

where $a = \frac{v_{d,t}\chi}{\phi_{f,t}} > 0$,

$$b = -\left[(p_{d,t} - q_{d,t})\pi_{d,t} + (p_{f,t} - q_{f,t})\pi_{f,t}\right] < 0,$$

and

$$c = -(1 - \delta_h)\left[H_{d,t-1}(p_{d,t} - q_{d,t}) + H_{f,t-1}(p_{f,t} - q_{f,t})\right] < 0.$$

The enforcement parameter, $\psi_{f,t}$, is governed by an AR(1) process with contemporaneous and one period ahead news shocks:

$$\log(\psi_{f,t}) = \rho_f \log \psi_{f,t-1} + \epsilon_{f,t} + \epsilon_{f,t-1}^1, \tag{14}$$

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[15]The introduction of convex costs faced by middleman which must be financed in advance with a within period loan and the introduction of a time-varying enforcement constraint differentiate our specification of the middleman from Drozd and Nosal (2012)

where equation (14) is written as a log deviation from the steady state value of $\bar{\psi}_f$ and where $0 \le \rho_f \le 1$, and $\epsilon_{f,t}$ and $\epsilon^1_{f,t-1}$ follow an $i.i.d$ normal distribution with zero mean.

The idea of generating business cycles from variations in the severity of the borrowing constraint follows a similar use in Jermann and Quadrini (2012) in a closed economy context. We differ from that specification by adding news shocks. We can think of $\psi_{f,t}$ as a parameter that governs the ability of the lender to recover goods from the middleman in case the loan is not repaid. Lenders will limit the amount that the middleman can borrow in the absence of any commitment to repay the loan to a multiple of what can be recovered in default as is standard in this class of models. In this specific case, the lender can recover only a fraction of the match surplus, either because the rest can be hidden or because it is lost in the default process. If $\psi_{f,t}$ falls, lenders expect to recover a smaller fraction of middleman revenue in case of a default. As a result they make a smaller loan to the middleman, who in turn, are forced to send out fewer agents and reduce the number of matches with both domestic and foreign producers. The ensuing fall in customers, would cause production cutbacks and a fall in overall economic activity.[16] The mechanism described here is meant to capture the idea that tightening credit constraints may have influenced economic activity through cutbacks and closures in the (substantial) sectors of the economy that are involved in the distribution of goods. Note that the tighter credit constraints have a symmetric impact on domestic and foreign producers trying to build relationships with the domestic middleman. As we will see below, despite this symmetry, home producers will respond differently from foreign producers in terms of their marketing activity in the domestic market which will, in turn, cause a larger decline in foreign trade relative to domestic trade.

## 2.4 Bargaining

Prices are determined by Nash bargaining. There are four producer prices, $q_i$, that need to be determined. The subscript $i$ denotes which goods the middleman and producer are bargaining

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[16]Since we are not interested in exploring the origins of the financial crisis in this paper, we follow the literature and generate an economic downturn in our model by exogenously decreasing $\psi_{f,t}$.

over, $i \in \{d, d^*, f, f^*\}$.[17] The producer's value function is the markup earned on selling a unit of the good plus the expected value of future sales taking into account the probability of the match breaking up.

$$W_{i,t} = \max\{0, q_{i,t} - v_{i,t}\} + (1 - \delta_H)E_t Q_{t+1} W_{i,t+1}. \tag{15}$$

Similarly, the middleman earns the difference between the customer price and the producer price, where the valuation equation takes into account that in the future the match may break and prices may change. The middleman's expected per unit surplus from matching with a domestic producer will be referred to as $J_{d,t}$, and matching with a foreign producer as $J_{f,t}$.

$$J_{i,t} = \max\{0, P_{i,t} - q_{i,t}\} + (1 - \delta_H)E_t Q_{t+1} J_{i,t+1}. \tag{16}$$

Overall, the expected surplus from each match is

$$J_t = \pi_{d,t} J_{d,t} + \pi_{f,t} J_{f,t}. \tag{17}$$

Based on these values, middleman and producers engage in Nash bargaining to determine the producer price, $q_{i,t}$, paid in exchange for one unit of good. The parties renegotiate every period while remaining matched, thus the prices change based on the state in each period.

$$q_{i,t} = \arg\max_q \{J_{it}^\theta W_{it}^{1-\theta}\} = \arg\max_q \{(P_{it} - q_{it})^\theta (q_{it} - v_{it})^{1-\theta}\},$$

so that

$$q_{i,t} = (1 - \theta)P_{i,t} + \theta v_{i,t}, \tag{18}$$

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[17]A producer price or value function with subscript $d$ denotes bargaining between the home middleman and home producer, subscript $d^*$ denote bargaining between foreign middleman and home producers, subscript $f$ is between home middleman and foreign producers, and subscript $f^*$ is between foreign middleman and foreign producer. And, note that $v_d = v_{d^*}$ and $v_f = v_{f^*}$ in a symmetric equilibrium.

where $\theta$ represents the bargaining power of the middleman. Equation (18) shows that the producer price, $q_i$, is a weighted average of the customer price, $P_i$, and the economy-wide marginal cost, $v_i$.

## 2.5 Equilibrium

An equilibrium in this economy is defined by the following contingent infinite sequences that solve the respective optimization problems of each agent: $C_t$, $N_t$, $K_t$, $I_t$, $G_t$, $D_{t+1}$, $d_t$ and $f_t$ for the household in home country, $C_t^*$, $N_t^*$, $K_t^*$, $I_t^*$, $G_t^*$, $D_{t+1}^*$, $d_t^*$ and $f_t^*$ for the household in foreign country, $n_t$, $k_{t-1}$, $d_t$, $d_t^*$, $a_{d,t}$, $a_{d^*,t}$, $H_{d,t+1}$, $H_{d^*,t+1}$ for the home firms, $n_t^*$, $k_{t-1}^*$, $f_t$, $f_t^*$, $a_{f,t}$, $a_{f^*,t}$, $H_{f,t+1}$, $H_{f^*,t+1}$, for the foreign firms, $h_t$ for the home middleman, $h_t^*$ for the foreign middleman, prices, $Q_t$, $w_t$, $w_t^*$, $r_t$, $r_t^*$, $P_{d,t}$, $P_{d,t}^*$, $P_{f,t}$, $P_{f,t}^*$, $q_{d,t}$, $q_{d,t}^*$, $q_{f,t}$, $q_{f,t}^*$ and real exchange rate, $e_t$ that satisfy the following conditions.

The bond market clearing requires

$$D_t = D_t^*. \tag{19}$$

Intermediate goods market clearing requires that the output of each firm is fully used up in sales or marketing costs:

$$z_t n_t^{1-\alpha} k_{t-1}^{\alpha} = d_t + d_t^* + a_{d,t} + a_{d,t}^* \quad \text{and} \quad z_t^* n_t^{*1-\alpha} k_{t-1}^{*\alpha} = f_t + f_t^* + a_{f,t} + a_{f,t}^*. \tag{20}$$

Factor market clearing requires $N_t = \int_0^1 n_{i,t} di$ and $K_t = \int_0^1 k_{i,t} di$ where the integration is over the unit mass of producers and the middleman in the home country. A similar set of equations apply to the foreign country factor markets. Imposing symmetry on the two countries, the steady state prices are equal to

$$P_{d,t} = \Gamma P_{d,t}^* \quad \text{and} \quad P_{f,t}^* = \Gamma P_{f,t}, \tag{21}$$

where the $\Gamma$ is the price differential solely introduced by the marketing cost differential. Similarly,

$$P_{d,t} = P_{f,t}^* \quad \text{and} \quad P_{d,t}^* = P_{f,t}. \tag{22}$$

The proportion of middleman's agents matched with producers from the Home country and from the Foreign country add up to one:

$$\pi_f + \pi_d = 1 \quad \text{and} \quad \pi_f^* + \pi_d^* = 1. \tag{23}$$

For future reference, we also define total trade, GDP and the trade - GDP ratio as calculated from the model as follows:

$$GDP = P_{d,t}d_t + P_{f,t}f_t + e_t q_{t,d^*}d_t^* - q_{f,t}f_t, \quad Trade = q_{f,t}f_t + e_t q_{d,t}^* d_t^*,$$

$$\frac{Trade}{GDP} = \frac{q_{f,t}f_t + e_t q_{d,t}^* d_t^*}{P_{d,t}d_t + P_{f,t}f_t + e_t q_{t,d^*}d_t^* - q_{f,t}f_t}. \tag{24}$$

# 3 Quantitative Results

In this section we present quantitative results based on a parameterized version of the model where some parameters are chosen to match key features of the US economy while other parameters are taken from the literature. Since, in the model, each period represents a quarter, data moments are calculated using quarterly data. We solve the model by linearizing the model equations around the stationary steady-state. Parameter values used in the simulation exercises are reported in Table 1.

## 3.1 Parameterization

The parameter values used in our paper can be found in Table 1. Here we describe the process determining these values. We begin with preference and technology parameters that are typical in the literature. The discount factor, $\beta$, is given a value of 0.99 which implies a 4 percent average annual risk-free real interest rate. We follow the literature and set the coefficient of relative risk aversion, $\sigma$, to 2. We also explore the sensitivity of changing this parameter on our results in section 3.3. We set $\gamma = 7.9$, the long run trade elasticity which is taken from Head and Ries (2001). None of the other parameters can be individually identified however we group them into

18

two categories. The first set of parameters are common to many models and our targets and values are also commonplace. The technology and preference parameters are targeted with : (i) the investment to GDP ratio of 0.23; (ii) the percent of the time endowment worked equal to 30%; (iii) the share of labor income to GDP of 0.64; and (iv) the trade to GDP ratio of 0.26. We target these moments respectively with the capital depreciation rate, $\delta_k$, the leisure preference parameter, $\psi$, the capital share parameter in the production technology, $\alpha$, and the home-bias parameter, $\omega$. We note, however, that these steady state ratios are also somewhat sensitive to the remaining parameters, in particular, the depreciation rate of relationship capital, $\delta_h$. As a result the values assigned to the above parameters need to be chosen jointly with the targets and parameters discussed below. These cause only small changes from the values used in the literature. For example, compared to the values used in Drozd and Nosal (2012), our values differ only in the second or third decimal place.

Table 1: Parameter values

| Parameter | Description | Value |
|---|---|---|
| $\beta$ | Discount factor | 0.99 |
| $\sigma$ | Household's utility | 2.00 |
| $\psi$ | Household's utility | 0.340 |
| $\alpha$ | Production function | 0.314 |
| $\delta_k$ | Capital depreciation | 0.035 |
| $\gamma$ | Long-run trade elasticity | 7.90 |
| $\bar{\psi}_f$ | Financial enforcement | 0.108 |
| $\theta$ | Bargaining power | 0.40 |
| $\delta_h$ | Relationship capital depreciation | 0.12 |
| $\zeta_d$ | Home marketing cost | 1 |
| $\zeta_d^*$ | Foreign marketing cost | 2.16 |
| $\omega$ | Home bias | 0.5353 |
| $\phi_a$ | Marketing adjustment cost | 0.0276 |
| $\rho_f$ | Persistence of financial shock | 0.8330 |
| $\rho$ | Persistence of TFP | 0.8701 |
| $\sigma$ | Variance of TFP shock | 0.0045 |
| $corr(\epsilon_z, \epsilon_z^*)$ | Correlation of TFP shocks | 0.425 |

Next, we discuss non standard parameters that relate to the relative weight of the middleman in the economy and to the size of marketing expenditure incurred by producers at home and abroad in steady state. Since the relative marketing cost difference between domestic and foreign markets

is important for our work (as opposed to the absolute value), we normalize the cost of marketing to the home market, $\zeta$, to unity while calibrating the foreign cost, $\zeta^*$. By rearranging the optimality conditions of $a_{d,t}, a^*_{d,t}, H_{d,t}, H^*_{d,t}, d_t$, and $d^*_t$ evaluated at the steady state, we obtain the following relationship:

$$\frac{\zeta^*}{\zeta} = \frac{q^*_d - v_d}{q_d - v_d}. \tag{25}$$

Equation (25) implies that the ratio of $\frac{\zeta^*}{\zeta}$ determines the relative markup of selling abroad and at home. Crucini and Yilmazkuday (2014) estimate that the long run average price differences across borders is about 10 percent after controlling for relative wages, distances, city dummy variables, etc. Since cross-border cost differences have already been accounted for in their estimation exercise, we can view the price difference as a markup difference between selling at home and abroad. Using the 10 percent result, we can back out the parameter $\zeta^*$, to equal 2.16.

As discussed in the Introduction, we target middlemen related variables and parameters to the wholesale sector of the economy while the marketing parameters are tied down using sales and marketing occupation data. Our target ratios in steady state are: valued-added in wholesale sector to GDP of 5.9%, and marketing expenditure to GDP of 3.7%. For the marketing expenditure to GDP ratio, we identify marketing/sales occupations from the Occupational Employment Statistics survey.[18] Then, we divide the wage bill of all these occupations by the wage bill of all occupations in the economy from 1999 to 2015.[19] Under the model assumption of constant returns to scale, the wage bill is proportional to output. As a result the ratio of the wage bill on marketing to the total wage bill should be similar to the share of marketing and sales output in GDP. For the wholesale value-added to GDP target which was obtained from the Bureau of Economic Analysis, we used data series in real terms between 1997 and 2015. In order to get a longer time-series, we also use

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[18]These occupations are (i) Advertising and promotions managers, (ii) Marketing managers, (iii) Sales managers, (iv) Parts salespersons,(v) Advertising sales agents, (vi)Insurance sales agents, (vii)Sales representatives, wholesale and manufacturing, technical and scientific products, (viii) Sales representatives, wholesale and manufacturing, except technical and scientific products.

[19]In 1999, the Bureau of Labor Statistics changed the definition of occupations. Therefore, we cannot utilize the whole dataset.

the nominal data series which is available from 1947 to 2015, and obtain only a slightly higher ratio of 6.1%. As a result we stay with the previous value. In addition to these aforementioned targets, we also use a producer markup of 10 percent which is quite commonplace in the literature and is based on Basu and Fernald (1997)).

To target these values, we set the relationship capital depreciation rate, $\delta_H$, to 0.12; the steady state financial enforcement parameter, $\psi_f$, to 0.108; and the bargaining power parameter between a middleman and a producer, $\theta$, to 0.4. Drozd and Nosal (2012) use a baseline value of .5 but find that the effect of bargaining power is mainly on pass-through. Since price movement plays only a small role in our work, this has a limited impact on our variables of interest. See section 3.3 for a confirmation. Since $\chi$ only appears as a ratio with $\psi_f$ in equation (12), we set it to unity. The values of the other above-mentioned parameters are: the home bias parameter, $\omega$, set equal to 0.537; the preference parameter on leisure, $\psi$, set to 0.34; the capital depreciation rate, $\delta_k$, set equal to 0.035; and the parameter $\alpha$ in the production function, set to 0.314.

The adjustment cost parameter, $\phi$, in the relationship capital accumulation equation is chosen to match the empirical value of the relative standard deviation of investment to the standard deviation of GDP which is equal to 2.66 in hp-filtered US data from 1947 to 2015. Since this is a long-run moment commonly targeted in studies without credit shocks, we use only the TFP shock processes for both countries to match the data. We proceed in a manner similar to Drozd and Nosal (2012): we pick the moments of the productivity process so that the model generates a correlation of 0.3 between the solow residual of the home and foreign country. The targeted volatility of the solow residual is 0.79%, and it displays a first order auto-correlation of 0.91. Since our model has several differences from Drozd and Nosal (2012), our parameter values needed to target the same data values are different. For example, the standard deviation of the TFP process in their work is 0.0083 while it is 0.0045 in ours while the autocorrelation coefficient is 0.79 versus 0.87 in our work.[20]

In order to uncover the parameters of the shock process on the financial enforcement parameter, we rearrange equation (12), recognizing that the total credit taken by the middleman is equal to the

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[20]The usual business cycle moment table associated with this exercise can be found in Table A2 in the Appendix along with a comparison to the data and related model moments.

cost incurred. Moreover, since the value added by the wholesale sector (which is our proxy for the middleman) comes about from the margin made by buying and selling goods, we can rewrite (12) as $\phi_f = \frac{Credit}{\text{Value added of the Wholesale Sector}}$. To construct this series for $\phi_f$, we need a measure of the amount of credit used by the wholesale sector but this is unavailable so we proxy it with the issuance of non-financial commercial paper and divide by the value added of wholesale trade sector from 2005 to 2015. Then, we regress the detrended $\phi_f$ series on its lag. This yields a value of $\rho_f$ equal to 0.833 and a standard deviation of .088. Later we study the impact of varying this parameter.[21]

## 3.2    Trade, Marketing and the Impact of Credit Shocks

In this section, we ask if our model has the ability to quantitatively explain the large fall in the trade-GDP ratio in response to a financial shock. Since we do not have data on the amount of short term credit used by the wholesale sector, we cannot directly measure the size of the credit shock. Instead, we hit the model with a credit shock so that we can match the observed fall in employment in the wholesale sector. As shown in Figure 2, employment falls 3.62 percent below steady state (note that data is annual). To generate this fall in wholesale sector employment, we need a shock that reduces credit to $7.9\%$ below steady state values. This is a pretty conservative shock relative to the data. By comparison, non financial commercial paper fell 37% below steady state levels. Given the global nature of the financial crisis, we hit both countries with identical shocks.

In response to the credit shock, the model generates a sizeable trade collapse and a fall in GDP so that the trade to GDP ratio falls 4.5% below steady state levels (see the impulse response plots in Figure 4). Before discussing in detail the mechanism by which the model generates the trade collapse, we briefly mention an alternative quantitative exercise where we ask how big must the fall in credit be in order to account for the entire fall in the trade-GDP ratio of 10%. This required credit to fall by 17.63% which is also substantially less than the actual fall in commercial paper.

In order to understand how the credit shock causes a trade collapse, we discuss the impulse

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[21]Alternatively, we use the commercial and industrial loan as another proxy for credit, with a resulting value of $\rho_f$ equal to 0.89 in the sensitivity sub-section 3.3.3 below.
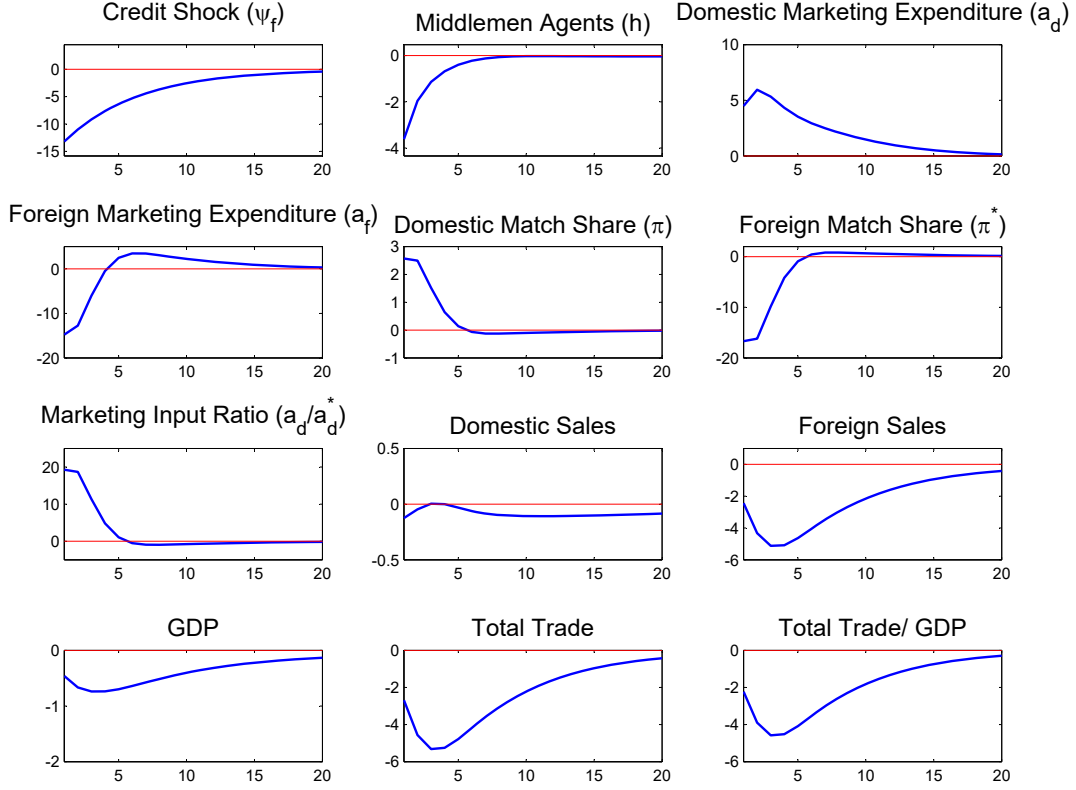
Figure 4: Impulse Responses to a Credit Shock

*Note*: All graph are in percent deviation from steady state.

response plots in turn. Our credit shock implies a tightening of the enforceability constraint through a reduction in $\psi_{ft}$ in equation (12). Since the middleman must use this credit to pay for expenses in advance, the tighter constraint implies that the total number of agents sent into the matching market must be reduced in order to cut expenses in keeping with the fall in credit availability. The credit shock and the fall in agents, $h_t$, can be seen in the first two panels of the top row of Figure 4. The fall in agents equals the observed fall in wholesale employment as discussed above. The fall in middleman agents in the matching market has implications for the producers. Recall that producers must incur marketing expenses in both countries in order to add new relationships to their existing set of relationships, $H_t$. As shown in equation (8) acquiring new relationships requires inputs from both sides of the matching market. The fraction of marketing resources spent on the domestic market by the home country producer, relative to the resources spent by the foreign

country producer determine the share of middleman agents that the home producer will match with. A similar calculus applies to the matches formed in the foreign country. On impact of the credit shock, in the face of a decline in agents, producers realize that they will add fewer new relationships to their lists, $H_t, H_t^*$, which will fall below their steady state levels if the amount of marketing expenditure remains unchanged. In fact, producers will find it optimal to reallocate marketing expenses between the two markets - reducing the amount spent on marketing in the foreign country while increasing the marketing in the home country. This can be seen in the third and fourth panel of Figure 4 as a rise in $a_d$ and a fall in $a_f$. The rise in marketing expenditure in the home country increases the share of matches made by the domestic producer in the home market while the fall in $a_f$ correspondingly reduces the share in the foreign market. This reallocation, therefore attenuates the fall in domestic relationship capital while exacerbating the fall in foreign country relationship capital caused by the fall in agents in the matching market. These changes in relationship capital translate into changes in the amount produced for domestic and foreign markets via the constraints shown in equation (10). As can be seen in the third row of Figure 4, by reallocating marketing expenses, the domestic producer manages to almost entirely protect his domestic market sales which drop less than 1% while accepting an almost 5% fall in sales in the foreign market. The reallocation of marketing expenses is driven by a desire to save resources in the more costly foreign market in order to spend it in the domestic market – in effect, it is cheaper to steal matches in the domestic market.

The importance of asymmetries in the cost of foreign marketing can be seen in Figure 7 where we remove the cost difference. Here, the producer responds to a fall in agents, $h$, by increasing marketing expenses in both countries by the same amount, leading to an equal but small reduction in domestic and foreign sales. As a result, trade falls by the same order of magnitude as GDP resulting in a very small fall in the trade-GDP ratio. Return to the present asymmetric cost case, the large fall in foreign marketing expenses causes an overall reduction in the marketing costs of the producer for one period but beyond that, the producer overall spends more resources on marketing to combat the persistent fall in agents in the matching markets of both countries. While the

marketing expenses in the domestic market stay above steady state levels throughout, the foreign marketing expenses initially fall and then slowly rise back to steady state levels and then above.

To understand the overall result, by combining the relationship accumulation equation (8) and the sales constraint (10), we have[22]

$$d_t = (1 - \delta_h)d_{t-1} + \pi_d h_t. \tag{26}$$

The amount of goods sold this period is a function of the amount of goods sold last period, market share, $\pi_d$, and number of matching agents, $h$. The producer mitigates the impact of the fall in agents, $h$ on domestic sales by engineering an increase in market share, $\pi_d$. So, the total sales of domestic goods barely falls. While there are some movements in prices in the economy in response to the credit shock, these are all less than one percent deviations from steady state values and play a very small role in the general equilibrium dynamics of the model. As a result, we do not discuss prices here but impulse responses are shown in the appendix.

Since both countries are hit with symmetric credit shocks, producers in both countries sell less in the other country's market so that both imports and exports decline a lot. This can be seen in Figure 4 as a roughly 6% fall in total trade. The large decline in both imports and exports coupled with a small decline in sales in the domestic market lead to a big fall in trade relative to GDP in the model. At this point, it is worth commenting on the mechanism in operation in the model which involves supply chain relationships in an economy's distribution networks. Essentially, the distribution network cutbacks force the ultimate user of goods to buy more domestic goods and fewer foreign goods. At first pass, one might think that these distribution networks change only very slowly, but this is not true in major recessions where a wholesale company engaged in buying and selling goods goes out of business, closes a regional office or downsizes salesmen who travel to different markets looking for firms with new products. While the ultimate buyer may still be aware of the existence of the products they used to buy, these products may no longer be distributed

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[22]Since it is costly to accumulate extra relationships, a firm would never over-invest in $a_d$ or $a_d^*$. As a result, in equilibrium, $H_t = d_t$. We check for this binding condition in our simulations.

in a market so a switch to a different product takes place. Similarly producers may decide not to operate sales offices in certain countries and concentrate marketing efforts where profit margins are higher. Once again, certain products may disappear from some markets but not from others.
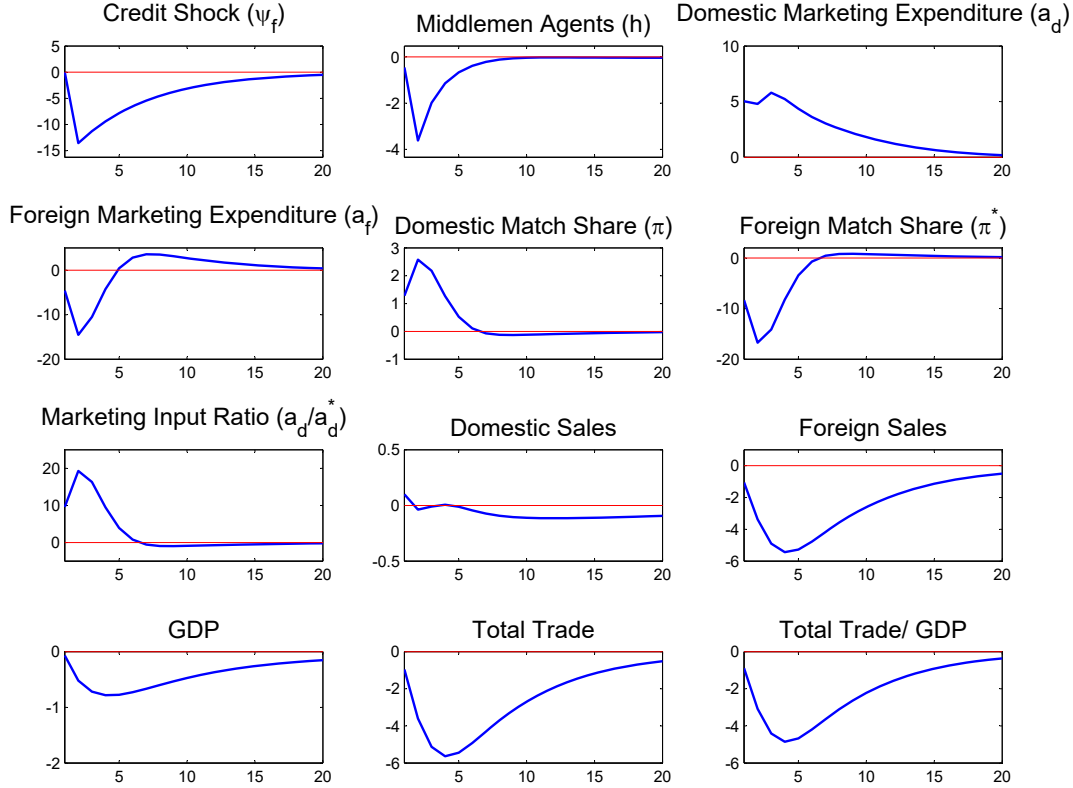
### 3.2.1 News About Credit Shocks



Figure 5: Impulse Responses to a Credit News Shock

*Note*: All graph are in percent deviation from steady state.

As discussed earlier, trade begins to fall one quarter before our measures of credit in US data. In this section, we study the model response to a one period ahead news shock to the enforceability constraint of the middleman. Since the responses will be the same as in the previous section after the shock is realized in period 2, here we only discuss the response of the model on arrival of the news in period 1 (see Figure 5). Not surprisingly, the peak response of the credit shock moves from period 1 to 2 as far as credit use by the middleman is concerned. Most of the fall in middleman

agents occurs in period 2 as well, though there is a small fall on impact of the news. Producers respond immediately to the news that credit will be tighter for the middleman next period. Anticipating the large fall in agents next period, they immediately begin the reallocation of marketing resources towards the domestic market. In order to understand why producers respond immediately to an anticipated future fall in agents, we focus on the relationship capital accumulation equation (8) where we have substituted in the sales constraint as before and recursively substituted backwards by one period to obtain

$$d_2 = (1 - \delta_h)^2 d_0 + (1 - \delta_h)\pi_{d1}h_1 + \pi_{d2}h_2. \tag{27}$$

Consider now a situation where producers receive news in period 1 that $h$ will fall in period 2. Given $h$ in period 1, producers can try to protect their sales in period 2 by increasing market share $\pi_d$ in period 1 which is in fact what occurs in the impulse responses shown in Figure 5. An increase in market share requires producers to spend more on marketing, $a_d$, which rises about 5% above steady state levels on arrival of the news which in turn causes a 1% rise in domestic market share of the home producer. This translates into a small increase in domestic sales. This rise in marketing expenses is driven by an increase in the shadow value of relationship capital which rises about 4% above steady state (see Figure A3 in the Appendix). As before, the presence of higher marketing costs in the foreign market lead to a reallocation effect where the producer lowers the amount spent on marketing in the foreign country to about 5% below steady state levels. The loss of market share in the foreign country causes an immediate 1% decline in sales to that market. The fall in foreign sales combined with a small increase in domestic sales translates into a bigger fall in trade relative to GDP so that the trade-GDP ratio falls in period 1 by 1%. Once the credit shock actually hits in period 2, this initial decline is amplified resulting in a pattern similar to the data where the decline in credit occurs after the decline in trade begins.

To show that the effects of news on producer actions are driven by the enduring nature of relationship capital (and to understand the influence of adjustment costs and $\delta_h$ on our results), we
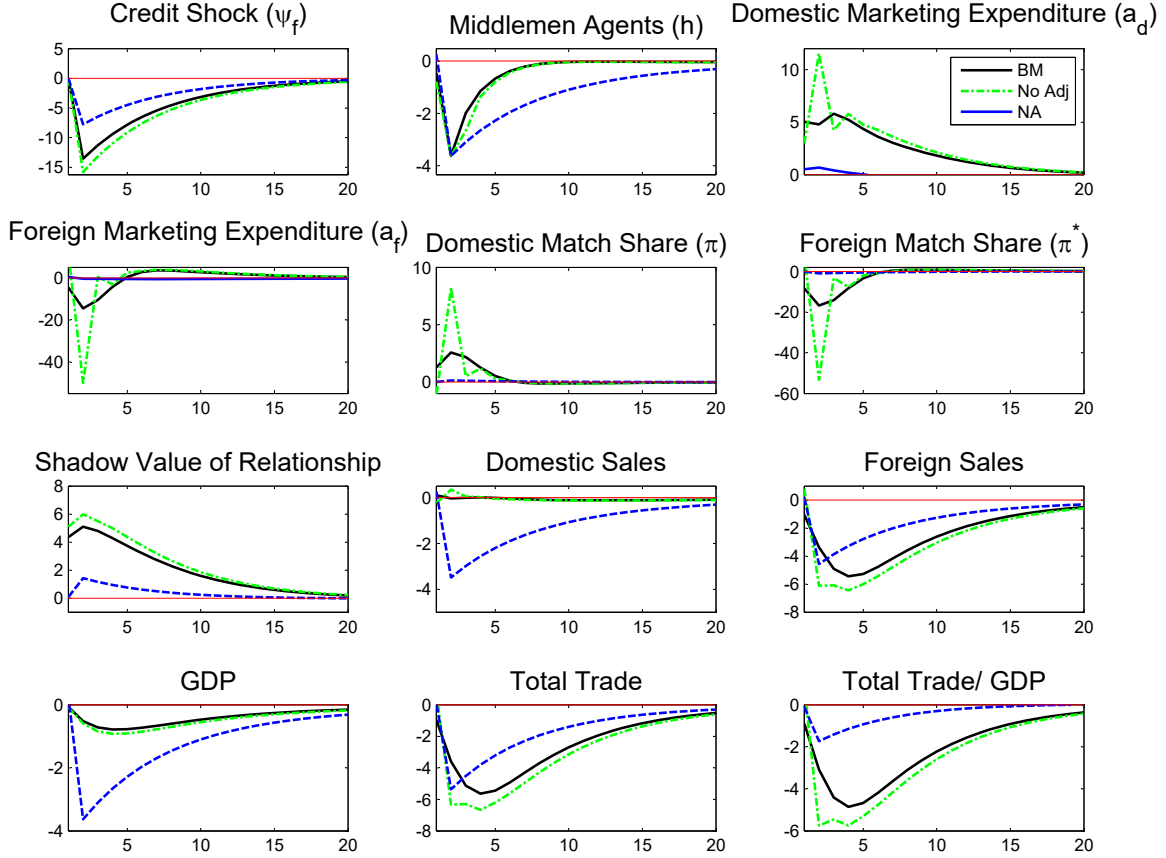
Figure 6: Impulse Responses to a Credit News Shock: Two Specifications Without Adjustment Costs

*Note*: All graph are in percent deviation from steady state. BM: Benchmark; No Adj: No adjustment cost, benchmark $\delta_h$; NA: No adjustment cost, $\delta_h = 1$

consider two additional special cases of the model. In the first case, we turn off the adjustment costs and set the depreciation rate of relationships capital, $\delta_h = 1$. Now, on impact of news, the (the dashed blue line) impulse responses in Figure 6 indicate that there is almost no rise in the value of relationship capital (about 0.1% vs. 4% ) and in turn, no increase in market share (about one hundredth of one percent). Since market share does not move, $d$ also does not move significantly from steady state levels in period 1 (nor does $f$) as can be seen from the equation above. The combined equations after imposing the sales constraint in our simpler model without adjustment costs and $\delta_h = 1$, as before, we have:

$$d_t = \frac{a_{d,t}}{\bar{a}} h_t. \tag{28}$$

Sales of domestic goods at home is now only a function of current marketing inputs and the number of agents of the middleman. Since firms have no accumulated relationships available to sell their products, they must expend marketing resources each period in order to sell any product. This implies that the reallocation effect in response to a fall in agents is muted as can be seen in the impulse response graphs where the rise in domestic marketing and the fall in foreign marketing are less than 1% from steady state levels. Once again, the lack of movement in market share implies that the path of $h$ dominates the behavior of $d$ and $f$ which both fall (3% and 4%) below steady state levels. As expected, trade falls only a little more than GDP leading to a small drop in the trade-GDP ratio of less than 2% as compared to 4.5% in the baseline case. The transitional dynamics of trade and GDP follow the path of credit back to steady state with no visible hump in the dynamics. Clearly the accumulation of relationships plays an important role in propagation of the credit shock through the economy and especially for the dynamics of the trade-GDP ratio.

In the next case (dot-dashed green line), we revert to the baseline depreciation rate of relationship capital but we leave adjustment costs turned off. Now the producer is free to adjust marketing expenses in both countries without the penalty imposed for large movements in the period that news arrives. Anticipating the future fall in agents, $h$, in both markets, producers immediately increase spending on marketing in both countries.[23] The key impact of adjustment costs can be seen in the behavior of marketing in the foreign country where the initial rise in period 1 is followed by a sharp fall in period 2. Since these large changes are penalized in the presence of adjustment costs in the baseline model, there the producer prefers to slowly lower marketing expenses in period 1 followed by a further fall in period two when the credit actually tightens.

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[23]The key element driving the rise in the shadow value of relationship capital is the depreciation rate and not the presence of adjustment costs as can be confirmed by allowing adjustment costs with depreciation set to unity.

## 3.3 Special Cases, Extensions and Robustness Checks

In the next few subsections, we discuss various versions of our model in order to understand the contributions of key economic mechanisms. We begin with removing the marketing cost differential, then we remove the ability of producers to change market share thus bringing out their importance in generating a large trade collapse. Then, we discuss the sensitivity of the results to some key parameters and finally present responses to TFP shocks.

### 3.3.1 No Marketing Cost Differential

One important element that drives the trade collapse in our model is that the marketing expense ratio, $a_d/a_d^*$, rises in response to the drop in agents sent out by the middleman. This rise is the result of the marketing cost differential, $\zeta^* > \zeta$. To show the impact of removing this cost differential, we produce impulse responses to the news shock case when $\frac{\zeta^*}{\zeta} = 1$, in Figure 7. The shock to the enforcement constraint causes the middleman to lower the number of agents and in response the producer increases marketing expense in both countries in order to protect market share, however, since marketing expenditure is increased symmetrically in all countries, the marketing expense ratio does not change. As a result, the matching market share remains unchanged so the fall in $h$ causes a symmetric fall in $d$ and in $f$. As a result, the quantity of trade falls only slightly more than GDP, leading to a very small drop in the trade-GDP ratio as can be seen in Figure 7.[24]

### 3.3.2 Static Market Share

In our earlier discussions of the impulse responses, we have highlighted the role played by the desire of the producer to control market share in driving the dynamics of the trade collapse. In order to understand the importance of this choice, we study the case where a firm's marketing expense is predetermined and static. This implies that the accumulation of new relationship capital is driven only by the number of agents of the middleman. Specifically, we replace $\pi_d$ and $\pi_d^*$ in equation (8) and (9) with constants that give the steady state trade-GDP ratio of 26 percent in both

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[24]The small drop in the trade-GDP ratio is coming from the small fall in the prices.
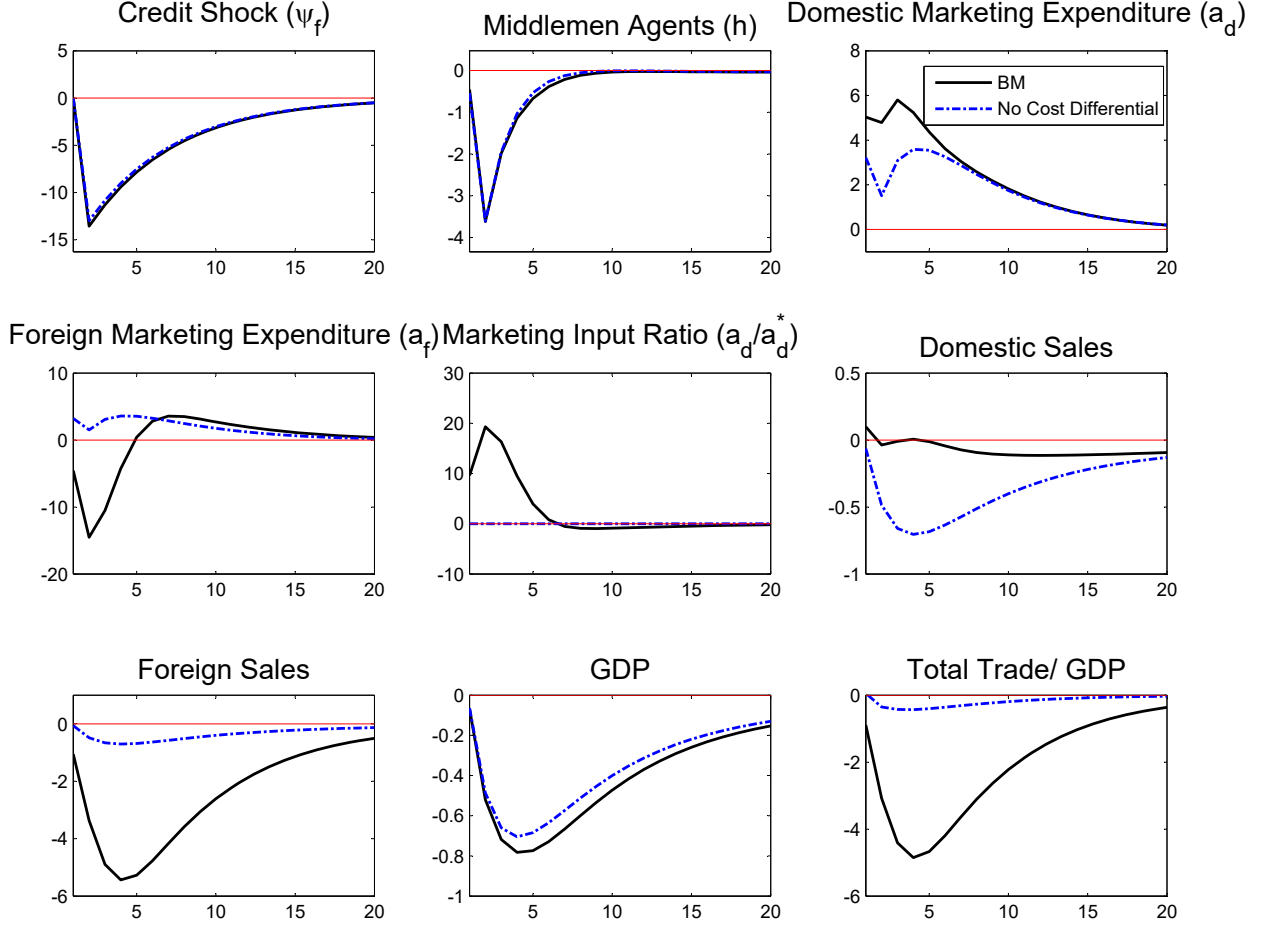
Figure 7: Impulse Responses to a News Shock: No Marketing Cost Differential

*Note*: All graph are in percent deviation from steady state.

the home and foreign market. Replacing $H_t$, the list of relationships with the quantity of goods sold, $d_t$, the relationship capital accumulation equation can be written as:

$$d_t = (1 - \delta_H)d_{t-1} + \bar{\pi}_H h_t, \tag{29}$$

where $\bar{\pi}_H$ is a static market share. We parameterize this model using the same steady state targets as the benchmark model with the natural exception of the target for marketing expenditure which is removed since the marketing input variables are constant terms here. As shown in Figure 8, when the model is hit with tighter credit conditions as before, the fall in the trade-GDP ratio is
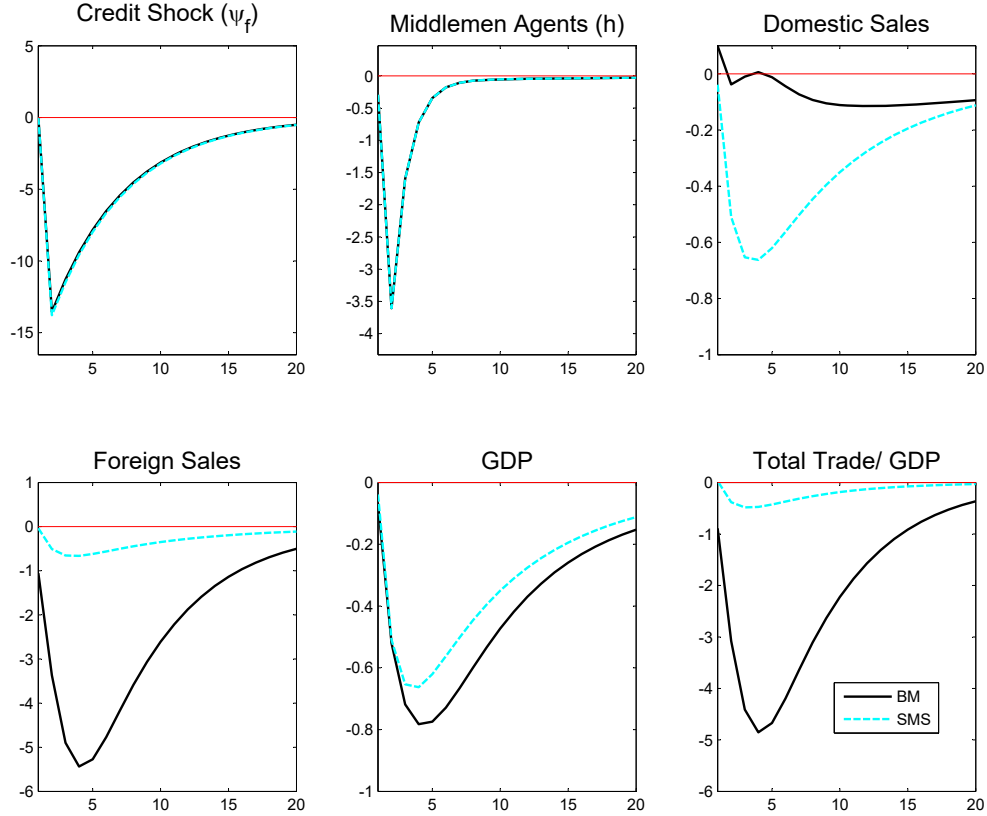
Figure 8: Impulse Responses to a News Shock: Specifications with Static Market Share (SMS)

*Notes*: BM: Benchmark; SMS: Static market share. Parameters are calibrated to steady state targets for each cases. Shocks are adjusted to match a fall in wholesale labor of 3.62%. All graph are in percent deviation from steady state.

much smaller than our benchmark model despite a similar fall in the number of agents looking for matches with producers. The initial story remains the same in response to the financial shock: the middleman lowers $h$ and given the static market shares, slows down new relationship acquisition and, this implies lower sales. Since no reallocation of marketing expenses is possible, both foreign and domestic production is equally hit. As a result the fall in trade is much closer in magnitude to the fall in GDP in contrast to the data.

### 3.3.3 Sensitivity to Key Parameters

To test the robustness of our mechanism, we look into the sensitivity of key parameters in generating the trade collapse holding all other parameters constant. Figure 9 plots the impulse response
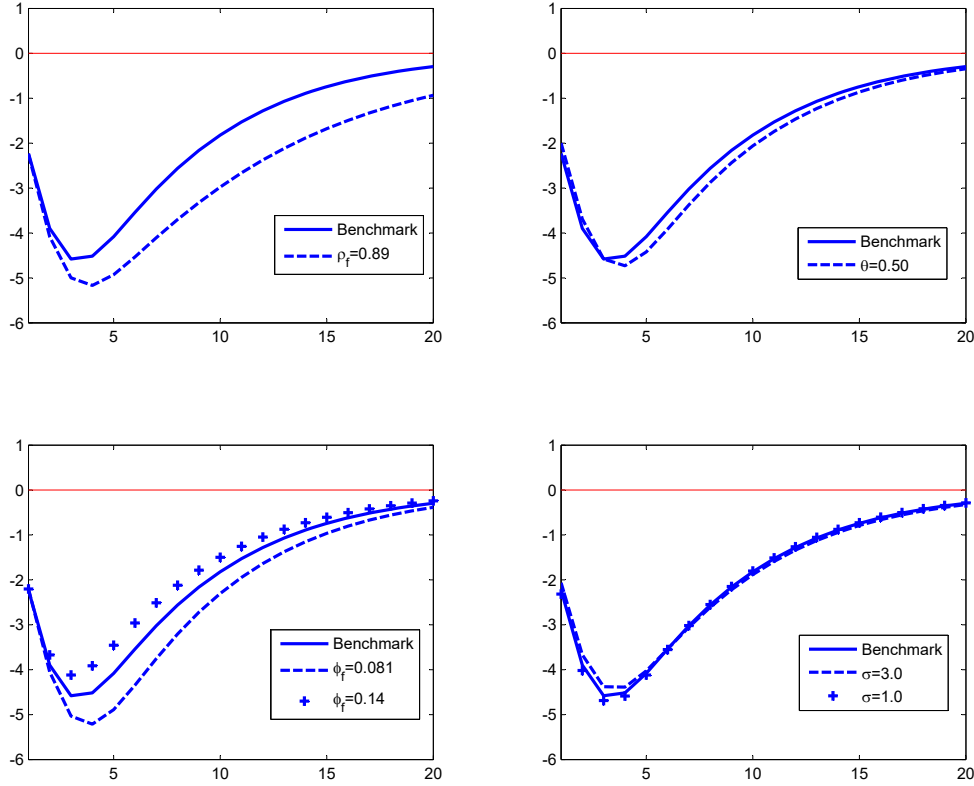
Figure 9: Trade/GDP Responses: Sensitivity to Parameter Changes

*Note*: All graph are in percent deviation from steady state.

of trade-GDP ratio for each sensitivity test on the following four parameters: $\theta, \Psi_f, \sigma$, and $\rho_f$. The sensitivity tests involve increasing $\theta = 0.5$ which implies equal bargaining power, considering values of $\Psi_f$ that are 25% above and below our benchmark calibrated value, increasing $\sigma = 3$ and decreasing $\sigma = 1$ from the benchmark value of 2 and increasing the persistence of the shock process to .89 which is the estimated value using commercial and industrial loans instead of non-financial commercial paper as in our benchmark calibration. The responses are largely insensitive to the change in parameters except for $\rho_f$. Increasing the persistence of the credit shock leads to a bigger and longer trade collapse as one would expect.

### 3.3.4 TFP Shock

Our model contains one other stochastic processes, a shock to producer's total factor productivity $z_t$. The impulse responses are in Figure 10 (see also Figure A4, A5 and A6 in the appendix). We will discuss them here with the main goal being to point out that this shock cannot easily explain the fall in the trade-GDP ratio.
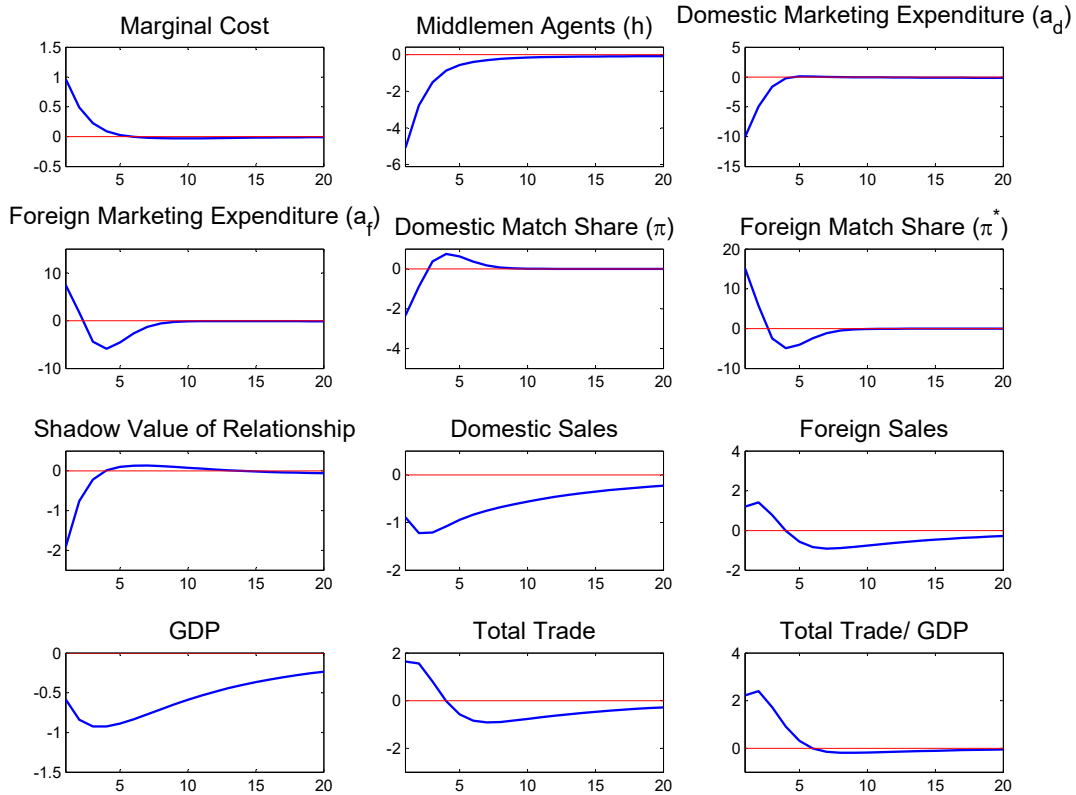


Figure 10: Impulse Responses to a TFP Shock

*Note*: Impulse response to a 1% TFP shock. All graph are in percent deviation from steady state.

The main impact of a 1% fall in TFP in both countries is to cause marginal costs to rise in the economy. This has an impact on all firms: producers produce less output and spend less on marketing while middlemen send fewer agents into the matching market. This can be seen in Figure 10 which shows that marginal costs rise roughly 1% above steady state levels and then slowly return to steady state over the next two years. In response producers cut marketing expenses by about 7% symmetrically in both countries (note this is the no cost differential case – see Figure A5) and

immediately reduce production by 0.5% for both markets. Similarly the middleman reduces agents by 5%. As relationship capital declines, the fall in production increases to a trough of roughly 1%. Since GDP falls slightly more than total trade the trade-GDP ratio rises ever so slightly. The presence of a cost differential makes the case for TFP shocks worse since trade rises while GDP falls leading to an overall rise in the trade-GDP ratio. The rise in trade is driven by an increase in sales in the foreign market while the fall in GDP is driven by a decrease in sales in the home market. Ignoring adjustment costs for a minute and replacing the sales constraints into the relationship capital accumulation equations in both markets, we notice that since the number of middleman agents fall in both markets, the differential response of sales must come from differences in the behavior of $\pi_d$ and $\pi_d^*$ which, in turn, depends on differences in the behavior of marketing expenditure by the producer in the home and foreign country. This is confirmed in Figure 10 where we see that $a_d$ falls while $a_d^*$ rises on impact. The desire to reduce marketing expenses can be seen in the fall in the shadow value of relationships in both markets. This desire is temporarily overturned by the opportunity created by the cut in home marketing which increases the ability of producers to gain market share in the foreign market for one period before reverting to below steady state marketing levels in both countries. The extra relationships created by this temporary burst in marketing leads to increased foreign sales for three periods due to the persistence of relationships. The net result is a rise in the trade-GDP ratio during a recession. The presence of adjustment costs lengthen out and mitigate the burst of foreign marketing so that trade rises while GDP falls for several periods longer than in the absence of adjustment costs.

# 4   Conclusion

What explains the unusual collapse in trade during the Great Recession? The behaviour of trade during this recession was unusual not only in its severity relative to past episodes but is also puzzling relative to the predictions of international business cycle models where it is hard to generate movements in trade that are significantly larger than in GDP. We contribute to the existing litera-

ture by using a real two-country business cycle model with relationship capital and credit shocks to generate a size-able collapse in trade that explains roughly 44 percent of the fall in the trade-GDP ratio seen in the data. Key features of the model that contribute to trade moving more than GDP are a cost differential between marketing expenses to acquire supply-chain relationships in the home market relative to abroad and the presence of long-term enduring relationships. The basic mechanism driving the drop in economic activity is as follows: tighter credit constraints create a drop in demand for the product of firms which respond by switching scarce marketing resources from the foreign country to the home country. As a result, cross-border trade drops more than domestic trade, leading to a large movement in the trade-GDP ratio.

# References

Ahn, J., Khandelwal, A. K., Wei, S.-J., 2011. The Role of Intermediaries in Facilitating Trade. Journal of International Economics 84 (1), 73–85.

Alessandria, G., Kaboski, J. P., Midrigan, V., 2010a. Inventories, Lumpy Trade, and Large Devaluations. American Economic Review 100 (5), 2304–39.

Alessandria, G., Kaboski, J. P., Midrigan, V., December 2010b. The Great Trade Collapse of 2008–09: An Inventory Adjustment . IMF Economic Review 58 (2), 254–294.

Amiti, M., Weinstein, D. E., 2011. Exports and Financial Shocks. Quarterly Journal of Economics 126 (4), 1841–1877.

Antràs, P., Costinot, A., 2011. Intermediated Trade. Quarterly Journal of Economics 126 (3), 1319–1374.

Arkolakis, C., 2010. Market Penetration Costs and the New Consumers Margin in International Trade. Journal of Political Economy 118 (6), 1151 – 1199.

Backus, D. K., Kehoe, P. J., Kydland, F. E., 1992. International Real Business Cycles. Journal of Political Economy 100 (4), 745–75.

Bai, X., Krishna, K., Ma, H., 2017. How You Export Matters: Export Mode, Learning and Productivity in China. Journal of International Economics 104, 122–137.

Basu, S., Fernald, J. G., 1997. Returns to Scale in US Production: Estimates and Implications. Journal of Political Economy 105 (2), 249–283.

Beaudry, P., Dupaigne, M., Portier, F., 2011. Modeling News-driven International Business Cycles. Review of Economic Dynamics 14 (1), 72–91.

Beaudry, P., Portier, F., 2014. News-driven Business Cycles: Insights and Challenges. Journal of Economic Literature 52 (4), 993–1074.

Chor, D., Manova, K., 2012. Off the Cliff and Back? Credit Conditions and International Trade during the Global Financial Crisis. Journal of International Economics 87 (1), 117 – 133.

Crucini, M. J., Yilmazkuday, H., 2014. Understanding Long-Run Price Dispersion. Journal of Monetary Economics 66, 226 – 240.

Devereux, M. B., Yetman, J., 2010. Leverage Constraints and the International Transmission of Shocks. Journal of Money, Credit and Banking 42 (s1), 71–105.

Drozd, L. A., Kolbin, S., Nosal, J. B., 2014. Long-Run Price Elasticity of Trade and the Trade-Comovement Puzzle. Unpublished manuscript.

Drozd, L. A., Nosal, J. B., 2012. Understanding International Prices: Customers as Capital. American Economic Review 102 (1), 364–395.

Durdu, C. B., Nunes, R., Sapriza, H., 2013. News and Sovereign Default Risk in Small Open Economies. Journal of International Economics 91 (1), 1–17.

Eaton, J., Eslava, M., Jinkins, D., Krizan, C., Tybout, J., 2014. A Search and Learning Model of Export Dynamics. Unpublished Manuscript.

Gilchrist, S., Zakrajšek, E., 2012. Credit Spreads and Business Cycle Fluctuations. American Economic Review 102 (4), 1692–1720.

Gortz, C., Tsoukalas, J. D., Forthcoming. News and Financial Intermediation in Aggregate Fluctuations. Review of Economics and Statistics.

Gourio, F., Rudanko, L., 2014. Customer Capital. Review of Economic Studies 81 (3).

Gunn, C. M., Johri, A., 2013. An Expectations-driven Interpretation of the "Great Recession". Journal of Monetary Economics 60 (4), 391–407.

Gunn, C. M., Johri, A., 2015. Financial News, Banks, and Business Cycles. Macroeconomic Dynamics, 1–26.

Head, K., Ries, J., 2001. Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade. American Economic Review 91 (4), 858–876.

Jaimovich, N., Rebelo, S., 2008. News and Business Cycles in Open Economies. Journal of Money, Credit and Banking 40 (8), 1699–1711.

Jermann, U., Quadrini, V., 2012. Macroeconomic Effects of Financial Shocks. American Economic Review 102 (1), 238–271.

Johri, A., Lahiri, A., December 2008. Persistent Real Exchange Rates. Journal of International Economics 76 (2), 223–236.

Johri, A., Leach, J., May 2002. Middlemen and the Allocation of Heterogeneous Goods. International Economic Review 43 (2), 347–362.

Kalemli-Ozcan, S., Papaioannou, E., Perri, F., 2013. Global Banks and Crisis Transmission. Journal of International Economics 89 (2), 495–510.

Kamber, G., Theodoridis, K., Thoenissen, C., March 2017. News-driven Business Cycles in Small Open Economies. Journal of International Economics 105, 77 – 89.

Kollmann, R., 2013. Global Banks, Financial Shocks, and International Business Cycles: Evidence from an Estimated Model. Journal of Money, Credit and Banking 45 (s2), 159–195.

Kollmann, R., Enders, Z., Müller, G. J., 2011. Global Banking and International Business Cycles. European Economic Review 55 (3), 407 – 426.

Levchenko, A. A., Lewis, L. T., Tesar, L. L., 2010. The Collapse of International Trade during the 2008–09 Crisis: In Search of the Smoking Gun. IMF Economic Review 58 (2), 214–253.

Novy, D., Taylor, A. M., 2014. Trade and Uncertainty. Working Paper 19941, National Bureau of Economic Research.

Schmitt-Grohé, S., Uribe, M., 2012. What's News in Business Cycles. Econometrica 80 (6), 2733–2764.

Shi, S., 2016. Customer Relationship and Sales. Journal of Economic Theory 166, 483–516.