Trade Liberalization and Firm Sales Volatility
Evidence from India

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ABSTRACT I look at the impact of trade liberalization on product-level sales volatility of firms. Exploiting India's externally imposed trade reform to identify trade liberalization effects, I find that while a fall in the tariff on the final product produced by the firm is associated with an increase in volatility in Indian manufacturing firms, a fall in the tariff on intermediate inputs is associated with a decrease in volatility, with the latter effect dominating the former. I hence propose an additional channel for gains from trade liberalization, relevant particularly for developing countries with weaker mechanisms in place to deal with volatility.

JEL codes: F13, F14, O14
Keywords: Trade liberalization, Volatility, Input varieties, Diversification, Firm-level data, India

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1. Introduction

As developing countries have liberalized trade over the past few decades, the debate on the benefits of trade reform for the domestic economy continues to rage in the literature. One concern is that increased international exposure might be associated with increased volatility. Di Giovanni and Levchenko (2009) show that more open industries experience greater output volatility. Bergin, Feenstra and Hanson (2009 and 2011) find that employment in the offshoring industry in Mexico is significantly more volatile than the corresponding industry in the United States. More recently, Caselli, Koren, Lisicky and Tenreyro (2014) have argued the opposite. They look at aggregate GDP and argue that trade openness can lower volatility by reducing exposure to domestic shocks and allowing countries to diversify sources of demand and supply across markets.

Despite the contention, the literature concedes that isolating the link between greater trade exposure and volatility is an important exercise. Aggregate volatility has implications for workers, given that volatility may be associated with greater job and income uncertainty. This is particularly relevant for developing countries, where unemployment benefits and welfare are typically non-existent. Volatility in output can also affect price volatility, resulting in greater uncertainty in the macroeconomic climate. This can in turn lead to lower investments in capital, including human capital. Additionally, price volatility can also adversely affect household welfare, particularly in developing countries (Bellemare, Barrett and Just, 2013 for rural households in Ethiopia).

The literature on trade and volatility has focused largely on aggregate analyses at the level of the industry or the macro economy, though recent studies like Kurz and Senses (2013) and Buch, Döpke, Jörg and Strotmann (2009) utilize firm level data to delve into this relationship at a more micro level[1]. A study of volatility at the firm level can provide useful insights into

[1] Kurz and Senses (2013) focus on employment volatility. This is related to, but not synonymous with output volatility, which is the focus of my study. Looking at employment volatility is outside the scope of my paper, and in fact, cannot be done with the data I use in this study due to lack of information on employment. In their study, the authors use data on transactions at the firm level to analyze the relationship between trading status and employment volatility of US firms. They show that importing firms experience greater employment volatility than purely

factors affecting aggregate volatility, including trade openness. However, establishing a relationship between trade and firm volatility is challenging for two main reasons. First, unobserved firm-specific factors that determine trading status of a firm can also affect volatility. For instance, firms that experience greater volatility in their supply of raw materials from domestic sources might choose to import from abroad. Similarly, firms that face greater volatility for their final product in the domestic market might wish to diversify into foreign markets. Alternatively, technology shocks may make output less volatile, but also increase participation by firms in global markets.

Second, trade can affect firm volatility via various potential channels, and parsing these out can be difficult. The first channel is that trade can lead to specialization and a less diversified production portfolio, increasing volatility (di Giovanni and Levchenko, 2009). Next, import competition might increase the elasticity of demand through a pro-competitive effect, in which case, cost shocks might translate into greater volatility in output (Hasan, Mitra and Ramaswamy, 2007)[2]. Finally, if firms import inputs from a greater range of countries, they may more easily tide over shocks in input availability by substituting to other varieties. This would induce a negative relationship between importing and volatility (Caselli, Koren, Lisicky and Tenreyro, 2014).

In this study, I tackle both these challenges. I exploit India's trade liberalization episode in the 1990s, characterized by a fall in tariffs across sectors, as a natural experiment to study the impact of trade liberalization on volatility of product-level sales of Indian manufacturing firms

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domestic or exporting firms, and attribute this to the fact that these firms can more easily substitute imported inputs for domestic workers in response to a domestic wage shock. Note that this ability of firms to substitute across inputs might actually result in lower output volatility.

[2] I note here that there is a potential link between exporting and volatility that several studies have examined (Buch, Döpke, Jörg and Strotmann, 2009). Exporters may experience greater volatility if conditions in their destination markets are more volatile. However, if exporters experience uncorrelated shocks in their destinations, they may experience less volatility (Vannoorenberghe, 2012). My focus is on the relationship between greater import competition due to tariff reform and volatility, and hence, I mostly abstract from discussions on exporting and volatility.

over the period 1989 through 1997. I argue that the tariff reform was exogenous to Indian firms since it was imposed as a part of an IMF restructuring package following a balance of payments crisis, and hence allows me to estimate the impact of greater trade exposure on firm product-sales volatility, thereby tackling the first challenge.

Further, in this study, I am able to tease out some of the channels via which trade may affect volatility. Since I look at volatility of firm sales in each product that a firm produces, I am able to rule out within-firm specialization in products from trade liberalization as a source of increased volatility (the first channel). Additionally, considering decreases in both the tariff on the final product produced by the firm (output tariff), and the tariff on intermediate inputs used in the production of the final product (input tariff) allows me to disentangle the effect of trade liberalization on volatility attributable to better access to intermediate inputs, from that attributable to greater competition in the final product market (channels two and three).

I hypothesize that a fall in the input tariff results in a fall in prices for intermediate inputs. If firms pay a fixed cost to import intermediate input varieties, the fall in price and the resulting increase in variable profits can increase the range and variety of inputs available to a firm, which can now source both foreign and domestic varieties. Diversity in input varieties means that one single variety becomes less important in production, and hence production becomes less volatile. Also, in response to a given shock in input markets, firms have a greater ability to substitute toward alternate input varieties, which further reduces output volatility[3].

I also posit that a fall in the output tariff will increase output volatility via separate channels. First, a fall in the output tariff may be associated with lower variable profits as the firm faces import competition. This will lower the range and variety of inputs available to the firm, which might increase output volatility. Second, a fall in the output tariff may decrease the elasticity of demand for a firm's final product as consumers avail of more substitutes. This means that a given input cost shock would translate into greater changes in output, increasing output volatility.

Baseline estimates indicate that a ten percentage point decrease in the input tariff is associated with a four percent decrease in sales volatility of the product. A ten percentage point

[3] Koren and Tenreyro's (2013) study, on which my conceptual framework is based, attributes this to benefits from technological diversification.

decrease in the output tariff is associated with a one percent increase in sales volatility of the product. Consistent with my conceptual framework, evidence suggests that volatility of raw material expenditures of the firm responds similarly to trade liberalization. Results are robust to measuring volatility using an alternate measure, to the addition of a battery of control variables, and to accounting for unobserved initial firm-product and firm-level shocks that may be correlated with tariff declines.

Additionally, I look for heterogeneous tariff effects for firms importing raw material and for firms in industries that use more differentiated inputs, and are hence more contract intensive. I find that while the output tariff effect does not differ substantially for firms that import raw material from abroad, it is these firms that see a decrease in volatility from a fall in the input tariff. Also, a decrease in volatility associated with a fall in input tariffs is primarily in industries that use a greater proportion of differentiated inputs, suggesting that firms in these industries gain more from greater access to imported intermediate varieties. Finally, consistent with earlier studies, results indicate that trade liberalization effects did not differ systematically across Indian states by level of development, rigidity of labor regulation or location along the coastline.

This study highlights an important benefit of trade liberalization that, I believe, has not been previously highlighted in the literature. Greater import competition has been associated with increases in productivity due to reshuffling of resources to more efficient producers (Pavcnik, 2002) and due to pro-competitive effects that reduce market power of domestic producers (Topalova and Khandelwal, 2011). In addition, access to better, cheaper and a wider variety of inputs due to falling input tariffs can result in opportunities for productivity improvements, and can result in product quality upgrading and greater scope of products produced (Amiti and Konings, 2007; Goldberg, Khandelwal, Pavcnik, 2010; Goldberg, Khandelwal, Pavcnik, Topalova, 2010; Amiti and Khandelwal, 2013, Cadot, Carrère and Strauss-Kahn, 2013).

I show that while lower output tariffs may be associated with a slight increase in volatility, a lower input tariff can grant firms access to a wider variety of inputs that they might be able to exploit to substitute between varieties when faced with shocks in intermediate goods markets, lowering volatility. I hence argue that trade liberalization can have a stabilizing effect, in addition to a level effect. The rest of my paper proceeds as follows. In section 2, I present a

conceptual framework to think through the effects of a fall in input and output tariffs on volatility. I discuss the empirical specification in Section 3. Section 4 presents the data, Section 5 discusses results and Section 6 concludes.

2. Conceptual framework

In this section, I present a conceptual framework to look at the impact of a fall in tariffs on firm-level volatility in product sales. I first focus on the input tariff. The idea is that trade liberalization increases access to a variety of intermediate inputs. When input tariffs fall, prices of intermediate inputs, both foreign and domestic, fall. If importing each variety is associated with a fixed cost, a fall in prices may allow firms to import a wider variety of intermediate inputs. Indeed, Goldberg, Khandelwal, Pavcnik and Topalova (2010) find that over the period of India's trade liberalization, falling input tariffs were associated with imports of a greater variety of intermediate inputs by Indian firms, whose imports were virtually throttled in the period before the reforms. Given access to a greater variety of intermediates, each intermediate can become less important for production and firms can better mitigate shocks in intermediate input markets by substituting towards other varieties. Hence, I argue that a fall in the input tariff would be associated with a decrease in volatility.

To formalize this argument, I adapt the framework in Koren and Tenreyro (2013). I start with a firm that produces a final good by combining a variety of inputs

$$y(j,t) = \left[\sum_{i \in I(j,t)} \chi_i(t) l_i(j,t)^{1-1/\epsilon}\right]^{\epsilon/(\epsilon-1)} \quad (2.1)$$

Here, firm j's output at time t is $y(j,t)$. i indexes domestic and foreign input varieties from a set of varieties $I(j,t)$, l_i is labor allocated to the operation of input i, ε is the elasticity of substitution between varieties and $\chi_i(t)$ is the productivity of variety i. I assume that $\varepsilon > 1$. Varieties may be hit by shocks, after which they cease to become productive (or contribute to production). Note that this framework encompasses situations where input varieties become suddenly unavailable to producers (or available at very high prices) due to weather related shocks, policy or political factors, or hold-ups from suppliers due to contracting issues.

Boehm, Flaaen and Pandalai (2014) analyze the role of multinationals in transmitting shocks in intermediate input supplies to output internationally in the aftermath of the Tōhoku earthquake and tsunami in Japan, where, along with the massive and unfortunate loss of lives, resultant disruptions in power, infrastructure provision and port services affected domestic and

foreign shipments of Japanese exports. Similarly Antras (2015) discusses a case where the Chinese government in 2004 banned all imports of Brazilian soybean since it found traces of carboxin (a toxic fungicide) in a shipment, thereby leaving Chinese soybean crushers and indeed, Brazilian soybean suppliers with stranded cargo.

Shocks are independent across varieties and arrive with a Poisson process, such that the input's productive lifetime follows an exponential distribution with parameter γ. Hence, conditional on working at time zero, the distribution of $\chi_i(t)$ is

$$\chi_i(t) = \begin{cases} 1 & with\ probability \quad e^{-\gamma t} \\ 0 & with\ probability \quad 1 - e^{-\gamma t} \end{cases} \tag{2.2}$$

Substituting into (2.1)

$$y(j,t) = \left[\sum_{i:\chi_i(t)=1} l_i(j,t)^{1-1/\epsilon}\right]^{\epsilon/(\epsilon-1)} \tag{2.3}$$

Let $n(j,t)$ denote the overall number of varieties, out of which $k(j,t)$ are not productive. Since varieties enter the production function symmetrically, firms allocate the same number of workers to each variety. Let $l(j,t)$ the amount of labor allocated to each productive variety. Then,

$$y(j,t) = l(j,t)[n(j,t) - k(j,t)]^{\epsilon/(\epsilon-1)} \tag{2.4}$$

Labor productivity is given by,

$$\omega(n,k) = [n(j,t) - k(j,t)]^{1/(\epsilon-1)} \tag{2.5}$$

Koren and Tenreyro (2013) show that the variance of output per unit of labor $Var(\mathrm{dln}\omega)/dt$ is decreasing in n for all $n \geq 1$. In other words,

$$\frac{\partial \ln Var}{\partial n} < 0 \tag{2.6}$$

Also, in this framework, firms that use more varieties are more productive due to the love-of-variety effect. They can hence produce a given amount of output with fewer workers, and since labor is the only cost of production, earn higher operating profits. Hence, firm operating profit is increasing in $n(j,t)$. Now, assume that firms pay a fixed cost of importing each intermediate variety, which, for simplicity, is the same across varieties[4]. In importing varieties, firms equate the marginal benefit from employing an additional variety to the fixed cost of importing it.

[4] Product-specific importing fixed costs are now a common feature of models capturing firm-level trade, for instance, Halpern, Koren and Szeidl, forthcoming.

Proposition 1: A fall in the input tariff τ_m is associated with a decrease in output volatility.

With a fall in the import tariff, firms now see an increase in their variable profits, which they can utilize to import additional varieties by paying the fixed cost of importing them. This expands the set of intermediate varieties $n(j,t)$. In other words, input tariff liberalization increases n. Or,

$$\frac{\partial n}{\partial \tau_m} < 0 \qquad (2.7)$$

Hence,

$$\frac{\partial \ln Var}{\partial \tau_m} = \frac{\partial \ln Var}{\partial n}\frac{\partial n}{\partial \tau_m} > 0 \qquad (2.8)$$

from (2.6) and (2.7).

Note that if firms that import intermediates directly have access to a wider range of inputs, they may be better able to mitigate shocks relative to other firms. I hence expect input tariff decreases to be associated with a larger decrease in volatility for direct importers. I also explore if the effect of a fall in input tariffs on volatility differs by the extent of differentiated intermediate inputs used in the firm's industry, since I expect availability of a greater variety of substitutes to be crucial for industries that are more susceptible to hold-up problems resulting from imperfect contracting.

Proposition 2: A fall in the output tariff τ_f on the final good produced by the firm is associated with an increase in output volatility.

I posit that a fall in the output tariff on the final good produced by the firm may be associated with a decrease in variable profits, which decreases the number of intermediate varieties n so that

$$\frac{\partial n}{\partial \tau_f} > 0 \qquad (2.9)$$

and hence,

$$\frac{\partial \ln Var}{\partial \tau_f} = \frac{\partial \ln Var}{\partial n}\frac{\partial n}{\partial \tau_f} < 0 \qquad (2.10)$$

from (2.6) and (2.7).

Note that there is a second way by which a fall in the output tariff is associated with greater output volatility. A fall in the output tariff increases the elasticity of demand faced by the firm in the market for its final product, since consumers are now able to substitute to other product varieties. This means that changes in prices brought about by shocks to input prices affecting firm costs translate into greater changes in output, increasing volatility. Overall, I expect a negative relationship between the output tariff and volatility: a lower output tariff would be associated with greater sales volatility.

3. Empirical analysis

The goal of the paper is to analyze the relationship between trade liberalization, captured by a fall in tariffs, and product-level sales volatility of Indian firms. To do this, I employ the following simple linear specification:

$$lnY_{ijw} = \alpha_1 + \beta_1 Input\ tariff_{jw} + \beta_2 Output\ tariff_{jw} + \gamma_{ij} + \delta_w + \epsilon_{ijw} \quad (3.1)$$

Here, Y_{ijw} captures firm i's sales volatility in product j in time window w. I consider two time windows, 1989-1993 and 1994-1998. Tariffs are lagged by one period. Hence, the tariff for window one is the average tariff for 1988-1992, while the tariff for window two is the average tariff for 1993-1997. Product-level sales volatility is calculated using a residual approach as follows[5]. First, the following equation is estimated separately for each window:

$$G_{ijt} = lnS_{ijt} - lnS_{ijt-1} = \theta_{ij} + \mu_{ts} + \vartheta_{ijt} \quad (3.2)$$

G_{ijt} is growth in the logarithm of S_{ijt}, where S_{ijt} is (1+sales of product j produced by firm i at time t), θ_{ij} is a firm-product fixed effect, μ_{ts} are time by industry (2-digit) fixed effects and ϑ_{ijt} is an idiosyncratic error term. I then obtain predicted residuals, which capture deviations in sales growth from the firm-product average for that window, after accounting for industry and time specific shocks to growth. I then calculate volatility as the standard deviation of the residual for the window

$$Y_{ijw} = \sqrt{\frac{1}{w}\sum \hat{\vartheta}_{ijt}^{\ 2}} \quad (3.3)$$

[5] This measure is also used by Kurz and Senses (2013).

where w is the length of the window and $\hat{\vartheta}_{ijt}$ are predicted residuals. The advantage of this approach is that it allows me to control for unobserved sector and time specific shocks to volatility common across all firms.

Since data are at the product level for each firm, I see firms frequently adding and dropping products. Since this extensive margin of product introductions and exits is an important component of volatility, I capture this by recording a value of zero for firm sales if the firm does not produce a product in a given year, and by retaining these firm-products in the sample. However, I exclude years before the year in which the firm first produces the product, and the years after the last year in which I observe the firm producing the product. Note that volatility measures can only be calculated for firm-products that appear for at least three consecutive years in the window-period.

I perform an additional robustness check by using an alternate measure of firm volatility. This is defined as the standard deviation of product sales growth in each window. Here, I can only include firm-products that have at least two unique growth values in each window. This measure is given by[6]

$$\sigma_{ijw} = \left[\frac{1}{w}\sum_{\tau=0}^{w-1}(G_{ijt+\tau} - \overline{G_{\iota Jt}})^2\right]^{1/2} \quad (3.4)$$

I capture trade liberalization by a fall in the import tariff associated with each product. The output tariff is the average tariff rate for product j over the window w. The input tariff is calculated by first obtaining a weighted average of tariff rates applied to products that are used as inputs in the production of product j, defined as:

$$Input\ tariff_j = \sum_p s_{pj} Output\ tariff_p \quad (3.5)$$

where s_{pj} is the value share of input p in product j. I obtain value shares from India's input-output table for 1994-95. Input tariffs are calculated for each year and then averaged over the window. In my preferred estimation of (3.1), I include a set of firm-product and window fixed effects. The firm-product fixed effects account for unobserved firm-product specific shocks that determine volatility and tariffs jointly. Window fixed effects account for unobserved shocks that vary between the two time windows.

[6] This measure is used by both di Giovanni, Levchenko and Mejean (2014) and Kurz and Senses (2013).

I argue that India's trade reform provides a unique opportunity to study the effect of trade liberalization on volatility. India's tariff reform was introduced as a result of an adjustment program imposed by the IMF after a balance-of-payments crisis. Tariffs fell significantly across manufacturing sectors. Both input and output tariffs fell sharply between 1989 and 1997. The tariff reform was unanticipated by Indian firms and tariff changes were uncorrelated with pre-reform firm and industry characteristics (Topalova and Khandelwal, 2011). Hence, to a large extent, using India as a case allows me to account for bias introduced by unobserved shocks driving volatility and tariff cuts simultaneously.

In an extended analysis, I look at heterogeneous effects of trade liberalization across firms and industries, and finally, across Indian states. Specifically, I first study the effects of trade liberalization differentially for firms importing raw material. I do this by interacting the input and output tariff with an indicator variable that takes on a value of one if the firm imports raw material in any year in the window. Next, I examine the effects of trade liberalization across industries that require varying proportions of differentiated inputs in production. I interact my tariff variable with an industry-level measure obtained from Nunn (2007) that is the fraction of differentiated inputs required for production (measuring contract-intensity of the product)[7]. Finally, I also interact tariff variables with a state-level dummy that equals one if the state is a pro-employer state (Besley and Burgess, 2004), a coastal state or an economically lagging state (Krishna, Mitra and Sundaram, 2010).

4. Data

Data on product-level sales for Indian firms are obtained from the Center for Monitoring the Indian Economy's (CMIE) Prowess database. I use data on all manufacturing firms from 1988 through 1998, though I lose the first year in my analysis, since I calculate growth rates for firm product-level sales. The dataset also includes information on the value of firm-level raw material imports. I classify a firm as a raw material importer in a given window if it imports a

[7] Contract intensity measures are for the US for 1997. However, I argue that the ranking of most contract-intensive products (or products that use more differentiated inputs) should remain similar across countries assuming similar technology. This data can be accessed at http://scholar.harvard.edu/nunn/pages/data-0 (accessed in July 2014).

positive value of raw material in any year in that window. My analysis includes 8,432 firm-products[8]. Tariff data are nominal rates of protection at the commodity (product) level.[9]

Table 1 (A), Rows (1) through (3) provide percentages of firms that import raw material and capital goods from abroad. In the most recent window (1994-1998), 27 percent imported both raw material and capital goods, 27 percent imported only raw material and 14 percent imported only capital goods. Rows (4) and (5) report output and input tariff rates for each window. The output tariff fell drastically from 144 percent to 53 percent between the two windows, while the input tariff fell from 133 percent to 48 percent, a roughly 60 percent decrease in protection. Table 1(B) reports mean volatility for broad industry groups. Textile and Apparel and Food are the most volatile industries and Other Manufacturing and Chemicals the least.

5. Results

5.1 Trade Liberalization and Sales Volatility

Table 2 presents results for specification (3.1). The first column includes window and product fixed-effects. Hence, it relates changes in volatility of firm sales in products that experienced large tariff cuts relative to products that experienced smaller cuts. Column (2) adds firm fixed-effects to account for unobserved firm-specific factors driving sales volatility. Results show that a ten percentage point decrease in the output tariff is associated with a 0.8 percent increase in volatility and a ten percentage point decrease in the input tariff is associated with a two percent decrease in volatility. Neither effect is estimated precisely. Note that if a firm produces a product in the first window, and does not produce that product in any year in the second window, I cannot observe volatility of that firm-product in the second window. If trade liberalization is associated with the exit of firm-products that are systematically more or less

[8] The CMIE Prowess database comes with its own product codes for products produced by firms that correspond closely to the Harmonized System (HS) 4-digit classification. My tariff data are at the commodity level, which corresponds to commodity codes in India's Input Output Transactions Table (IOTT) 1994. I map both these to Harmonized System (HS) codes and thereby assign tariffs to each CMIE product.

[9] A description of the tariff data can be found in Hasan, Mitra and Ramaswamy, 2007.

volatile, my estimate of the impact of trade liberalization on firm-product sales volatility in column (2) may be driven by selection.

To account for this, and for other unobserved shocks at the firm-product level, I present results with firm-product fixed-effects in column (3). Hence, I relate changes in volatility between the two windows for each firm-product to changes in the input and output tariffs. I use this as my preferred specification. Results from column (3) show that a ten percentage point decrease in the output tariff is associated with a one percent increase in volatility, while a ten percentage point decrease in the input tariff is associated with a decrease in product-level sales volatility of four percent. Both coefficients are now statistically significant.

Since I look at product sales for each firm, I am able to rule out specialization by firms in their more competitive products as a source of increased volatility due to trade liberalization. Also, I am able to isolate the effects of a fall in the output tariff on firm sales volatility from the effects of a fall in the input tariff. Results are consistent with the hypotheses proposed in Section 2. A lower output tariff can raise volatility by decreasing variable profits, hampering firms from diversifying across input varieties which can help mitigate shocks and/or increasing the elasticity of final demand. A lower input tariff can allow firms to better mitigate shocks by substituting intermediate input varieties.

I now look for evidence that the tariff effects I observe primarily operate via the channels I posit in my conceptual framework. In column (1) of Table 3, I look at trade liberalization and volatility of raw material expenditure at the firm level[10]. The idea here is that if trade liberalization results in input price shocks translating into greater volatility in output, I would expect to see this reflected in raw material expenditure at the firm level. Similarly, if trade liberalization affects firms' abilities to diversify across input varieties, this would be reflected in total raw material expenditure at the firm level. I find in column (1) that this is indeed the case. A fall in the output tariff is associated with greater volatility in raw material expenditure, and a fall in the input tariff is associated with a decrease in volatility in raw material expenditure.

In column (2) I restrict my sample to a balanced panel of firm-products. I only include those firm-products with positive sales values for each year between 1988 and 1998. This restricts my sample to firm-products that did not see any volatility due to entry and exit over the

[10] I do not have data on raw material expenditure for each product produced by the firm.

time period. I find that both the output and input tariff effects are no longer very precisely estimated. This suggests that the effect of trade liberalization on volatility operates mainly on products that are offered at the margin.

In column (3), I add the log of product unit-value as a control variable in my estimation of (3.1). Krishna and Levchenko (2013) argue that more complex products tend to be more volatile. If trade liberalization is associated with changes to product complexity, and if unit-values can serve as a rough proxy for product complexity, adding this control will enable me to account for this particular channel. Results in column (3) show that my baseline results still retain their flavor, suggesting that though this channel may be important, it cannot be the sole explanation for the tariff effects I identify. Hence, overall, results in Table 3 provide support for the ideas proposed in Section 2 on the channels through which trade liberalization affects product sales volatility of firms.

5.2 Robustness Checks

I conduct a battery of robustness checks in Table 4. Panel A employs an alternate volatility measure and also adds control variables to the estimation. Panel B tests for robustness of the key result to various initial conditions. I start with Panel A. In column (1), I use the alternate volatility measure given by the standard deviation of product sales-growth in each window (equation (3.4)). I find that results remain qualitatively similar, though the coefficient on the input tariff drops slightly.

In column (2), I explore the idea that trade liberalization affects volatility (which I measure as the standard-deviation of sales growth) through its effect on mean sales growth. In other words, if a fall in the input tariff were associated with a drop in firm growth in product-sales, and if it were the case that firm-products with lower growth rates are systematically more or less volatile, results might be driven by this phenomenon rather than by diversification across inputs. To tackle this, I introduce the mean of firm-product sales growth as a control variable in the baseline estimation. Note that I have to use the alternate volatility measure in this case, since by construction, the mean firm-product sales growth for each window under the residual approach is zero. Results are robust to the addition of this control. Column (3) addresses the same concern, but with the level of firm sales (to proxy for size). I hence introduce mean firm

sales in each window as a control variable. I measure volatility using the preferred residual approach. I find that results remain robust in flavor and magnitude.

In Panel B, I address the concern that tariff decreases may be correlated with unobserved initial conditions, which might bias my estimates. I interact initial firm-product volatility, initial mean firm-product sales growth and initial firm sales with window effects in columns (1), (2) and (3) respectively. Again, in column (2), I measure volatility using the alternate measure. I find that across all columns, coefficients on the tariff variables are consistent in sign, significance and are of roughly the same magnitude. In fact, in column (1), magnitudes of the tariff effects are larger, suggesting that not accounting for pre-existing trends underestimates the impact of a fall in tariffs on firm-product volatility.

5.3 Heterogeneity in Trade Liberalization Effects

In Table 5, I look at heterogeneous effects of trade liberalization for importing firms and across industries that employ more differentiated intermediate inputs. In column (1), I interact both tariff variables with an indicator variable for if a firm is a raw material importer in any year in the window period. Results in column (1) suggest that the impact of a fall in the input tariff on product-level sales volatility is much stronger for firms that directly import raw material from abroad. A fall in the input tariff is associated with a greater decrease in volatility for firms that import raw material. I do not observe a strong differential effect for the output tariff. Again, this is consistent with the idea that raw material importers may be better able to mitigate input price shocks by substituting to alternate varieties, while the effect of the output tariff that operates by increasing the elasticity of demand for the final product might operate more uniformly across firms.

In column (2), I interact each tariff variable with a measure of contract intensity from Nunn (2007). Nunn classifies a product as contract-intensive if it uses a greater fraction of differentiated inputs. The idea is to ascertain if products that are more intermediate input intensive and require more differentiated inputs into production see greater decreases in volatility due to trade liberalization. This is likely if firms that produce products requiring more differentiated inputs are more susceptible to shocks in their intermediate input markets due to imperfect contracting issues, and when they are subject to such shocks, are less able to substitute toward other suppliers when they are faced with fewer intermediate varieties. In this case, trade

liberalization may be expected to have a greater impact on them by offering opportunities to find alternate suppliers of intermediate inputs, relative to other firms. Results confirm this hypothesis. From column (2), the input tariff effect is evident for industries that use a greater proportion of differentiated relative to homogeneous inputs. Again, I do not observe a differential effect for the output tariff, consistent with theory.

In Table 6, I ask if trade liberalization in India was associated with differential effects on volatility across firms in states with relatively stringent labor regulation (column (1)), in coastal versus inland states (column (2)) and in leading versus economically lagging states (column (3)). Data on labor regulation are from Besley and Burgess (2004) and data on leading and lagging states are obtained from Krishna, Mitra and Sundaram (2010). If tariff transmission to domestic prices differs across regions in the country given India's shortfalls in infrastructure and service delivery that have resulted in high transport costs within the country, then I expect the effects of trade liberalization to vary across geographical regions within the country.

However, I find no evidence for such heterogeneous effects. In fact, from column (2), I find weak evidence (p-value=0.096) that firms in inland states benefited more from trade liberalization than firms in coastal states. The interactions of tariff variables with the flexible (labor regulation) and lagging state dummies are not statistically significant, suggesting that trade liberalization effects were uniform across these states. These results are consistent with earlier work by Goldberg, Khandelwal and Pavcnik (2010) who also document lack of differential trade liberalization effects on firm product scope across Indian states during the period of the reform.

6. Conclusion

In this study, I look at the impact of trade liberalization on product-level sales volatility. I find evidence that a decrease in the output tariff is associated with greater volatility, and a decrease in the input tariff is associated with lower volatility for Indian manufacturing firms, with the latter effect dominating the former. My study highlights an additional channel for gains from trade. Better access to intermediate input varieties can allow firms to mitigate shocks in intermediate input markets, smoothing production. This is an important concern for developing economies, where mechanisms to effectively deal with volatility in prices, and uncertainty in

employment, are limited, and a majority of the population lives without access to adequate social security nets.

Table 1(A): Descriptive Statistics

	1989-1993	1994-1998
Importers of Raw Material AND Capital Goods (% firms)	26	27
Importers of ONLY Raw Material (% firms)	31	27
Importers of ONLY Capital goods (% firms)	14	14
Output Tariff (%)	144	53
Input Tariff (%)	133	48

Source: CMIE data, author's calculations; Hasan, Mitra and Ramaswamy (2007)
Notes: A firm is classified as an importer if it imports in any year in the relevant time-period. Tariffs are nominal rates of protection.

Table 2(B): Mean Volatility, 1989-1998

Broad Industry Group	**Mean Volatility**
Food	0.76
Textiles/apparel	0.82
Leather/Wood/Paper	0.74
Chemicals	0.63
Pharmaceuticals	0.68
Rubber/Plastics/Nonmetallic Minerals	0.65
Metals	0.70
Machinery	0.65
Transport Equipment	0.72
Other Manufacturing[2)]	0.54

Source: CMIE data, author's calculations
Note: 1) Volatility is calculated using the residual approach and averaged over the two window-periods 1989-1993 and 1994-1998. 2) Other Manufacturing includes product categories like jewellery, toys, sports goods, musical instruments and medical instruments and supplies.

Table 2: Tariff Reform and Sales Volatility, 1989 – 1998

	(1)	(2)	(3)
Lagged Output tariff	-0.0002	-0.0008	-0.0012
	[0.0006]	[0.0006]	[0.0006]
Lagged Input tariff	0.0002	0.0019	0.0042
	[0.0012]	[0.0014]	[0.0014]
Window fixed effects	Yes	Yes	Yes
Product fixed effects	Yes	Yes	No
Firm fixed effects	No	Yes	No
Firm x Product fixed effects	No	No	Yes
Observations	12,087	12,087	12,087
R-squared	0.076	0.565	0.002

Notes: 1) The dependent variable is the log of volatility in product-level sales growth for each firm over two windows – 1989-1993 and 1994-1998. It is calculated using the residual approach. Tariffs are average product-level tariffs for 1988-1992 and 1993-1997 2) The analysis includes 8,432 firm-products. 3) Standard errors in parentheses are clustered at the product level.

Table 3: Tariff Reform and Volatility, 1989 – 1998, Further Evidence

	(1)	(2)	(3)
	Firm: Raw Material Expenses	Balanced panel	Firm-product Sales Volatility: Unit-value control
Lagged Output tariff	-0.0027	-0.0014	-0.0015
	[0.0005]	[0.0008]	[0.0006]
Lagged Input tariff	0.0053	0.0026	0.0045
	[0.0014]	[0.0023]	[0.0015]
Firm-products	-	1,149	7,917
Window fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	No	No
Firm-product fixed effects	No	Yes	Yes
Observations	4,802	2,298	11,299
R-squared	0.052	0.006	0.004

Notes: 1) The dependent variable is volatility in product-level sales growth in columns (2) and (3) and volatility in growth of raw material expenses for each firm in column (1), all measured using the residual approach. It is calculated over two windows 1989-1993 and 1994-1998. Tariffs are average product-level tariffs for 1988-1992 and 1993-1997. 2) The regression in column (1) is at the firm level, and not at the firm-product level. Hence, tariffs are 2-digit industry-level tariffs. 3) In column (2), only products that were produced in every year in the time period are included. 4) Column (3) adds a control variable for the log of the unit-value of the product. 5) Standard errors in parentheses are clustered at the product level in columns (2) and (3) and at the industry level in column (1).

Table 4: Tariff Reform and Sales Volatility, 1989 – 1998, Robustness Checks

Panel A: Alternate Volatility Measure and Controls			
	(1)	(2)	(3)
	Alternate volatility measure	Control: Mean firm-product sales growth	Control: Firm sales
Lagged Output tariff	-0.0012	-0.0013	-0.0014
	[0.0006]	[0.0006]	[0.0006]
Lagged Input tariff	0.0028	0.0030	0.0043
	[0.0014]	[0.0014]	[0.0014]
Observations	12,080	12,080	11,192
R-squared	0.004	0.004	0.005
Firm-products	8,426	8,426	7,799
Panel B: Control for Initial Conditions			
	(1)	(2)	(3)
	Initial volatility x window effect	Initial mean firm-product sales growth x window effect	Initial firm sales x window effect
Lagged Output tariff	-0.0018	-0.0013	-0.0014
	[0.0006]	[0.0006]	[0.0006]
Lagged Input tariff	0.0067	0.0026	0.0043
	[0.0011]	[0.0014]	[0.0015]
Observations	8,356	9,779	9,903
R-squared	0.367	0.006	0.005
Firm-products	4,701	6,125	6,477

Notes: 1) The dependent variable is volatility in product-level sales growth for each firm measured as the standard deviation of growth in firm-product sales in Panel A, columns (1) and (2) and Panel B, column (2), and using the residual approach in other columns. Volatility is calculated over two windows 1989-1993 and 1994-1998. Tariffs are average product-level tariffs for 1988-1992 and 1993-1997. 2) Column (3) in panels A and B use total sales at the firm level (across all products) to measure firm size. 3) All columns include window and firm-product fixed effects. 3) Standard errors in parentheses are clustered at the product level.

Table 5: Tariff Reform and Sales Volatility, 1989 – 1998, Heterogeneous Effects

	(1)	(2)
Lagged Output tariff	-0.0001	0.0008
	[0.0008]	[0.0011]
Lagged Input tariff	0.0015	-0.0011
	[0.0017]	[0.0022]
Lagged Output tariff x Raw Material Importer	-0.0016	
	[0.0009]	
Lagged Output tariff x Contract Intensity		-0.0022
		[0.0017]
Lagged Input tariff x Raw Material Importer	0.0031	
	[0.0012]	
Lagged Input tariff x Contract Intensity		0.0068
		[0.0026]
Observations	12,087	12,087
R-squared	0.006	0.007
Firm-products	8,432	8,432

Notes: 1) The dependent variable is volatility in product-level sales growth for each firm over two windows 1989-1993 and 1994-1998. It is calculated using the residual approach. Tariffs are average product-level tariffs for 1988-1992 and 1993-1997. 2) 'Raw Material Importer' is a dummy that equals one if the firm imported a non-zero rupee amount of raw material in any year in the window. 3) Contract intensity is an index from Nathan Nunn (2007), measuring the fraction of differentiated inputs used in production in each industry. 4) All columns include window and firm-product fixed effects. 5) Standard errors in parentheses are clustered at the product level

Table 6: Tariff Reform and Sales Volatility, 1989 – 1998, Heterogeneous Effects across States

	(1)	(2)	(3)
Lagged Output tariff	-0.0006	-0.0016	-0.0016
	[0.0006]	[0.0010]	[0.0006]
Lagged Input tariff	0.0031	0.0062	0.0047
	[0.0016]	[0.0018]	[0.0014]
Lagged Output tariff x Flexible labor state	-0.0020		
	[0.0015]		
Lagged Output tariff x Coastal state		0.0004	
		[0.0011]	
Lagged Output tariff x Lagging state			0.0013
			[0.0013]
Lagged Input tariff x Flexible labor state	0.0021		
	[0.0021]		
Lagged Input tariff x Coastal state		-0.0020	
		[0.0014]	
Lagged Input tariff x Lagging state			-0.0012
			[0.0017]
Observations	10,694	11,685	11,621
R-squared	0.003	0.005	0.003
Firm-products	7,408	8,124	8,075

Notes: 1) The dependent variable is volatility in product-level sales growth for each firm over two windows 1989-1993 and 1994-1998. It is calculated using the residual approach. Tariffs are average product-level tariffs for 1988-1992 and 1993-1997. 2) Flexible labor state refers to a state with flexible labor regulations (pro-employer states), obtained from Besley and Burgess (2004). 3) Coastal state refers to a state situated on India's coastline and hence has a major port. 4) Lagging state refers to a state with per capita income lower than the average for South Asia, obtained from Krishna, Mitra and Sundaram (2010). 5) All columns include window and firm-product fixed effects. 6) Standard errors in parentheses are clustered at the product level.

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