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FLUCTUATIONS

George Alessandria  
Horag Choi  
Joseph P. Kaboski  
Virgiliu Midrigan

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Microeconomic Uncertainty, International Trade, and Aggregate Fluctuations  
George Alessandria, Horag Choi, Joseph P. Kaboski, and Virgiliu Midrigan  
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**ABSTRACT**

The extent and direction of causation between micro volatility and business cycles are debated. We examine, empirically and theoretically, the source and effects of fluctuations in the dispersion of producer-level sales and production over the business cycle. On the theoretical side, we study the effect of exogenous first- and second-moment shocks to producer-level productivity in a two-country DSGE model with heterogeneous producers and an endogenous dynamic export participation decision. First-moment shocks cause endogenous fluctuations in producer-level dispersion by reallocating production internationally, while second-moment shocks lead to increases in trade relative to GDP in recessions. Empirically, using detailed product-level data in the motor vehicle industry and industry-level data of U.S. manufacturers, we find evidence that international reallocation is indeed important for understanding cross-industry variation in cyclical patterns of measured dispersion.

George Alessandria  
Department of Economics  
University of Rochester  
Harkness 204  
Rochester, NY 14627  
and NBER  
george.alessandria@rochester.edu

Joseph P. Kaboski  
Department of Economics  
University of Notre Dame  
434 Flanner Hall  
Notre Dame, IN 46556  
and NBER  
jkaboski@nd.edu

Horag Choi  
Department of Economics  
Monash University  
900 Dandenong Road  
Caulfield East, VIC 3145  
Australia  
horag.choi@monash.edu

Virgiliu Midrigan  
Department of Economics  
New York University  
19 W. 4th St.  
New York, NY 10012  
and NBER  
virgiliu.midrigan@nyu.edu

# 1 Introduction

A growing literature attributes an important fraction of cyclical fluctuations in output to changes in the distribution of idiosyncratic shocks affecting heterogeneous producers. This literature shows in a range of closed economy models that more volatile producer-specific shocks can generate a downturn in economic activity. A primary example is the Great Recession, during which there was a substantial increase in dispersion of growth rates across establishments. Still, understanding the extent to which volatility leads to recessions, or recessions lead to volatility, remains an important task.<sup>1</sup> In this paper, we revisit the relationship between idiosyncratic volatility and business cycles empirically and theoretically. We do so in the context of an open economy model with non-convex trade participation decisions across heterogeneous producers. Trade models and data constitute a natural laboratory for examining the role of uncertainty, since the selection into exporting is well understood. Moreover, firms rely to different extents on international trade, so swings in international trade affect firms differentially. Additionally, international business cycles are not perfectly synchronized, so net exports fluctuate in response to country-specific shocks.

On the theoretical side, our analysis focuses on the effects of both first- and second-moment shocks in a variation of the two-country real business cycle model of Backus, Kehoe, and Kydland (1994) extended to include producer heterogeneity and realistic entry and exit from the export market as in Alessandria and Choi (2007).<sup>2</sup> This model captures the well-

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<sup>1</sup>Bloom (2009) and Bloom et al. (2013) argue that volatility leads to recessions. In Bachmann and Moscarini (2012), recessions lead to experimentation and thus to micro volatility. Bloom (2013) gives an excellent review of the literature. The work by Decker, D’Erasmus, and Moscoso Boedo (2014) is perhaps the most relevant to ours. They model endogenous countercyclical volatility through firm’s choice of the number of markets in which to sell. Their empirical measures of markets are industries and the number and locations of establishments, however.

<sup>2</sup>The Alessandria-Choi model is a general equilibrium variation of the partial equilibrium model of firm export participation in the presence of idiosyncratic and aggregate uncertainty and a sunk export cost developed in a series of papers by Baldwin, Krugman, and Dixit to explain the non-linear relationship between the real exchange rate and net exports in the 1980’s. Variations of this model have been shown to

known features that (1) not all producers export, (2) those that do are relatively large, and (3) exporting is quite persistent. We first consider the effect of first-moment shocks to the level of productivity on aggregate output and measured producer-level dispersion. Here we find that a home productivity shock (e.g., a recession in the U.S.) will generate an increase in the dispersion in sales growth across heterogeneous producers through two channels. First, there is a direct cost channel. The country-specific shock affects the relative costs of imported and domestic goods, leading to a reallocation of purchases between the two and thus an increase in the dispersion of consumer purchases. Second, there is a market participation channel as domestic producers differ in their export participation. A country-specific shock affects non-exporters differently from exporters, leading to a reallocation of production across these heterogeneous producers. Clearly, these channels depend critically on openness. We show that the model can generate potentially quantitatively important fluctuations in dispersion.

We use the open economy model to consider the effect of exogenous second-moment<sup>3</sup> shocks to producer-level productivity, as studied by Bloom et al. (2013) and Arellano, et al. (2012) in a closed economy. Contrary to this closed economy literature, we find that a shock increasing producer-level dispersion increases exports. Though the increase in exports is small, it is two orders of magnitude larger than the impact on output itself, as higher dispersion allows exporting firms to export more. Thus, the ratio of trade to GDP rises. Given that trade fell substantially more than output during the Great Recession, this constitutes a puzzle for the model.

We next evaluate the importance of first-moment shocks on measured producer-level

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capture the cross-section and dynamics of export participation of producers in many countries (see Das, Roberts, and Tybout (2007) and Alessandria and Choi (2011a)) as well as the dynamics of trade growth (Alessandria and Choi (2011b)).

<sup>3</sup>Novy and Taylor (2014) examine the role of shocks to aggregate uncertainty on trade flows in an sS inventory model with higher fixed costs of sourcing abroad than at home as in Alessandria, Kaboski, and Midrigan (2010). Bekes, Fontagne, Murakozy, and Vicard (2014) study how changes in idiosyncratic demand uncertainty affect the size and frequency of trade flows. Carballo, Handley and Limao (2014) consider the effect of uncertainty about trade policy on trade in the great trade collapse.

dispersion by examining the role of reallocation from international trade in explaining the increase in dispersion measured by Bloom et al. (2013). We focus narrowly on the cross-sectional measures of sales and expenditure growth rather than on other measures, such as the volatility of stock earnings (e.g., Herskovic, Kelly, Lustig, and Van Nieuwerburgh, 2014, and Bloom et al., 2013), which our model is less suited to address.<sup>4</sup>

At the aggregate level, we find that international reallocation is as strongly related to fluctuations in uncertainty as GDP growth is. Across a wide range of industries, international reallocation is an important source of fluctuations in industry-level dispersion over time. Industries with the largest increase in dispersion are more open both in the narrow period 2007 to 2009 and in periods of international reallocation more broadly.

Finally, we look within a particular industry, using automobiles as a case study. The automobile industry is an important industry that had a large and persistent decline in economic activity during the Great Recession. It is also extremely well measured, allowing us to look at product-level variation as well as at variation for firms both within and outside of the U.S. We find that an important share of the increased dispersion in sales and production from 2008 to 2011 can be attributed to reallocation between the Big 3 firms and Japanese firms. This reallocation is driven by identifiable shocks: a spike in oil prices that has a relatively stronger impact on the Big 3, the pre-bankruptcy crisis and post-bankruptcy recovery of the Big 3, and the Japanese tsunami which lowered Japanese sales. Indeed, we find that the Japanese tsunami, a clear country-specific supply shock, generates a rise in dispersion of sales and production growth that is nearly as large and persistent as the rise observed during the Great Recession.

The next section develops and calibrates the two-country model of heterogeneous producers with an endogenous export decision. In Section 3, we study how the model economy

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<sup>4</sup>Fillat and Garetto (2012) do show that excess stock returns are related to export and multinational production participation and that these differences in returns can be rationalized in a model of with sunk costs of export participation and multinational production.

responds to first- and second-moment shocks. Section 4 presents evidence on the relationship between industry volatility and trade reallocation both across industries and within automobiles, our case study. Section 5 concludes.

## 2 Model

We describe and calibrate a modified version of the model of Alessandria and Choi (2007), augmented to allow for idiosyncratic volatility with country specific time-varying dispersion. Specifically, there are two symmetric countries, home ( $H$ ) and foreign ( $F$ ), each with a unit mass of heterogeneous producers producing differentiated intermediate goods. Intermediate goods producers differ exogenously by the variety they produce and their productivity, and endogenously by their capital and exporter status. Exporting requires both an up-front cost to start exporting and a fixed continuation cost to stay in the market in subsequent periods. In each country, competitive firms produce final goods with a CES technology that combines composites of domestic and imported goods. The domestic composite good is an aggregate of the full range of domestic intermediates, while the composite imported good combines only intermediate goods from the subset of the other country's firms that export.

### 2.1 Intermediate Goods Producers

In each country, a unit mass of monopolistically competitive intermediate goods producers are indexed by  $i \in [0, 1]$ . Each producer produces output for the domestic market ( $y_H$  for home), and potentially an export market ( $y_H^*$  for Home), using a constant returns to scale, Cobb-Douglas technology. Producers vary in their productivity  $z$ :

$$(1) \quad y_H(i) + m'(i)y_H(i)^* = y(i) = e^{z(i)} e^A k(i)^\alpha l(i)^{1-\alpha}.$$

Here  $A$  indicates a (stochastic) aggregate productivity parameter,  $z(i)$  is a stochastic idiosyncratic productivity shock drawn from a process with a time varying country-specific standard deviation of  $\sigma_\varepsilon$ ,  $k(i)$  is the producer's capital stock, and  $l(i)$  is the labor used in production. We denote whether or not a firm is exporting using the indicator function  $m'(i)$ , which equals 1 if the firm decides to export in the current period and 0 otherwise.

In addition to this exporting decision, intermediate firms accumulate capital, hire labor, and set prices. Given inverse demand functions  $p(y_H)$  and  $p^*(y_H^*)$ , within-period profits  $\pi$  depend on productivity, accumulated capital, and the choice of export status:

$$\pi(z, k; m') = \max_l p(y_H)y_H + m'p^*(y_H^*)y_H^* - W_t l \quad \text{s.t.} \quad (1),$$

where  $W_t$  is the wage.

The export and capital investment decisions,  $m$  and  $x$ , are dynamic. Capital depreciates at a rate  $\delta$  and must be purchased in the prior period. Exporting status,  $m'$ , is chosen contemporaneously, but it entails a cost that depends on whether the firm exported in the previous period,  $m$ . Specifically, the cost,  $f(m)$ , in units of labor, depends on the firm's past export status,  $m$ , with  $f(0) \geq f(1) > 0$ . That is,  $f(0) - f(1)$  is an up-front (sunk) cost of entering the export market, while  $f(1)$  is a per-period fixed cost of exporting.<sup>5</sup>

The intermediate firms choose exports and investment to solve the following dynamic recursive problem:

$$\begin{aligned} V(z, m, k; \Omega) &= \max_{m', x} \pi(z, k; m') - W_t m' f(m) - Px \\ &\quad + EQ'V(z', m', x + (1 - \delta)k; \Omega'), \end{aligned}$$

where  $P$  is the price of the investment good and  $Q'$  denotes the stochastic discount factor.

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<sup>5</sup>Only the previous period's export status affects the fixed cost of exporting, so once a producer stops exporting it must pay  $f(0)$  to reenter the market.

Here  $\Omega$  denotes the aggregate state. We assume that  $E(z'|z)$  is weakly increasing in  $z$ . The law of motion for idiosyncratic productivity,  $z$ , is potentially subject to stochastic idiosyncratic volatility shocks. If the distribution of idiosyncratic productivity is sufficiently dispersed, the fixed costs of exporting imply that the optimal export decision follows a threshold rule: export if  $z \geq \bar{z}(m, k)$ , where  $\bar{z}(m, k)$  is decreasing in both  $m$  and  $k$ . The optimal law of motion for capital also depends on the exporting decision  $m'$  and satisfies

$$(2) \quad P = E [Q' [V'_{k'}(z', m', k'; \Omega')]].$$

## 2.2 Final Goods Producers

The demand that intermediate goods producers face comes from the producers of the final goods. There exists a single final good in each country that can be used for either consumption or investment. A representative competitive final goods producer in each country aggregates intermediate goods into final goods consumption according to an Armington aggregator with a nested constant elasticity of substitution aggregator. For the home final goods producer, the available varieties of intermediates include all domestic varieties but only the varieties of foreign intermediates of producers that choose to export.

Using home as an example, it is convenient to define the domestic (i.e., home) and imported (i.e., foreign) aggregates,  $Y_H$  and  $Y_F$ , separately as follows:

$$(3) \quad Y_H = \left( \sum_{m=\{0,1\}} \int_{z,k} y_H^d(z, m, k)^{\frac{\theta-1}{\theta}} \psi(z, m, k) dk dz \right)^{\frac{\theta}{\theta-1}},$$

and

$$(4) \quad Y_F = \left( \sum_{m=\{0,1\}} \int_{z,k} y_F^d(z, m, k)^{\frac{\theta-1}{\theta}} \psi^*(z, m, k) dk dz \right)^{\frac{\theta}{\theta-1}},$$

where  $\psi(z, m, k)$  and  $\psi^*(z, m, k)$  denote the measure of home and foreign intermediate goods firms, respectively. Note that while the imported goods aggregator is defined over all foreign varieties, demand for foreign varieties that are not exported is constrained to be zero.

These domestic and imported composites are then aggregated in Armington fashion to produce final consumption,  $C$ , and investment goods,  $x(z, m, k)$ :

$$(5) \quad C + \sum_{m=\{0,1\}} \int_{z,k} x(z, m, k) \psi(z, m, k) dk dz = D = \left( Y_H^{\frac{\gamma-1}{\gamma}} + \omega_t^{\frac{1}{\gamma}} Y_F^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}},$$

where  $\omega < 1$  produces a bias for domestically produced goods. To match the cyclicity of trade we allow for shocks to  $\omega_t$ ,  $\omega_t^*$  in each country. Stockman and Tesar (1995) and Levchenko, Lewis, and Tesar (2010) find these preference shocks to be important determinants of trade flows.<sup>6</sup>

Taking the price of final goods,  $P$ ; intermediate prices,  $p_H(z, m, k)$ ,  $p_H^*(z, m, k)$ ; and the measures of intermediate firms as given, the static profit maximization of final goods producers yields iso-elastic demand functions for intermediate producers of the form

$$y_H(z, m, k) = \left( \frac{p_H(z, m, k)}{P_H} \right)^{-\theta} \left( \frac{P_H}{P} \right)^{-\gamma} Y,$$

$$y_H^*(z, m, k) = \begin{cases} 0 & \text{if } m'(z, m, k) = 0 \\ \omega \left( \frac{p_H^*(z, m, k)}{P_H^*} \right)^{-\theta} \left( \frac{P_H^*}{P^*} \right)^{-\gamma} Y^* & \text{if } m'(z, m, k) = 1 \end{cases},$$

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<sup>6</sup>Alessandria, Kaboski, and Midrigan (2013) show that these “shocks” may actually primarily reflect the differential inventory investment decisions of importers, exporters, and domestic firms over the business cycles. For our purposes, we abstract from these endogenous fluctuations in the import preference parameters.

and the following equilibrium price formulas:

$$\begin{aligned}
P &= (P_H^{1-\gamma} + \omega P_F^{1-\gamma})^{\frac{1}{1-\gamma}}, \\
P_H &= \left( \sum_{m=\{0,1\}} \int_{z,k} p_H(z, m, k)^{1-\theta} \psi(z, m, k) dk dz \right)^{\frac{1}{1-\theta}}, \\
P_H^* &= \left( \sum_{m=\{0,1\}} \int_{z,k} m'(z, m, k) p_H^*(z, m, k)^{1-\theta} \psi(z, m, k) dk dz \right)^{\frac{1}{1-\theta}}.
\end{aligned}$$

Given iso-elastic demand, the intermediate goods producers charge a constant markup over marginal cost:

$$p_H(z, m, k) = p_H^*(z, m, k) = \frac{\theta}{\theta - 1} mc(z, m, k),$$

where the

$$mc(z, m, k) = \frac{Wl(z, m, k)}{(1 - \alpha) y(z, m, k)}.$$

### 2.3 Consumer's Problem

The representative consumer in both countries is infinitely lived. Given the symmetry, we develop the home consumer's problem, and the analogous problem for foreign is denoted with an asterisk. The home consumer chooses sequences of consumption,  $C_t$ , labor,  $L_t$ , and bond holdings,  $B_t$ , to maximize expected utility:

$$V_{C,0} = \max_{C_t, L_t, B_t} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t)$$

subject to the sequence of budget constraints,

$$C_t + Q_t B_t \leq \frac{W_t}{P_t} L_t + B_{t-1} + \frac{\Pi_t}{P_t},$$

where  $\Pi_t$  is the sum of profits (net of export costs and capital investment) of the home country's intermediate goods producers.

The bond  $B_t$  is noncontingent, paying one unit of the home country's composite final good in period  $t + 1$ , and its price in period  $t$  is  $Q_t$ . An analogous bond exists for foreign. The Euler equation is therefore

$$Q_t = \beta E_t \frac{U_{C,t+1}}{U_{C,t}} = \beta E_t \frac{U_{C^*,t+1}}{U_{C^*,t}} \frac{P_t^*}{P_{t+1}^*} \frac{P_{t+1}}{P_t},$$

where  $U_{c,t}$  is the marginal utility of consumption.

## 2.4 Equilibrium and Computation

The equilibrium definition largely follows that in Alessandria and Choi (2007). The distribution of producers by country over export status, capital, and productivity in each country is part of the state of the economy  $(\psi(z, m, k), \psi^*(z, m, k))$ .

In addition, bond holdings and the stochastic levels of TFP,  $A$  and  $A^*$ , are also included in the aggregate state:

$$\Omega = (B, A, A^*, \omega, \omega^*, \sigma_\varepsilon, \sigma_\varepsilon^*, \psi, \psi^*),$$

where  $(\sigma_\varepsilon, \sigma_\varepsilon^*)$  denote the standard deviation of the idiosyncratic productivity.

## 2.5 Calibration

To perform our quantitative analysis, we need to calibrate the utility function, technologies, and exogenous stochastic processes for aggregate and idiosyncratic productivity. Our calibration again closely follows that of Alessandria and Choi (2007), with the exception of the shock process to idiosyncratic productivity  $z$ , which here allows for stochastic idiosyncratic volatility.

We use a constant intertemporal elasticity of substitution utility function that is Cobb-Douglas in consumption and leisure. Normalizing the time endowment to one, we have

$$U(C, L) = \frac{(C^\eta (1 - L)^{1-\eta})^{1-\sigma}}{1 - \sigma}$$

We choose standard values for the preference parameters: the discount factor  $\beta = 0.96$  with a period equaling a year, consistent with an annual return to capital of 4 percent; logarithmic utility ( $\sigma = 1$ ); and the share of consumption in utility is chosen so that one-quarter of non-sleep time is spent working.

For the Cobb-Douglas intermediate goods production functions, we assign  $\alpha = 0.36$ , consistent with standard measures of capital's share in income. We assign  $\delta = 0.1$  as the annual depreciation rate of capital, which is consistent with a steady state capital output ratio of 2.5. In the final goods aggregator, we choose an Armington elasticity  $\gamma = 1.5$ , in the midrange of estimates of the elasticity between domestic and imported goods in the U.S. (Gallaway, McDaniel, and Rivera, 2003). The elasticity of substitution between varieties is set to 3, so  $\theta = 3$ , and implies a markup of 50 percent over marginal cost. This structure implies that goods from the same country are better substitutes than goods from different countries and is necessary to have some chance of generating reasonable

international business cycles.<sup>7</sup>

We assume that  $z$  is drawn from log normal distribution with log mean of zero and a standard deviation,  $\sigma_\varepsilon$ . For simplicity, we also assume that these shocks are iid over time.<sup>8</sup> Given this iid structure and the persistent export decision, the optimal capital stock (determined the period before) will vary simply by whether or not the firm exported in the previous period.

The standard deviation for idiosyncratic productivity,  $\sigma_\varepsilon$ , export costs,  $f(0)$ ,  $f(1)$ , and the home bias parameter,  $\omega$ , jointly determine trade flows, export participation, exporter entry and exit, the size of exporters relative to non-exporters, and volatility of producer growth. We target a trade to GDP ratio of 20 percent, 22 percent of U.S. producers exporting, and an annualized exit rate from exporting of about 5 percent. The standard deviation of idiosyncratic shocks affects both the volatility of producer growth and the exporter premium. With the iid shocks we consider, we cannot simultaneously match both features of the data. We target instead intermediate values for these moments: an employment volatility of 16.5 percent (higher than the 10 percent in U.S. Manufacturing, e.g. Davis, Haltiwanger, and Schuh 1998) and 2.5 exporter premium (lower than the 4.5 ratio in the U.S. Census of Manufacturers).

This calibration yields  $\sigma_\varepsilon = 0.075$ , and a ratio of startup export costs to continuation costs of 1.03, i.e.,  $f(0)/f(1) = 1.03$ . The ratio of entry costs to continuation costs in this calibration is relatively low compared to previous estimates in the literature in models with persistent idiosyncratic shocks (see Das, Roberts, and Tybout, 2007, or Alessandria and Choi, 2011a). The highly persistent decision to export arises primarily from capital being predetermined and the slight cost advantage of serving foreign markets with existing

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<sup>7</sup>Having domestic and foreign varieties be equally substitutable leads to business cycles that are not very synchronized.

<sup>8</sup>Adding persistence to the  $z$  process requires recalibrating the export costs in order to match the persistence of exporter behavior but, after recalibration, has small impacts on the overall results we present.

exporters.<sup>9</sup> Given the important finding of high entry costs, we will also consider versions in which exporting has more of an investment component. Table 1 summarizes our parameter values.

Insert Table 1

Figure 1 shows how trade interacts with idiosyncratic productivity shocks to determine the (log) size distribution. With iid shocks, productivity is log normally distributed. The top panel shows the distribution of domestic shipments and overall shipments of domestic producers. Domestic shipments are close to log normally distributed, although there is more mass in the right tail owing to the different capital stocks of exporters and non-exporters.<sup>10,11</sup> The distribution of overall shipments, though, has a fatter right tail than domestic shipments as more productive producers are more likely to export and hence have larger sales. The middle panel shows the distribution of purchases by domestic producers. The distribution of domestic shipments is the same as before. In addition, there is a distribution of expenditures on imports. The typical importer sells more than the typical domestic producer. When these distributions are put together again, the distribution of consumer purchases has more mass in the right tail. Changes in export participation by domestic and foreign producers will affect the sales and production distributions. The bottom panel shows the distribution of changes in sales and expenditures.<sup>12</sup> Both distributions depart slightly from log-normal. The distribution of sales (shipments by manufacturers) has more producers that grow/shrink 30 to 50 percent than predicted by the shocks. These

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<sup>9</sup>Without a capital accumulation decision, the same dispersion of productivity shocks and stopper rate would lead to entry costs that are 66 percent larger than continuation costs.

<sup>10</sup>Recall that exporters with more capital are more likely to continue in the export market, and this extra capital can contribute to larger sales at home.

<sup>11</sup>The bimodality of the distribution disappears with more dispersion in idiosyncratic shocks.

<sup>12</sup>We calculate growth relative to averages over the two periods. Therefore, for sellers' sales growth dispersion, foreign exporters who leave the local (i.e., exporting) market are counted as having a decline of -2 while new exporters have sales growth of +2.

producers are the ones starting and stopping to export. In general, the model captures the well-known empirical feature that there is a hierarchy of growth rates related to changes in export participation (i.e. starters grow faster than continuing exporters who grow faster than continuing non-exporters who in turn grow faster than stoppers, Bernard and Jensen, 1999; and Alessandria and Choi, 2011a).<sup>13</sup>

### 3 Model Experiments

The benchmark model is a steady-state model with no aggregate uncertainty. Into this model we consider two types of experiments. First, we consider shocks to the first moments of productivity and import preferences that lead to recessions and trade flows similar to the data. Second, we study the impact of shocks to the second moment of idiosyncratic productivity shocks.

#### 3.1 First-moment Shocks

We first consider the impact of the business cycle on the dispersion in economic activity across producers and sellers in the presence of international trade. We ask: How would a typical U.S. recession affect measured dispersion in the U.S.? The recession is modeled with a persistent home negative productivity shock ( $A_t$ ) along with preference shocks on home and foreign imports ( $\omega_t, \omega_t^*$ ). The shock to the preference for imports is included to capture the well-known cyclical features of trade: Imports tend to fall more than expenditures on tradable goods, and exports tend to fall less than production of tradables and may even rise at the start of a recession.<sup>14</sup> In this way we can capture how the movements in trade

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<sup>13</sup>The model is consistent with growth premia related to changes in export status at different horizons. The quantitative fit of the model is slightly better over longer horizons.

<sup>14</sup>The preference shock allows us to address a shortcoming in standard international RBC models, where imports are less procyclical than in the data while exports are more procyclical. Additionally, imports tend not to fall enough in recessions. The relatively large drop in imports is not solely due to trade being

flows give rise to changes in dispersion across home producers and sellers.

Specifically we assume shocks to productivity and preferences for imports have a simple AR(1) formulation:

$$\begin{aligned}
 A_{t+1} &= \rho_A A_t + \varepsilon_{A,t} \\
 A_{t+1}^* &= \rho_A A_t^* + \varepsilon_{A,t}^* \\
 \ln \omega_t &= (1 - \rho_\omega) \ln \bar{\omega} + \rho_\omega \ln \omega_{t-1} + \varepsilon_{\omega,t} \\
 \ln \omega_t^* &= (1 - \rho_\omega) \ln \bar{\omega} + \rho_\omega \ln \omega_{t-1}^* + \varepsilon_{\omega,t}^*.
 \end{aligned}$$

We follow much of the literature in setting  $\rho_A = \rho_\omega = 0.95^4$ . We set  $\varepsilon_A = -0.05$  and hold productivity constant in foreign ( $\varepsilon_A^* = 0$ ). We then choose  $\varepsilon_\omega^*$  so that imports fall twice as much as production in the first period, and set  $\varepsilon_\omega^* = -\frac{\varepsilon_\omega}{2}$  to have exports grow slightly.

We follow the emerging literature on micro volatility and report the standard deviation of growth in producer-level outcomes. We use “sales” to refer to the distribution of total shipments of home producers (for both domestic use and exports) and “expenditures” when referring to the distribution of expenditures of home consumers on varieties (both domestic and imported) available at home.

To fix ideas, we report the results for a model in which the sunk cost of exporting is high enough to essentially fix export participation along with our benchmark model in which 5 percent of exporters exit each year. The results of the model with no entry and exit from exporting are presented in Figure 2.

With export participation essentially fixed, a typical recession will tend to temporarily increase both the dispersion of the growth in sales of domestic producers and the dispersion of growth of expenditures on goods at home. The increase in domestic shipments is a little

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intensive in cyclical goods like capital and durables, but remains even after controlling for composition. Alessandria, Kaboski, and Midrigan (2010) document these dynamics of imports and exports in the U.S. recessions since 1969.

over 1 percent, while the increase in expenditures is close to 4.8 percent. The increase in dispersion of domestic producer shipments growth arises because sales of home non-exporters fall more than those of exporters, since exports are initially fairly stable. Overall sales fall about 11.5 percent for the average non-exporters and only 7.4 percent for the average exporter.

Dispersion in expenditure growth rises by more than dispersion in producer shipments primarily because expenditures on imports fall more than expenditures on domestically produced goods. This feature of the model arises because of the presence of preference shocks. Additionally, stable export sales combined with the predetermined capital stock implies that non-exporter sales at home actually fall by less than those of exporters, which adds to the increase in sales growth dispersion (because the cost of production rises more for exporters than non-exporters).

Figure 3 shows that allowing export participation to respond endogenously to the shocks increases the change in the dispersion of domestic producer shipments growth from 1 to 2.5 percent.<sup>15</sup> The increase arises primarily because the stock of home exporters (denoted  $N$  in the figure) rises temporarily<sup>16</sup> through an increase in starters (denoted  $n_0$ ) and a reduction in stoppers (denoted  $n_1$ ). In the model and the data, starters grow faster than continuing exporters and non-exporters which grow faster than stoppers. The strong initial decline in imports leads to a decline in the number of foreign exporters driven by a bigger decline in exit than entry. The decline in foreign exporters is temporary since the aggregate shock affects only home production, and as the foreign country rebuilds its stock of exporters (through more entry and less exit) this generates a slightly more persistent increase in sales dispersion.

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<sup>15</sup>The shocks here have been adjusted to have the same impacts on output, imports, and exports as in the previous model with exogenous export participation.

<sup>16</sup>This feature of the model is strongly tied to countercyclicality of net exports, which arises in part from capital accumulation. With capital, real net exports will move into surplus in a recession, as the recession leads to a reduction in capital investment at home and a slight increase in foreign investment. Without capital, one needs much larger trade costs to generate the countercyclical nature of net exports.

## 3.2 Second-moment Shocks

We next consider the impact of changes in the volatility of shocks to producer-level productivity. This sort of shock has featured prominently in the work of Bloom (2009), Bloom et al. (2013), and Arellano, et al. (2012). Here we find that these shocks have a very small impact on output, but have somewhat larger effects on trade flows through the selection effects with endogenous exporting.

As is well known, increasing dispersion will generally increase output in models with heterogeneous producers (via the Oi-Hartman-Abel effect). As is standard, (Bloom, 2009), we eliminate this effect by utilizing an aggregate TFP shock that removes this effect in the closed economy.<sup>17</sup> It is assumed that the autoregressive process for  $\sigma_{\varepsilon,t}$  is

$$\ln \sigma_{\varepsilon,t} = (1 - \rho) \ln \sigma_{\varepsilon} + \rho \ln \sigma_{\varepsilon,t-1} + \varepsilon_t.$$

In keeping with the relatively short-lived movements of volatility measures in the data, we assume that shocks to volatility are all temporary ( $\rho = 0$ ) and unexpected. The country-specific shock increases the volatility of shocks hitting home producers by 10 percent ( $\varepsilon = 0.1$ ). The results for our benchmark model are plotted in Figure 4. This shock generates an increase in the dispersion of domestic shipments growth for two periods. There is very little change in the dispersion of expenditure growth across varieties.<sup>18</sup> In the initial period, producer shipment dispersion grows by almost 11.7 percent, and in the second period the increase is 2.5 percent. The magnified movements in producer shipment dispersion arise from the export decision as the more volatile shocks lead to both more entry and more exit. On net, entry increases slightly (0.2 percent) while exports rise more than

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<sup>17</sup>With the log-normal shocks this entails shift the mean of the productivity shock to  $\mu = -\left(\frac{\theta-1}{1+\alpha(\theta-1)}\right) \frac{\sigma^2}{2}$ .

<sup>18</sup>This arises primarily because not all producers are hit by the shock and there is some net exit by foreign exporters from the shock. Eliminating entry and exit would lead to a larger rise in the dispersion in expenditures.

double that (0.45 percent). Imports decline slightly, so the country temporarily runs a slight trade surplus. In the second period, exports and exporters temporarily fall back to below steady state. Raising the volatility of idiosyncratic shocks primarily affects trade flows because the greater dispersion in productivity gives exporters, who tend to be in the tails, an even greater advantage.

We next consider how sensitive this effect is to the initial productivity advantage of exporters by considering a case where exporters are larger than in our benchmark. To implement this, we increase the dispersion in baseline productivity four fold but hold the stopper rate constant at 5 percent. This case is also of interest because it makes exporting a more durable decision than in our baseline. To match the same exit rate from exporting with more volatile idiosyncratic shocks requires the ratio of entry to continuation cost to rise from about 1.1 to nearly 4, which is more in line with estimates in the literature. This increases the exporter premium only slightly, from 2.5 to 2.65.

Nonetheless, Figure 5 shows that this larger exporter premium has a substantial impact on the effects of the shock to volatility on both trade flows and dispersion measures. Dispersion in sales and expenditures growth now both rise but by less than the shock, even though entry and exit rise substantially. On net there are fewer exporters, even though exports rise by almost 2.5 percent. The boom in exports is temporary: by the second period exports have fallen below steady state as the stock of exporters is also below the steady state. The dynamics are a bit more prolonged than in our benchmark model because of the more durable aspect of the export decision.

The central finding here is that increases in uncertainty primarily affect trade flows rather than output. The increase in exports is much larger than the increase in output. In the case of the slightly larger exporter premium, this increase becomes quantitatively significant. Unfortunately, such an increase implies counterfactual business cycle patterns. Empirical patterns show that, while measured producer-level volatility is high in recessions,

trade is procyclical, with aggregate trade much more volatile than output. In recessions, with the Great Recession as a chief example, trade falls and does so precipitously. This apparent discord between model and empirics constitutes a puzzle for dynamic business cycle models with extensive export decisions.

### 3.2.1 Global Uncertainty Shock

Last, we examine the effect of a global rise in idiosyncratic uncertainty on the global economy. This experiment is motivated by the highly synchronized nature of the Great Recession. We consider the effects of this shock in our baseline calibration (*low*) and one with a larger exporter premium (*high*) in which there is a larger sunk cost to exporting. Unlike the country-specific increase in uncertainty, the global increase impacts exporters in both countries symmetrically, highlighting the potential impact on global trade rather than just movements in trade balances.

Figure 6 shows that a global shock to idiosyncratic volatility raises dispersion in sales and expenditures a little more than 10 percent. The magnified increase in dispersion of growth rates arises from a slight increase in export participation. The global uncertainty shock stimulates output and trade, although the increase in output is quite small (about 0.013 percent) while the increase in exports is much larger (0.32 percent).

Turning to the case with a larger exporter premium and more volatile steady-state idiosyncratic shocks, we find that the effects on micro volatility are more muted as the increases in expenditures and sales are about half of the benchmark case. This muted rise in dispersion of growth arises because there is now a contraction in export participation. Despite the reduction in export participation, there is a substantial increase in trade of almost 3.4 percent and in output of about 0.2 percent.

This case shows that uncertainty shocks may be a potentially important driver of trade flows. If micro-level uncertainty shocks were an important factor during the Great Reces-

sion, then the research seeking to explain the collapse in trade during this period faces a potentially larger challenge as these types of shocks can potentially expand trade quite strongly.

## 4 Empirical Evidence

The experiment in Section 3.1 suggests that reallocations stemming from country-specific first-moment shocks may lead to increases in the dispersion of firm growth rates. We now examine whether there is evidence for such mechanisms. We begin by examining whether the dynamics of changes in industry dispersion measures are associated with aggregate international reallocations, the absolute values of the change in the real exchange rate or the net export ratio. We then ask whether variation in openness across industries explains the cross-industry variation in the dynamics of dispersion. Finally, using detailed data from the auto industry, we examine whether the composition of output within an industry is important in explaining the variation in measured dispersion over time.

### 4.1 All Industries

Our starting point for industry-level analysis is the NBER Industry Uncertainty Data from Bloom et al. (2013), which gives a cross-sectional measure of annual growth rate variation across 4-digit SIC industries in the U.S.<sup>19</sup> The data are an annual panel. Bloom et al. examine various industry-level measures, but none are able to significantly explain cross-industry variation, so the determinants of cross-industry variation are an open question. We focus on the sample from 1989-2012, since these are the available years for our international industry-specific data that we will utilize later.

In the model, the causal mechanism is clear: the joint shocks to country-specific produc-

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<sup>19</sup>These data include the NBER CES manufacturing database.

tivity and tastes generate reallocation which leads to an increase in measured dispersion of firm growth rates, even if there is no increase in actual micro uncertainty. In these cross-industry regressions, we do not claim to test causation, but only whether the data lead to correlations consistent with the theory. Recall that identification of industry-level correlates in these Bloom et al. data, whether causal or not, represent a contribution.

We begin by examining whether the time variation in industry-level volatility is associated with two aggregate measures associated with international reallocation: 1) absolute changes in the real exchange rate and 2) the absolute change in normalized net exports. We use the absolute values, since the theory indicates that any change in reallocation will have heterogeneous effects on firms, regardless of its sign. For the real exchange rate, we use the real “effective” (i.e., trade-weighted by country) exchange rate for the U.S. obtained from the Bank of International Settlements. We look at a one-year lag, since trade is slower to respond to changes in the real exchange rate, and we construct percentage changes as  $\Delta RER_t = (RER_t - RER_{t-1})/RER_{t-1}$ . For net exports, based on current nominal values, the absolute change in normalized net exports at time  $t$  is constructed as

$$\Delta NX_t = \left| \frac{X_{t+1} - M_{t+1}}{Y_{t+1}} - \frac{X_t - M_t}{Y_t} \right|.$$

We regress the log of the NBER industry sales volatility measure for industry  $j$  at time  $t$  on a time trend, industry fixed effects, and these aggregate predictors of volatility ( $X$ , where  $X$  represents  $\Delta RER_t$ ,  $\Delta NX_t$ , and/or, for comparison, real GDP growth at time  $t$ ):

$$V_{j,t}^{salesgrowth} = \beta X_t + \delta t + \phi_j + \epsilon_{j,t}.$$

We cluster the standard errors by industry. Here, the estimate of  $\beta$  is of interest.

The results are presented in Table 2.

Insert Table 2

Consistent with the theory, in the univariate regressions, the absolute changes in both the real exchange rate and the net export ratio are associated with increased measured dispersion in sales growth, and these are significant at the one percent level. The  $R^2$  values indicate that the explanatory power of these regressors is comparable to the explanatory power of real GDP growth, the more standard explanatory variable for cyclical behavior. (The  $R^2$  values are relatively high, but much of this comes from the industry fixed effects and the linear time trend.) In the regression that combines all three, GDP growth is the most significant, but the change in the real exchange rate is still significant at the 5 percent level, and the change in net exports is marginally significant at the 10 percent level. Thus, the trade reallocation variables seem to have some additional explanatory power beyond that of GDP growth alone.

We next examine whether we can explain *cross*-industry variation in the cyclicity of dispersion using measures of openness and trade. Recall that trade-driven dispersion in the model depended critically on the openness of the economy. As an analog here, we examine the openness of particular industries. We construct these measures of industry openness using annualized import and export data by HS-code from 1989-2012 from Schott (2008), aggregated to the 4-digit SIC level. Combining this with industry shipment data from Bloom et al. (2013), we define the following measures of openness for 4-digit industry  $j$  at

time  $t$ :<sup>20</sup>

$$\begin{aligned} Open_{j,t}^{Overall} &= \frac{exports_{j,t} + imports_{j,t}}{shipments_{j,t}} \\ Open_{j,t}^{Import} &= \frac{imports_{j,t}}{(shipments_{j,t} - exports_{j,t}) + imports_{j,t}} \\ Open_{j,t}^{Exports} &= \frac{exports_{j,t}}{shipments_{j,t}}. \end{aligned}$$

We start by focusing on the recent recession. Our motivation is the fact that the recession was large and was associated with a large collapse and recovery in trade. The size of the recession is likely to swamp other potential industry-specific trends, so our specification is quite simple.<sup>21</sup> We look at whether the absolute change in industry-specific sales volatility from 2009-2007 is correlated with our measures of openness. Note that this is the drop in the cross-sectional variance of sales growth, not the drop in average sales. Table 3 presents the results of these regressions. The coefficients on industry openness are presented in the first row, but the exact measure of industry openness varies by column.

Insert Table 3

The coefficients on all three measures of openness are positive and significant, indicating that openness was associated with larger increases in uncertainty. Since we use the log of

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<sup>20</sup>Merging at the industry, we lose data at several levels. First, the trade data include agricultural goods, but these are not included in the NBER data. Second, the concordance between HS and SIC is not perfect, and we lose many manufacturing industries. Even a cursory examination indicates that this is not because these industries have zero trade, but is a result of an imperfect concordance. Reconstructing a correspondence goes beyond the task of this analysis. Third, the NBER Industry Uncertainty Data have fewer industries for reasons unknown. The NBER CES manufacturing database has 459 industries, whereas the NBER Industry Uncertainty Data include 320 to 390 over the years. Schott's data has 402 to 447 sectors.

<sup>21</sup>One potential criticism, especially as it relates to our model, is that while the sources of the Great Recession are not fully understood, there appears to have been a substantial global element to it. Nonetheless, we believe our mechanism is more general, in that international reallocation, caused by differences in a broader range of aggregate shocks hitting countries differently, should lead to greater dispersion. It is this aspect of the mechanism that we evaluate.

the uncertainty measure, the coefficient on export openness, for example, indicates that uncertainty is roughly 1.4 percent higher in an industry that exports all of its shipments relative to a hypothetical industry that exports none. The magnitude and explanatory power are substantially larger for import and overall openness than for export openness. The  $R^2$  values are not large for any of the three, but they are comparable to the partial  $R^2$  values for the aggregate measures in Table 2.

We now return to the role of the absolute changes in the real exchange rate and net exports in explaining changes in industry-specific uncertainty in the broader time series. The dependent variable is again the log of the cross-sectional volatility of sales growth in industry  $j$  in year  $t$ . However, since our benchmark is an industry-specific measure, we use the industry-specific growth in shipments rather than overall GDP growth to control for change in economic activity. This is shown in the first column of Table 3. Total shipment growth, i.e., the first moment, is highly significant. (Although the  $R^2$  is high, again most of this comes from the industry-specific fixed effects and the time trend.)

Insert Table 4

Columns two through four show that industry openness alone is not a significant predictor of volatility in the overall time series as it was during the Great Recession. The reason may be that both the numerator and denominator of openness change over time and cyclically. When we add the aggregate real exchange rate (RER) in the third column and interact it with the industry-specific measure of openness, however, we get a positive and significant coefficient. That is, an absolute change in the real exchange rate seems to be associated with an increase in cross-sectional volatility, but especially in open industries, i.e., industries where trade is sizable. Similarly, the fourth column shows that the absolute change in net exports to GDP is again associated with an increase in cross-sectional volatil-

ity. The interaction indicates that this is especially true in industries that are open, but this term is only marginally significant (at the ten percent level).

We should note the limitations of our explanatory power. Bloom et al. (2013) evaluate alternative measures of uncertainty, including volatility of (firm-level) stock returns. Their data include three variants of these financial uncertainty measures: 1) cross-sectional variation in stock returns at a point in time, 2) cross-firm average 12-month variation in monthly stock returns within a firm, and 3) variance of pooled (by firm and month) monthly returns within a year. Our international reallocation measures are less successful in explaining cross-industry variation in these financial variants. For example, in the regressions in Tables 2 and 3, if we construct our dependent variables using these financial measures rather than those based on sales growth, we do not find a relationship with openness (although the aggregate reallocation measures themselves are still significant). This is not inconsistent with our model; given the forward-looking nature of financial prices, the information in aggregate shocks that leads to more prolonged reallocation dynamics and differential firm growth rates may lead to only immediate one-time variation in stock returns when the shock is realized.

In sum, the results are consistent with the model's prediction where (1) country-specific shocks lead to increased dispersion because changes in exports and imports lead to reallocation of production, but (2) this happens only when trade plays a quantitatively important role.

## 4.2 Autos

Having shown suggestive evidence consistent with the model at the economy-wide and cross-industry level, we now examine the determinants of measured dispersion within a particular industry. Similar to Bloom et al. (2013) we find that dispersion is high when activity is low, but consistent with our model, this seems to come in large part from reallocation between

domestic and foreign producers rather than among all producers.<sup>22</sup> Such reallocation is consistent with our theoretical finding from country-specific shocks. An advantage of the auto data are that they more readily identify causality, since the Japanese tsunami was a well-identified exogenous, country-specific shock causing international reallocation.

Data are available on production,  $y_t$ , and sales,  $s_t$ , of autos in the U.S. at the monthly level. The data are from Autonews and IHS Automotive and are quite disaggregate (by company, trim, brand, and product). For each producer, a measure of production and sales growth is constructed as

$$\Delta x_{it} = \ln(x_{it}/x_{it-1}).$$

The standard deviation of this variable,  $\sigma(\Delta x_{it})$ , is weighted by each firm's current-period share of the variable.<sup>23</sup> This measure of dispersion is then logged and seasonally adjusted using a month dummy. Thus, the dispersion measures can be thought of as the log change in volatility. Quarterly measures are an average of the monthly measure.

Figure 7 plots the level and volatility of sales and production in a seven-year period that includes the Great Recession. As is already well known, sales are a bit smoother than production and fall by less (see Alessandria, Kaboski, and Midrigan, 2013). Indeed, the drop in production is almost twice that of sales in the first two quarters of 2009, when economic activity was contracting at a fast pace. Figure 7 also plots the change in the standard deviation of sales and production growth. These two dispersion measures increase quite substantially as economic activity starts to stagnate in late 2007 (prior to the start of the recession). Production dispersion rises more initially and surges in 2009.

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<sup>22</sup>Aggregation bias is also a clear driver of rising dispersion as dispersion increases 1) more at the company level than product level (i.e., split between truck/SUV and cars) and 2) more at the quarterly level than the monthly level.

<sup>23</sup>Unweighted measures are strongly influenced by the exit and entry decisions of producers since their sales growth can be extreme. However, these producers tend to have small market shares in the lead up to exit or period soon after entry.

By mid-2010, both measures of volatility have returned to normal levels, while the level of activity remains quite low. Volatility picks up again at the start of 2011. The increase in volatility coincides with another country-specific shock: the Japanese tsunami.

To clarify the role of reallocation across countries, we consider the reallocation between the Big 3 and Japanese producers. Specifically, let

$$\Delta ms = 100 \left( \frac{x_t^{Big3} - x_t^{Japan}}{X_t} - \frac{x_{t-1}^{Big3} - x_{t-1}^{Japan}}{X_{t-1}} \right)^2,$$

where  $X_t$  is the total production or sales. This is a measure of the amount market share is being reallocated across country of ownership. Obviously, holding reallocation within groups constant, more reallocation between the groups will increase the dispersion measure. Figure 8 plots these dispersion measures for production and sales. The non-seasonally-adjusted data are plotted. This measure helps clarify that an important source of the rise in dispersion is predictable and due to the two types of plants having a different timing of production. Specifically, at year-end and mid-year, there are recurring increases in growth dispersion. These spikes correspond to the establishments in these periods shutting down for different lengths. Once the factories are up and running there is very little dispersion in growth in the other periods. This point is particularly important since the spike in volatility in 2009m1 to 2009m7 is larger and more persistent than in the rest of the period. This seems to correspond to GM and Chrysler experiencing prolonged shutdowns as they reorganized in early 2009. The monthly sales data tell a similar story: increases in sales growth dispersion tend to be associated with reallocation between the Big 3 and Japanese brands rather than within these brands. Comparing reallocation between Big 3 and Japanese producers, there are much larger swings in production reallocation than sales reallocation at the monthly level.

To further explore the idea that a rise in dispersion of sales growth reflects realloca-

tions from country or country-industry shocks, Figure 9 plots the quarterly sales growth dispersion against log change in market share of trucks, imports, Big 3, and Japanese firms (all measured as averages of the monthly numbers). The data are not seasonally adjusted. Clearly, the increase in dispersion in 2008 is accounted for by a shift away from trucks and the Big 3 toward cars, imports, and Japanese firms. There are two clear phases to this reallocation in 2008 and 2009. In 2011, sales growth dispersion again rises sharply. This rise reflects a shift away from sales of Japanese cars (produced in the U.S. or imported) as the tsunami in Japan had a much larger effect on Japanese firms' sales of cars produced in the U.S. and Japan.

## 5 Conclusions

Using quantitative theory and data, we have examined 1) the impact of aggregate international shocks on measured producer-level volatility or dispersion through the channel of international trade, and 2) the impact of stochastic micro-level volatility on the cyclical patterns of international trade and output.

Examination of the first channel uncovered a potentially important source of measured cyclicity in firm-level dispersion: shocks that affect international trade patterns increase sales growth dispersion. The model indicates that such a channel could be quantitatively important, and our empirical evidence shows that industry volatility measures are indeed associated with measures of trade reallocation shocks and measures of openness. Moreover, within the auto industry, through careful investigation, we have confirmed the importance of such country-to-country reallocation at the firm level. Examination of the second channel, in contrast, uncovered a puzzle for the standard business cycle model used to understand micro-level trade dynamics: Increases in firm-level dispersion lead to large increases in trade rather than the steep declines typically observed during recessions.

The first channel we have uncovered motivates several avenues for future research. First, although autos represent an important industry, it would be informative to examine whether other industries behave in a similar fashion. This would require access to comprehensive firm-level data.

Second, although trade-induced reallocation appears to be an important channel, it doesn't appear to be the entire story. Recall that we are not able to explain cross-industry variation in the volatility of stock returns. Similarly, the mechanism may also have little to say about neither the implied volatility of a 30-day option (i.e., Chicago Board Options Exchange Market Volatility Index, or VIX) that Bloom (2009) examines, nor the differences in aggregate predictions and greater dispersion in firm-level forecast errors documented by Bachmann, Elstner, and Sims (2013). These two empirical patterns may both primarily reflect aggregate uncertainty, and, of course, even firm-level business cycle dynamics from country-specific shocks would presumably be predictable. In any case, a quantitative decomposition of the fraction of cyclical changes in dispersion that can be explained by trade reallocations remains to be done.

Our analysis is a starting point for examining the impact of country-specific shocks on cyclical fluctuations in producer level dispersion. We undertake this in a benchmark model that captures the key differences in producer heterogeneity and export participation. Future quantitative work should take into account the differences in international input usage, the high share of durables and capital goods in trade, and additional shocks to trade or monetary policy.

Finally, aggregate uncertainty in trade policy may itself be important to business cycle and trade dynamics. A quantitative analysis of this channel is the subject of our ongoing work.

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Table 1: **Parameter Values**

Common	$\sigma$	$\gamma$	$\theta$	$\beta$	$\alpha$	$\delta$
	1	1.5	3	0.96	0.36	0.10
		$\sigma_\varepsilon$	$f_0/f_1$	$\omega$	$\eta$	
Benchmark		0.075	1.03	0.3659	0.3592	
High Dispersion		0.30	1.66	0.3603	0.3599	

Table 2: **Industry-level Dispersion and Aggregate Reallocation (1989 - 2011)**

	GDP Growth	$\Delta$ RER	$\Delta$ Net Exports	All 3
<b>GDP Growth</b>	-0.005***	.	.	-0.005***
	0.002	.	.	0.002
<b><math>\Delta</math>RER</b>	.	0.265**	.	0.247**
	.	0.113	.	0.113
<b><math>\Delta</math>Net Exports</b>	.		1.296***	0.841*
	.		0.512	0.486
<b>R<sup>2</sup></b>	0.61	0.61	0.61	0.61
<b>Observations</b>	5088	5088	5088	5088

Note: \*, \*\*, and \*\*\* denote significance at 10, 5, and 1 percent levels, respectively. Standard errors are below each coefficient and are clustered by industry.

Table 3: Industry-level Dispersion and Industry Openness (2007 - 2009)

	Overall <sub>jt</sub>	Import <sub>jt</sub>	Export <sub>jt</sub>
<b>Industry Openness</b>	0.034***	0.040**	0.014**
	0.011	0.011	0.005
<b>R<sup>2</sup></b>	0.05	0.07	0.03
<b>Observations</b>	195	193	195

Note: \*, \*\*, and \*\*\* denote significance at 10, 5, and 1 percent levels, respectively. Standard errors are below each coefficient.

Table 4: Industry-level Dispersion, Aggregate Reallocation and Openness (1989 - 2011)

	$\Delta$ Industry Shipments	Industry Openness	$\Delta$ RER Interact	$\Delta$ Net Exports Interact
$\Delta$ Shipments	-0.236***	.	.	.
	0.028	.	.	.
<b>Openness</b>	.	0.010	0.007	0.006
	.	0.011	0.011	0.012
$\Delta$ RER	.	.	2.392***	.
	.	.	0.756	.
$\Delta$ RER x Open	.	.	0.773**	.
	.	.	0.375	.
$\Delta$ NX	.	.	.	0.549***
	.	.	.	0.164
$\Delta$ NX x Open	.	.	.	0.135*
	.	.	.	0.071
<b>R<sup>2</sup></b>	0.64	0.64	0.63	0.63
<b>Observations</b>	4840	4840	4840	4840

Note: \*, \*\*, and \*\*\* denote significance at 10, 5, and 1 percent levels, respectively. Standard errors are below each coefficient and are clustered by industry.

Figure 1: Distributions 20 Percent Trade

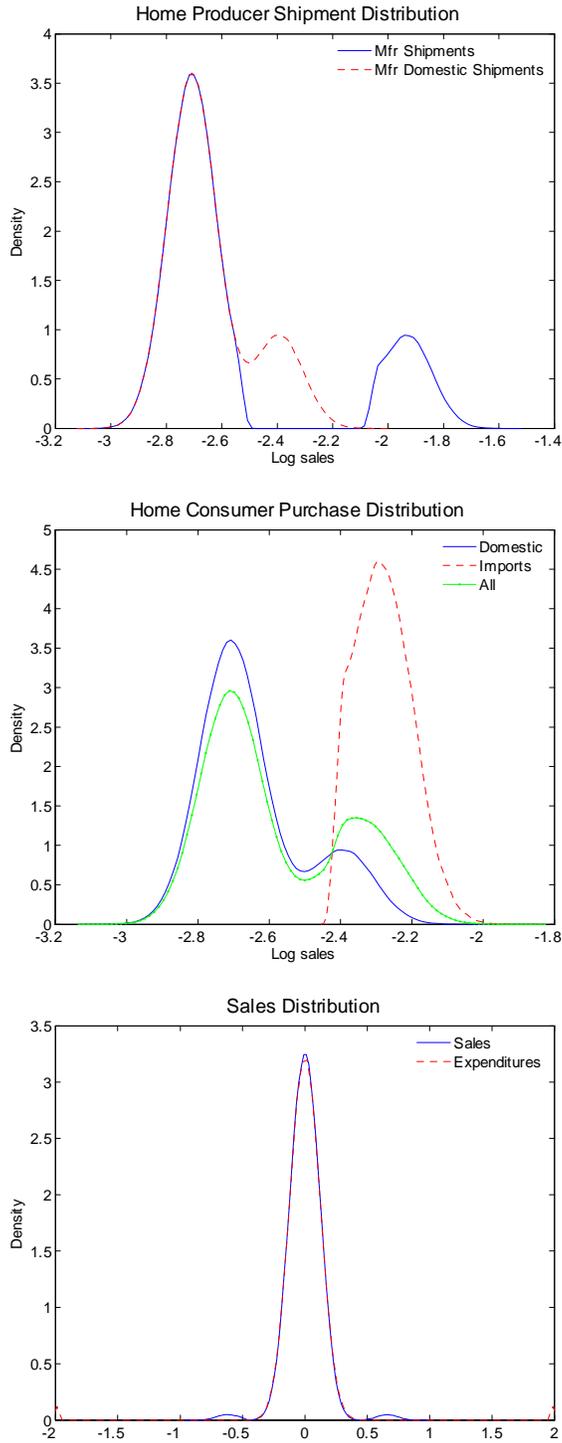


Figure 2: Home Recession: Exogenous Export Participation

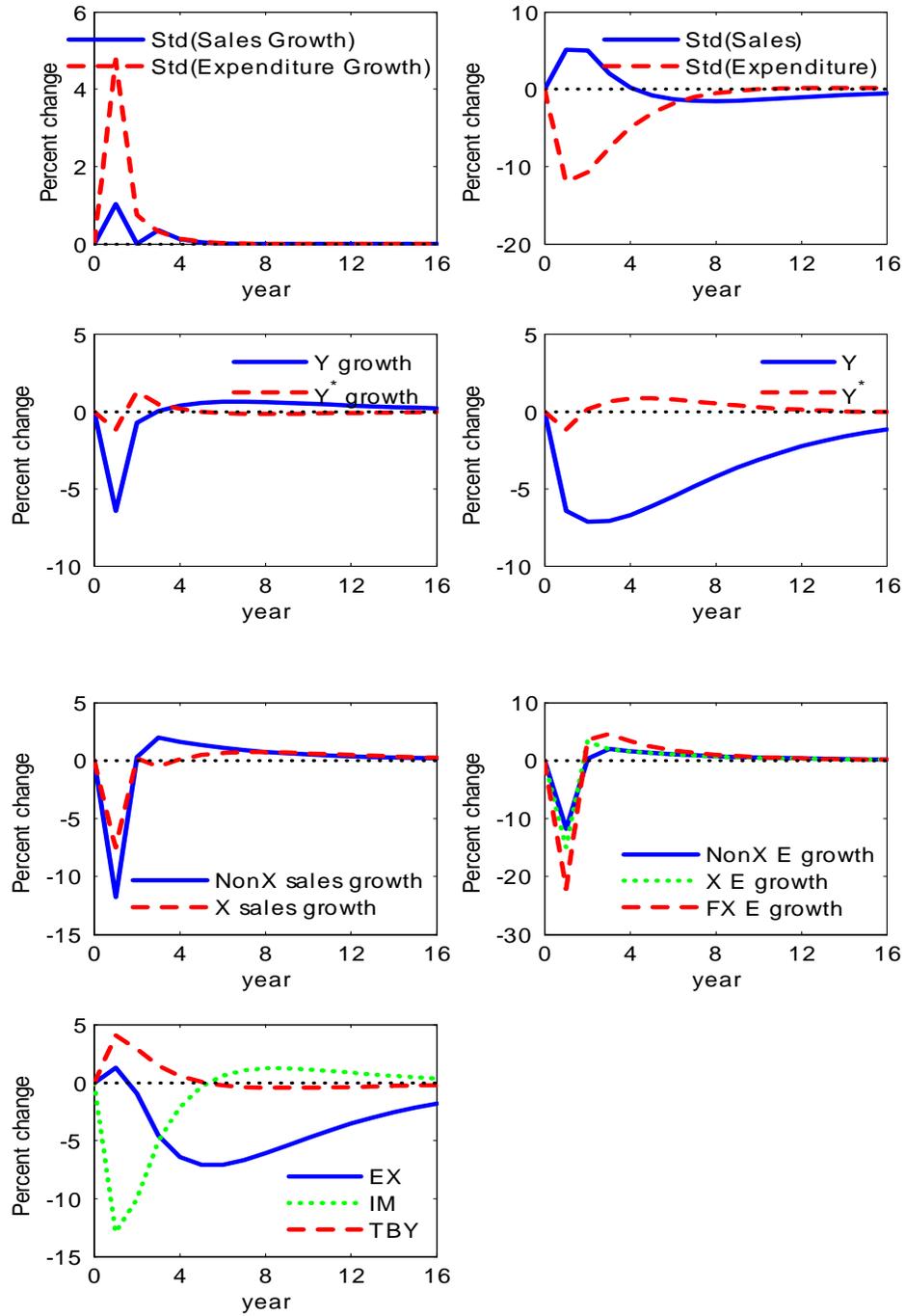


Figure 3: Home Recession: Benchmark Model

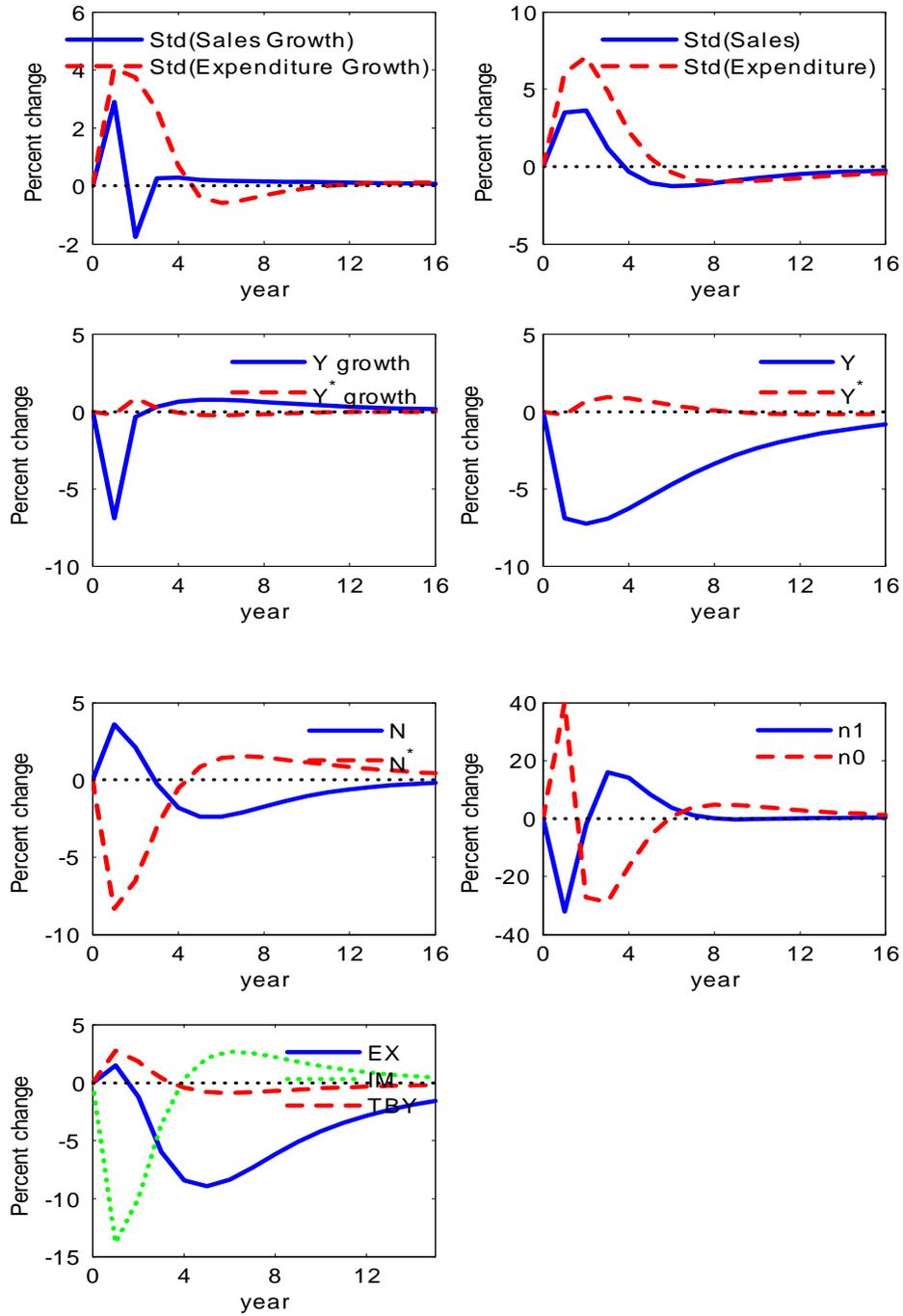


Figure 4: Home Uncertainty Shock

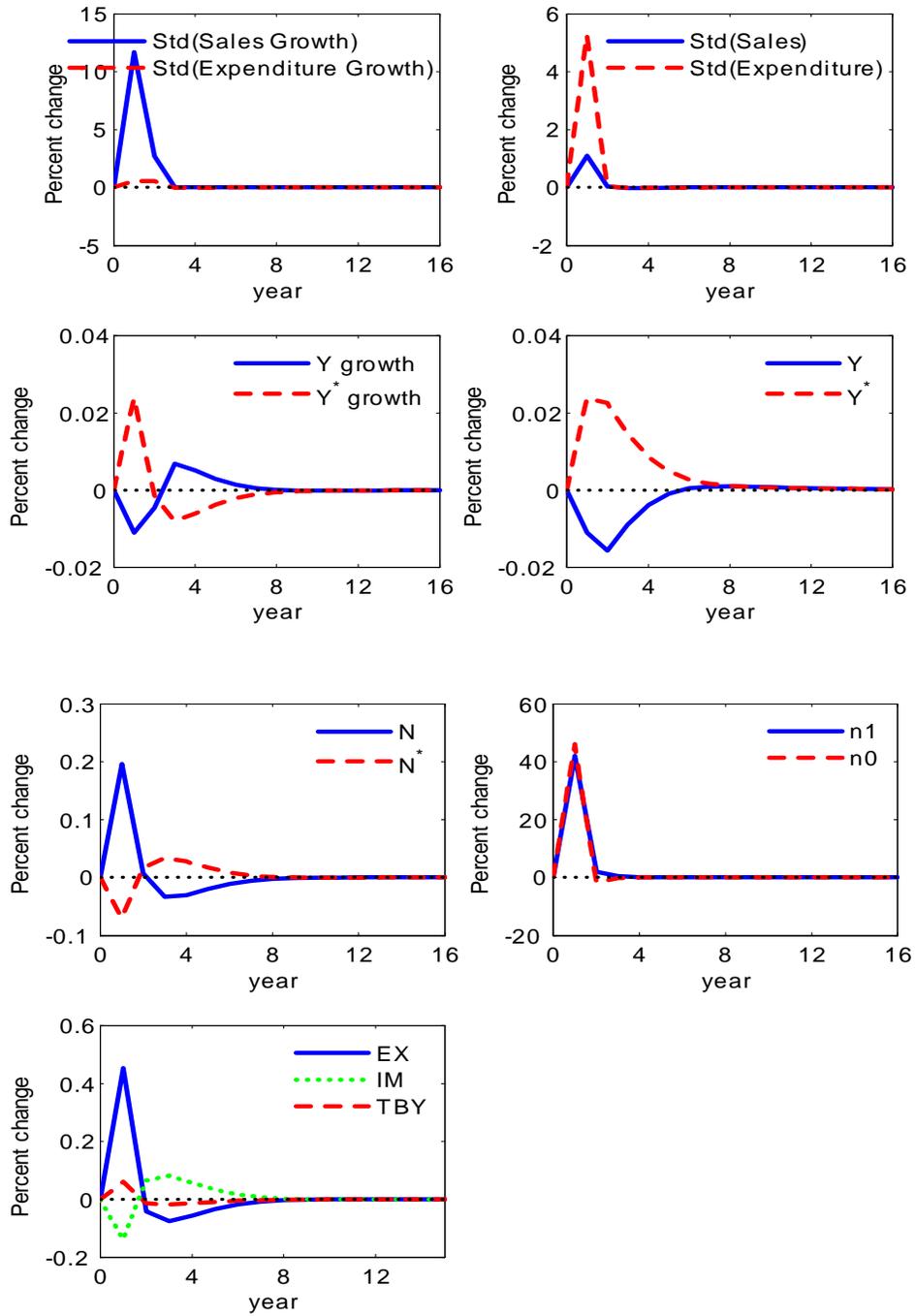


Figure 5: Home Uncertainty Shoc: High Export Premium

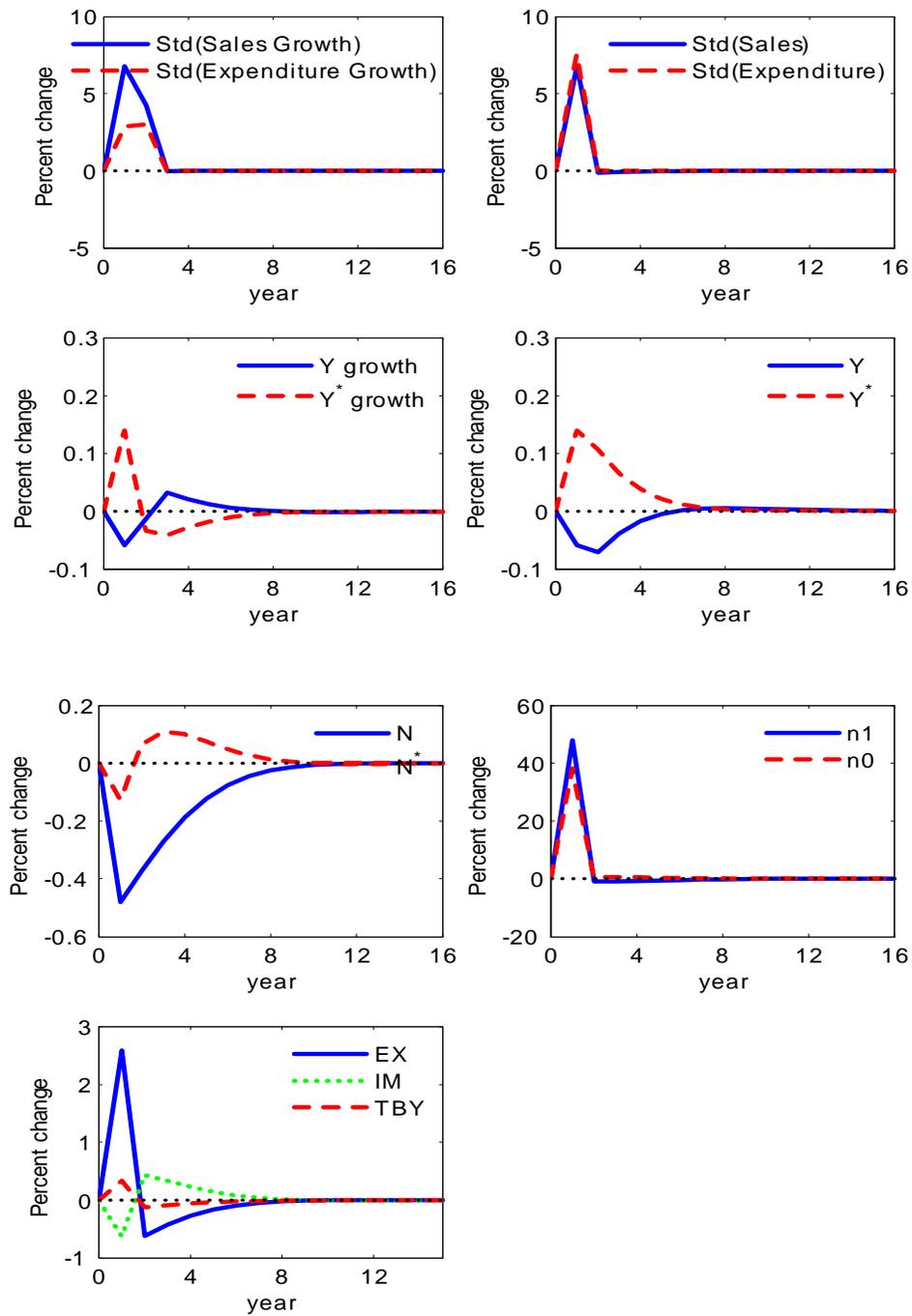


Figure 6: Global Uncertainty Shock

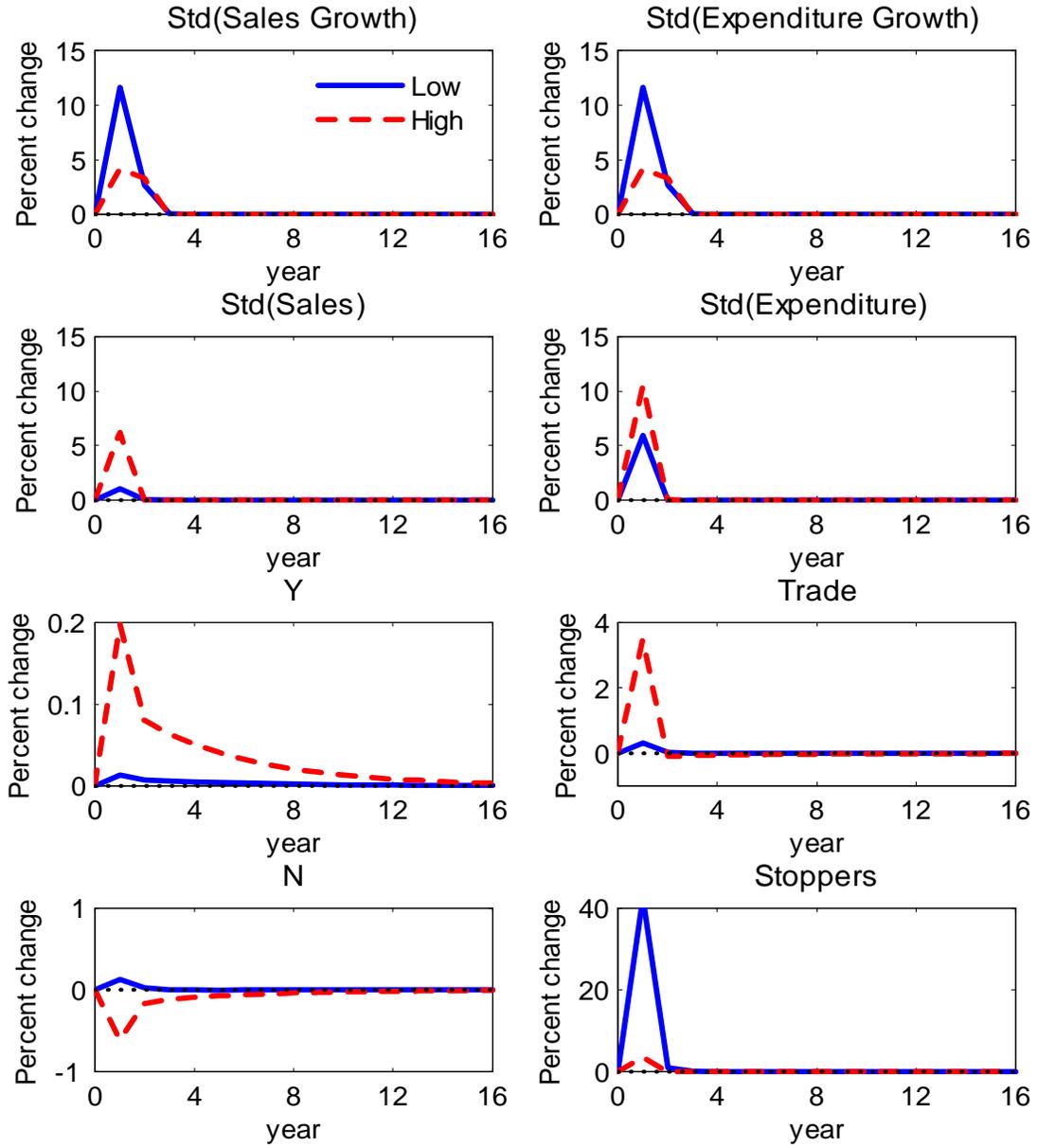


Figure 7: Volatility and Level of Activity (Sales and Production of Autos)

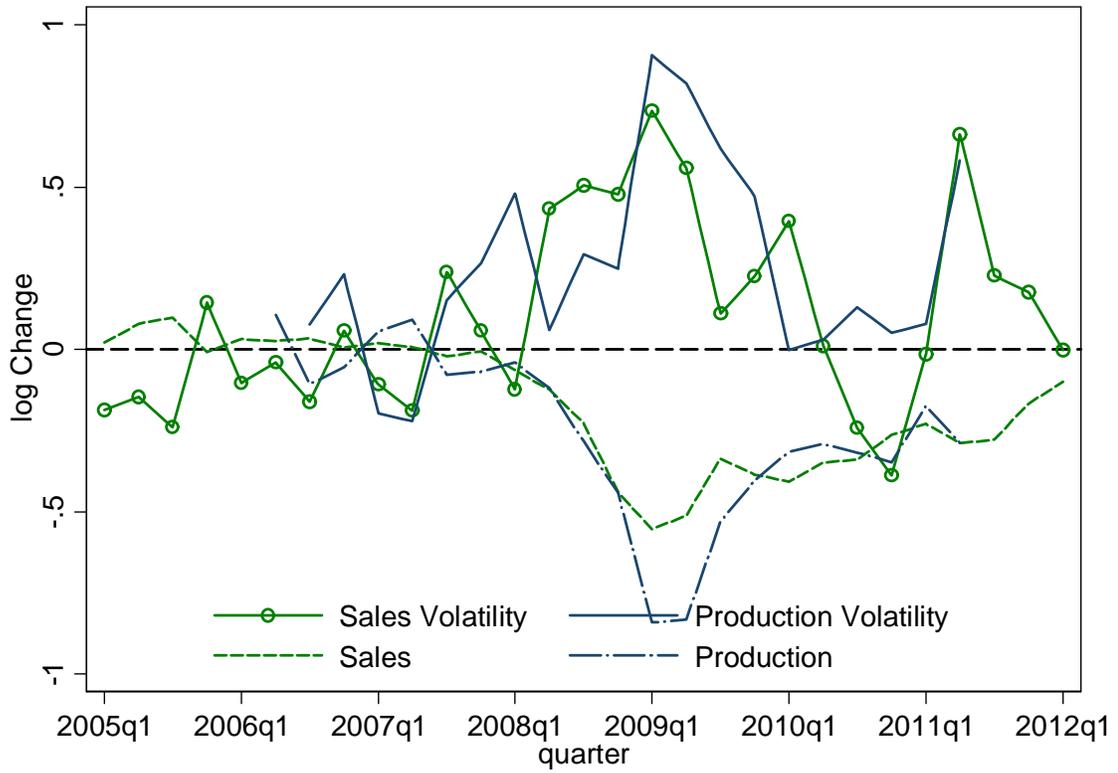


Figure 8: Volatility and Reallocation by Country Ownership

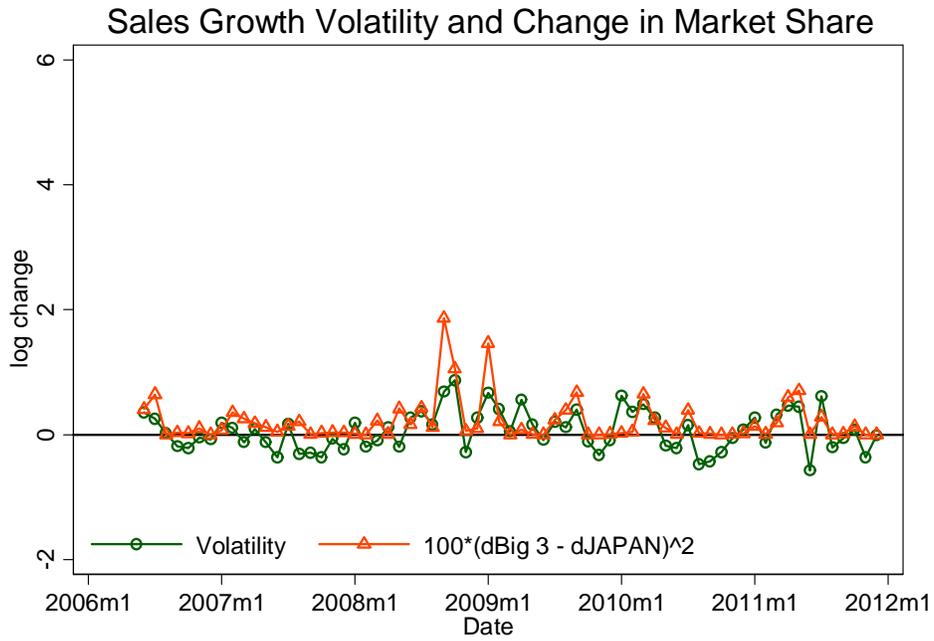
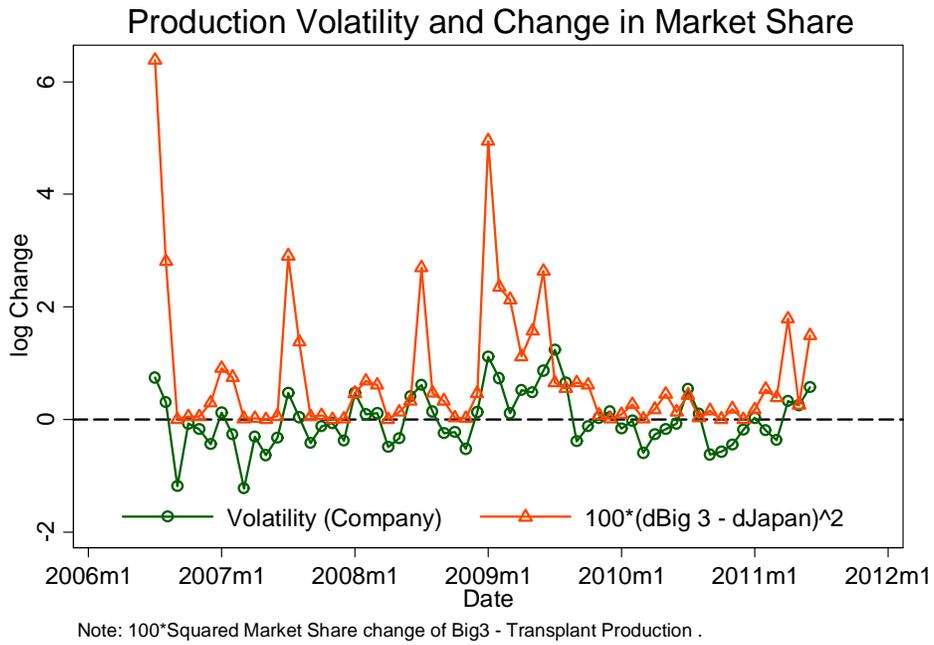
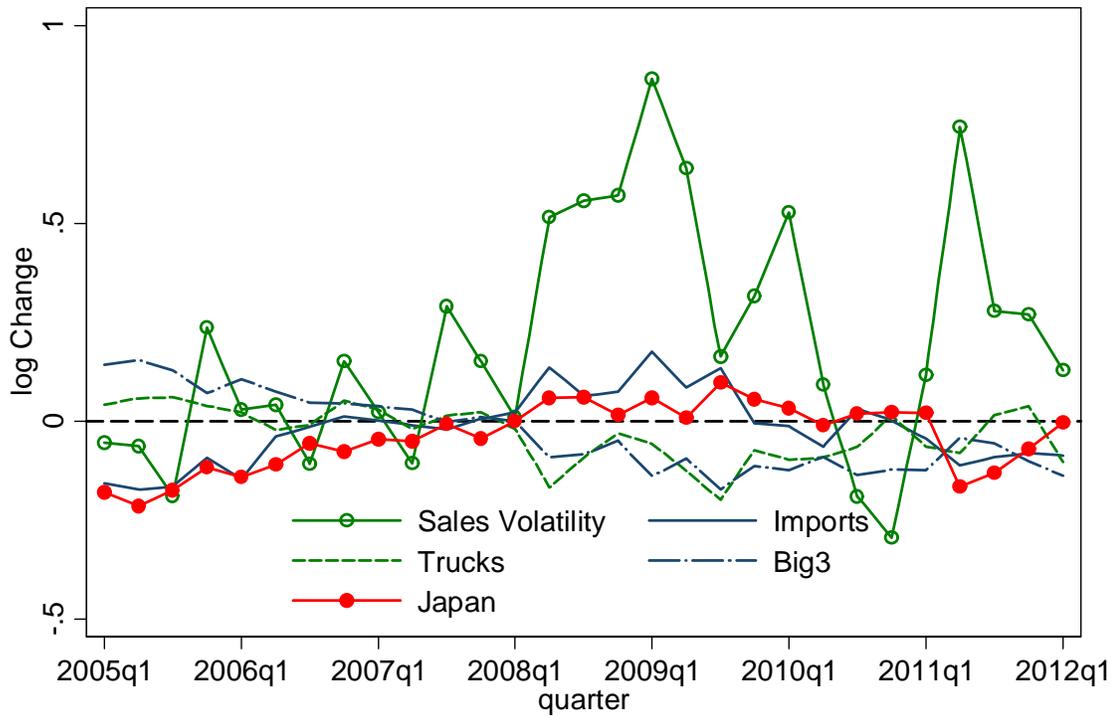


Figure 9: Sales Volatility and Market Shares



Note: Data are not seasonally adjusted.  
Market shares are log deviations from pre-recession mean.