Trade and Growth Over the Life Cycle

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Abstract

This study shows that firms' responses to trade shocks depend on their age. Focusing on India's trade liberalization during the 1990s, we find that when input tariffs decline, younger firms exhibit a significantly larger increase in quantities sold compared to older firms. There is no differential age effect on prices, and thus, younger firms experience greater sales growth relative to their older counterparts. On the other hand, the effects of output tariffs on firm performance do not differ by age. The observed differences are not driven by selection effects, nor are they explained by other age-varying firm characteristics. This indicates that other unobservable traits associated with firm age are crucial in determining their response to trade shocks, which turns firm age into an important observable to consider when evaluating the impact of trade policy changes on firms.

Keywords: Trade liberalization; Firm life cycle; Firm dynamics.
JEL Codes: F14, F61, O24.

1 Introduction

Trade liberalization has profound impacts on firm performance, but these effects are far from uniform. The present paper documents that the life cycle of firms constitutes an important factor mediating these heterogeneous effects. We argue that firm age is a critical dimension in understanding heterogeneous firm behavior and performance for two main reasons. First, age serves as an observable and easily measurable characteristic that acts as a sufficient statistic for many unobserved attributes, such as experience, organizational learning, and the accumulation of intangible assets. By focusing on age, we can infer and study these underlying dynamics without directly observing them, making it a practical tool for both researchers and policymakers. Second, because as surviving firms are bound to mature, supporting younger firms today holds long-term promise: as firms age, they often become more productive, resilient, and innovative. Policies aimed at helping young firms overcome early-stage challenges, are therefore investments in future economic dynamism and growth. This opens the door for effective policy to be temporary and concentrated on the early-years of firms. The latter is a matter that should be of interest both for academic research and for the design of trade and industrial policies.

We first make use of a well-known case: trade liberalization in India in the 1990's. It has been extensively documented that the reduction of the tariff schedule in this case followed broad structural reforms and can be considered as exogenous to firms (see De Loecker et al., 2016). The dataset that we use as our main source (PROWESS), comprise information on a broad scope of firm-level dimensions that enable us to evaluate the extent to which the age effect that we find is correlated to other observables. We document that age mediates the effect of input tariffs on firm revenues and quantities sold. Lowering import tariffs on the products that are used as inputs by a firm has a positive effect on revenues and quantities sold for young firms. But this effect becomes smaller the older firms are. On the other hand, lowering import tariffs on the products that firms sell lowers revenues and quantities sold, but there is no differential effect by age.

As firms mature, many of their characteristics evolve. We exploit the extensive information contained in PROWESS to explore whether any of the observable dimensions that can change with firm maturity are responsible for the age effect that we find. The set of dimensions include: efficiency levels, market power (mark-ups), output product scope, capital intensity, labor intensity, export intensity, imported input intensity, financial constraints, and output quality. We find that none of the above characteristics wipe the age effect found, suggesting that the mediating effect of age should be rooted in unobservable characteristics of firms evolving through the life cycle. This highlights the importance of including age as a relevant factor when analyzing firm responses to trade shocks.

Our observation that younger firms respond differently to trade shocks could be based on two different mechanisms. First, firms could change different characteristics as they age. This mechanism can explain our result without relying on initial differences across firms. On the other hand, there could be within-cohort selection. One could think of a setting where firms initial heterogeneity is substantial and, as time goes by, successive shocks force the more responsive firms out. In such a setting, we would still observe older cohorts being less responsive to reductions in input tariffs, even if individual firms do not change much with age in any relevant characteristic. To explore the extent to which selection drives our results, we replicate our main specification for a balanced panel containing only firms that survive the entire period. In this exercise, older cohorts feature no selection advantage with respect to younger cohorts, since both comprise only those firms that survive similar periods of time. Our results are very similar to our baseline results, which we interpret as selection not being an important force behind the heterogeneous effects across cohorts.

Furthermore, we study whether tariffs lead to a different response in terms of product creation and destruction by firm age. It turns out that younger firms are less likely to start producing a new product (for them) when the input tariff decreases compared to old firms. Whereas young firms are more likely to stop producing a product when the input tariff declines. We do not find a differential age effect on product entry and exit in response to changes to the output tariff.

Our paper speaks to the literature analyzing how the reaction to shocks depends on firm's characteristics, and highlighting age as an important dimension.

More broadly, our paper speaks to two main strands of literature. The international trade literature has highlighted the heterogeneous responses of firms to trade shocks, emphasizing that differences in productivity play a critical role in shaping outcomes.[1] A separate strand of research has examined how firms evolve over their life cycle, improving their efficiency level among other things.[2] This life-cycle perspective provides an essential framework for understanding firm heterogeneity, yet it remains underexplored in the context of firms' responses to external shocks such as trade liberalization. The present paper bridges these two streams of literature by examining how firms' positions in their life cycle influence their responses to trade liberalization. Using a firm-level dataset that captures detailed information on age, size, and other firm characteristics and performance metrics, this study investigates the interaction between trade cost changes and firm age. The findings reveal that younger firms, characterized by higher growth potential and adaptability, exhibit different responses compared to older firms, which often rely on established networks and routines. By integrating insights from trade and firm dynamics research, this paper sheds new light on the mechanisms through which trade liberalization impacts firms, contributing to a deeper understanding of heterogeneity in trade effects.

Finally, our paper can also speak to the literature highlighting a productivity slowdown experienced in many western economies over the last two decades.[3] As shown in Decker et al. (2017) for the case of the US, the declining dynamism experienced by firms is among the main causes of the aggregate slowdown. The same period is one where trade costs fell sharply for developed economies. In particular, trade competition increased greatly since the entrance of China to the WTO in 2000. By showing that younger firms are more vulnerable to trade policy changes, we put forward a new mechanism that contributes in explaining the rise in concentration, and the fall in business dynamism that accounts for a large part of the slowdown.

[1] The early works by Clerides et al. (1998) and Bernard and Jensen (1999) showed that exporters and domestic producers had different characteristics, paving the way for a long literature documenting the heterogeneous effects of trade by productivity levels using the frameworks of Eaton and Kortum (2002) and Melitz (2003) as points of view. In these, trade liberalization induces resource reallocation, leading more productive firms to expand and less productive firms to exit. Subsequent studies have refined these insights, exploring how factors such as innovation capacity (Bloom et al., 2016), input sourcing strategies (Halpern et al., 2015), and access to credit (Manova, 2013) determine firms' ability to adapt and thrive in the face of global competition.

[2] The firm dynamics literature shows that younger firms typically experience rapid growth, higher volatility, and higher rates of entry and exit (Hopenhayn, 1992; Haltiwanger et al., 2013), while older firms tend to exhibit more stable but slower growth and greater resilience to shocks (Davis et al., 1996; Caves, 1998). The literature has underscored the critical role of age in shaping firm behavior, including investment decisions, innovation rates, and market competitiveness (see, for example, Evans, 1987 or Fort et al., 2013).

[3] See for example Gordon (2017).

The rest of the paper is structured as follows. Section 2 discusses the data used and Section 3 provides more background to the trade liberalization episode in India. The results are presented in Section 4 while Section 5 concludes.

2 Data

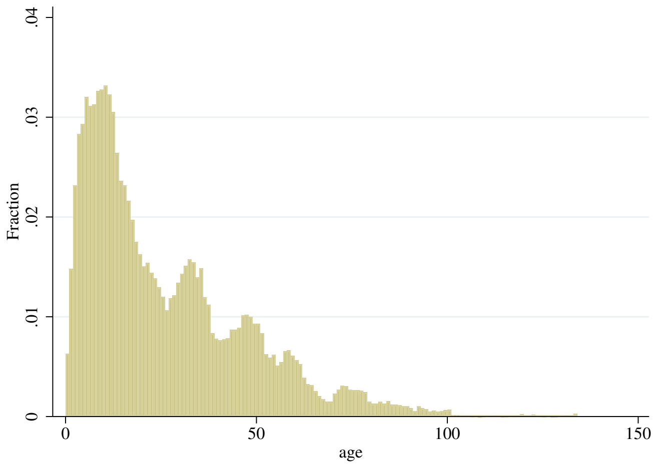
We use data on Indian firms from PROWESS. This includes panel data at the firm level and at the product level. Firm-level variables we use include year of incorporation, total sales revenue, capital, labor, materials, export earnings, financial frictions, and the industry in which the firm is (mainly) active. Age of the firm is defined as number of years after incorporation. Note that the incorporation year is the year in which the company came into existence as a distinct legal entity, which does not always correspond to the year in which the enterprise came into existence. A company may have a relatively recent year of incorporation because of privatization, corporate re-structuring, a demerger, or because the enterprise existed as a partnership or as a proprietorship before it was incorporated as a company.

Product-level variables we use are production quantity and its unit of measurement, sales quantity and its unit of measurement, and sales value. Products are classified according to 20-digit Centre for Monitoring Indian Economy (CMIE) codes, giving some 800 unique products in the estimation sample. In addition, we use data on Indian output and input import tariffs at the product level in the years 1989-2001 from Topalova and Khandelwal (2011) and De Loecker et al. (2016). The output tariffs are simply the observed import tariffs, while the input tariffs are constructed using the input-output table. Namely, the input tariffs are a weighted average of the output tariffs on all the inputs used to produce a given product, where the weights come from the 1993-1994 input-output table for India.

To reach our final estimation sample, we drop financial firms. We then merge in the product-level data, including the tariffs. In the tariff data, products are classified according to the National Industrial Classification (NIC), thus we make use of a concordance table in order to match these codes to the CMIE codes from the PROWESS data. We drop observations for which we do not have tariff data. Furthermore, we focus on the years 1989-1997 since Topalova and Khandelwal (2011) find some evidence against orthogonality of the tariff shock to sectoral productivity for the period after 1997. See the appendix for more details on the data cleaning process.

PROWESS does not cover the universe of firms. It contains information on all listed companies in India and a subset of unlisted companies. For our purposes, it matters whether firms of a given age are representative of all Indian manufacturing firms of that age. Figure 1 shows a histogram of the distribution by age. Although there are firms present for any age up to age 100, there are relatively few firms at the low end of the age distribution. If the entry rate is constant over time we would have that the number of firms of a certain age in a given period of time is declining in age. This does not hold for the youngest firms. For instance, there are fewer 2-year-old firms present than 3-year-old firms. This suggests that selection is most worrisome for the the youngest firms. Therefore, in our baseline analysis we exclude the firms that are younger than six years old. Figure 1 also shows there are relatively many firms aged around 50. These are the firms that were founded around the time of India's independence.

Figure 1: Histogram of age distribution



3 Background: trade liberalization in India

Following its independence, India's development strategy relied largely on import substitution policies which entailed large tariffs. By the late 1980's the economy was widely considered as one of the most protected against international trade in the world. This strategy concluded in a massive balance of payments crisis that required the injection of foreign currency. In 1991 the government signed an agreement with the IMF, according to which India had to drastically reduce tariff levels and non-tariff barriers among other things.

This episode has been exploited extensively in the trade literature as many of its characteristics conform a setting with a sufficiently exogenous shock to firms. First, the reduction of tariffs came as a surprise to firms as it was sudden, proposed by an external body and approved by a government where most figures were openly against these kind of measures in the past (Hasan et al., 2007). The adjustment program was approved promptly and with little debate so as to avoid political opposition. Second, the aim of the tariff cut was to bring all tariffs to relatively similar and much lower levels. Topalova (2010) documents indeed a strong correlation between the pre-reform tariff levels and the decline in tariffs experienced by the industry. This resulted in the mean tariff falling from 128% in July 1991 to 35% in 1997, and the standard deviation falling from 41 percentage points to roughly 15 over the same period (Hasan et al., 2012). This harmonization of trade tariffs implies that the most affected sectors are the ones that faced high tariffs initially, while trade policy was set earlier and remained largely the same while the economy evolved. Indeed, Topalova and Khandelwal (2011) shows that output tariff changes during the trade liberalization were uncorrelated with preexisting firm or industry characteristics. Goldberg et al. (2010) presents similar evidence for changes in the schedule of input tariffs.

The literature has also argued that vested-interests do not seem to have affected the intensity or timing of the tariff changes during this reform. As opposed to that, similar evidence has not been presented for the reform in 1997, which is why most of the subsequent literature focuses on tariff-changes over the period 1989-1997 as do we.

4 Results

In this section, we study how changes in trade tariffs affect firm outcomes based on the age of the firm. Firms face product-specific trade tariffs. This allows us to exploit variation in tariffs within a firm-product pair over time. That is, we control for firm-product fixed effects, as well as industry-year fixed effects. This gives the following regression equation,

$$y_{ijt} = \beta_1 \tau^{out}_{jt} + \beta_2 \tau^{out}_{jt} \times Age_{it} + \beta_3 \tau^{in}_{jt} + \beta_4 \tau^{in}_{jt} \times Age_{it} + \alpha_{ij} + \lambda_{st} + \varepsilon_{ijt} \, , \tag{1}$$

where y_{ijt} denotes the outcome variable for firm i, product j in year t. α_{ij} denotes the firm-product fixed effect, λ_{st} the industry-year fixed effect and ε_{ijt} the error term. Our coefficients of interest are β_2 and β_4, which measure the extent to which older firms respond differently to changes in tariffs. We cluster standard errors at the industry level.

Note that equation (1) does not allow us to identify the effect of age by itself on the outcome variable. This is due to the presence of both firm fixed effects and time fixed effects, which absorbs all variation in age. However, due to the variation in tariffs over time we do identify the differential response of tariff changes by age. Equation (1) assumes that the differential effect by age is linear. Later in this section we will discuss non-linear effects.

Table 1: Effect of tariffs on log sales

	(1)	(2)
τ^{out}	0.214***	0.190
	(0.0541)	(0.139)
τ^{out} x age		-0.00166
		(0.00450)
τ^{in}	-0.570	-1.373*
	(0.517)	(0.711)
τ^{in} x age		0.0424***
		(0.0142)
N	30877	25711
R^2	0.117	0.121

This table shows the effects of an increase in the tariff by 100 percentage points. This table only includes firms that are between 6 and 50 years old. Standard errors clustered at the industry level are reported in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1 shows the effect of the tariffs on log sales. The first column ignores age and shows that higher output tariffs lead to higher sales. When output tariffs increase by 10 percentage points, log sales increases by 0.0214. This coefficient is statistically significant. This result is expected as a higher import tariff on the product that a firm produces means that the firm is more protected from competition from abroad. The input tariff shows a negative coefficient, though insignificant. A negative effect is expected as a higher input tariff means it becomes more expensive to import the inputs needed for production, therefore lowering the competitiveness of firms using those inputs.

The second column of Table 1 includes as regressors age interacted with both the output and input tariff respectively. Younger and older firms do not respond differentially to changes in the output tariff. On the other hand, the interaction effect between age and the input tariff is positive and significant. When the input tariff increases by 10 percentage points a firm that is 10 years old lowers its sales by 0.1 log points, while a firm that is 30 years old does not change its sales on average after a change in tariffs.

Non-linear age effects

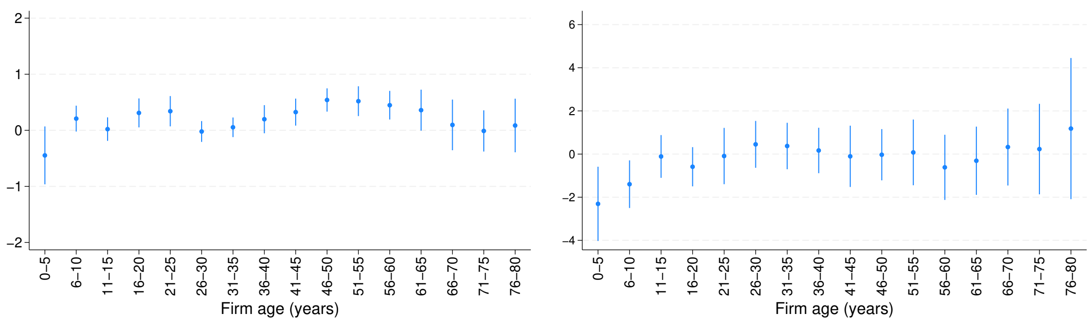
The results in Table 1 show the average results for firms between the ages of 6 and 50. In the construction of that table we exclude firms that are younger than 6 as sample selection is the most worrisome for this subset of firms. We also exclude firms older than 50 as there might be non-linear effects and there is ex ante no reason to believe that firms that are 70 years old are affected differentially by tariff changes compared to firms that are 60 years old. Furthermore, Table 1 shows the linear effects of age, but it is of course likely that the true effects are non-linear. It seems natural that a twenty-year-old firm responds differently than a ten-year-old firm, while it is not clear why a fifty-year-old firm responds differently than a forty-year-old firm.

To study the non-linear age effects we group firms in age bins of five years,

$$y_{ijt} = \beta_1 \tau_{jt}^{out} + \sum_b \beta_2^b \tau_{jt}^{out} \times Age_{it}^b + \beta_3 \tau_{jt}^{in} + \sum_b \beta_4^b \tau_{jt}^{in} \times Age_{it}^b + \alpha_{ij} + \lambda_{st} + \varepsilon_{ijt} \,. \quad (2)$$

$Age_{it}^b = 1$ if firm i in year t is in age bin b and otherwise Age_{it}^b equals zero.

Figure 2: Differential effect of output tariffs and input tariffs on log sales by firm age



(a) Effect of output tariffs (β_2^b) (b) Effect of input tariffs (β_4^b)

Figure 2 shows the non-linear effects for the output and input tariffs respectively. For completeness, we also include here firms younger than six years old, and firm older than fifty. As panel (a) shows, we do not find a strong effect by age when the output tariff changes. The effect does, however, fluctuate by age. For instance, firms between 16 and 25 years old present a stronger response than firms between 26 and 35 years old. However, as shown by Table 1, there is no statistically significant effect when we treat age as a continuous variable. The exception is perhaps the effect for firms five years or younger. The coefficient is -0.5 and markedly different than the other coefficients. However, the latter result might be due to selection which is most prevalent for the youngest age group as there are relatively few firms in this age group.

Panel (b) documents a clear non-linear age relationship of the input tariff on sales. Young firms respond negatively in terms of sales with respect to an increased tariff while for older firms there is no such effect. The age threshold after which the effect disappears is not high: we find no effects for firms belonging to all age bins from 30 years old onward. The differential age effect is significant on average, as shown by Table 1, for firms between the ages of 6 and 50.

Prices versus quantities

The above effects on sales could be due to differential age effects on either prices or quantities, or both. Table 2 shows the results of estimating equation (1) when the outcome variable is the log price and the log quantity, respectively.

Table 2: Effect of tariffs on log prices and log quantity

	prices		quantities	
	(1)	(2)	(3)	(4)
τ^{out}	0.200***	0.196	0.0280	0.0106
	(0.0476)	(0.145)	(0.0549)	(0.177)
τ^{out} x age		-0.00201		-0.000631
		(0.00487)		(0.00553)
τ^{in}	-0.0910	0.654	-0.511	-2.078***
	(0.293)	(0.681)	(0.389)	(0.567)
τ^{in} x age		-0.0119		0.0559***
		(0.0145)		(0.0157)
N	29002	24168	29002	24168
R^2	0.130	0.114	0.036	0.042

This table shows the effects of an increase in the tariff by 100 percentage points. This table only includes firms that are between 6 and 50 years old. Standard errors clustered at the industry level are reported in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Recall that Table 1 shows an overall positive effect of output tariffs on sales. Table 2 highlights that this is due to a positive effect on prices while the output tariff has no effect on quantities (columns 1 and 3). Moreover, the negative effect of input tariffs found above is mainly associated with a negative effect on the quantity sold.

Focusing on the age-tariff interaction effect, Table 1 does not show a differential effect of the output tariff on revenue by age. In theory, this could be because there are two opposing effects on prices and quantities. Table 2 shows that this is not the case and that there is no differential effect by age of the output tariff on both prices and quantities. Finally, column 4 shows that the positive age effect of input tariffs on revenues is due to a positive effect on quantities, while there is a weak negative effect on prices. Thus, young firms that face a decline in input tariff respond more in terms of increasing their quantity sold compared to old firms.

Also here, the effect on prices and quantities could be non-linear. Figure 4 in Appendix B shows there is some variation by age in terms of the effect of tariffs on prices, but no clear pattern emerges. This is in line with the results of Table 2. Figure 5 in Appendix B shows there are no strong non-linear age effects of output tariffs on the quantity (except for the youngest age category). However, the second panel of this figure shows that firms up to 20 years are more negatively affected by input tariffs in term of quantity sold than older firms.

Explanations for age effect

The results above document that young firms respond differently to changes in input tariffs than old firms do. There could be many reasons for this. Is it for instance the case that old firms respond differently because they are larger, or because they have a higher productivity? The literature has highlighted many observable characteristics as important determinants of how firms react to shocks. In this section we evaluate the degree to which such observables can be the cause of the differential effect by age found here.

To do so, we include in our regression additional mediation variables that we interact with the tariffs,

$$y_{ijt} = \beta_1 \tau_{jt}^{out} + \beta_2 \tau_{jt}^{out} \times Age_{it} + \beta_3 \tau_{jt}^{in} + \beta_4 \tau_{jt}^{in} \times Age_{it} + \beta_5 x_{it} + \beta_6 \tau_{jt}^{out} \times x_{it} + \beta_7 \tau_{jt}^{in} \times x_{it} + \alpha_{ij} + \lambda_{st} + \varepsilon_{ijt} \,. \quad (3)$$

x_{it} denotes the mediation variable, which varies only at the firm level as does age. Suppose that the effect of age is completely explained by large firms responding differently to tariffs compared to small firms, and that old firms differ in their size compared with young firms. In that case, if x_{it} denotes firm size, we would expect that β_2 and β_4 become zero when x_{it} is included. On the other hand, when adding the variable x_{it} does not significantly change the coefficients β_2 and β_4 compared to our baseline estimate, this suggests that the age effect does not come from differences in x_{it} along the life cycle.

Table 3 shows the effects on the tariff times age interaction term when a range of mediation variables are included one by one. We aim at being comprehensive in the list of observables utilized for this exercise and include variables that cover different relevant dimensions of the firm: their size, efficiency level, market power, input mix, product scope, financial position, openness level, and the quality of the products they sell. Given that the interaction term for the output tariff is not significant, we only include the coefficients on the input tariff in Table 3. However, the regression does also include the output tariff as shown in equation (3).

The first column repeats the baseline result from Table 1 showing that there is a positive interaction effect of input tariffs and age. The second column shows that when x_{it} is equal to firm size measured by firm-level sales (in logs), the larger firms have higher product-level sales (0.151), and that there is a negative interaction effect between firm size and the input tariff (-0.118) though insignificant. However, the interaction effect between age and the input tariff, our coefficient of interest, does not change much when firm size is included in the regression. This implies that the age interaction effect is not directly due to firms differing in their size by age. It is relevant to note here that as the left-hand side is product-level sales there is by construction a relationship between x and y. For instance, for single-product firms all variation in y would be absorbed by x in this case. Likewise, also for multi-product firms there is a mechanical relationship as high sales at the product level will also lead to high sales at the firm level. Therefore, to measure the effect of firm size we measure firm size here as firm-level sales of the other products each firm is producing (thus, this equals firm sales leaving out sales of the product that is on the left-hand side). We only run this regression for multi-product firms. Column 3 uses the number of products each firm is

Table 3: Effect of tariffs on log sales with mediation variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Mediation var		sales (log)	number products	TFP (log)	sales/L (log)	markup (log)	K/L (log)	M/L (log)	export/sales	import M (%)	fin fric	liab/sales (log)	quality
τ^{in}	-1.373*	-0.473	-1.199	-0.538	0.201	-0.862	-1.002	-1.117	-1.656**	-2.169***	1.202	-1.455*	-1.666**
	(0.711)	(0.902)	(0.822)	(0.971)	(1.510)	(0.900)	(1.187)	(0.826)	(0.790)	(0.769)	(2.038)	(0.780)	(0.743)
τ^{in} x age	0.0424***	0.0364**	0.0414**	0.0454***	0.0453**	0.0468***	0.0307*	0.0514***	0.0531**	0.0396*	0.0378	0.0402***	0.0460***
	(0.0142)	(0.0158)	(0.0172)	(0.0144)	(0.0189)	(0.0148)	(0.0174)	(0.0153)	(0.0212)	(0.0202)	(0.0461)	(0.0147)	(0.0139)
x		0.151***	0.00624	0.394***	0.889***	-0.114*	-0.0786*	0.647***	0.365**	-0.00230	-5.943***	-0.625***	0.230***
		(0.0280)	(0.00602)	(0.0785)	(0.0502)	(0.0687)	(0.0470)	(0.0460)	(0.159)	(0.00291)	(0.902)	(0.0521)	(0.0816)
τ^{in} x x		-0.118	-0.00323	-1.136***	-0.520*	-0.878***	-0.0598	-0.0507	-0.830	0.0309	8.329	0.151	-0.135
		(0.0867)	(0.0304)	(0.377)	(0.288)	(0.317)	(0.216)	(0.186)	(1.643)	(0.0396)	(5.496)	(0.271)	(0.381)
N	25711	22841	23214	25169	25270	25219	25228	25157	16460	7726	10209	25297	23681
R^2	0.121	0.125	0.119	0.134	0.194	0.133	0.134	0.193	0.149	0.122	0.064	0.183	0.127

This table shows the effects of an increase in the tariff by 100 percentage points. This table only includes firms that are between 6 and 50 years old. Standard errors clustered at the industry level are reported in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

producing as alternative measure of firm size. Also this does not lead to a change in the age times tariff coefficient.

The fourth column shows that when x_{it} is equal to firm-level total factor productivity (in logs), the more productive firms have higher product-level sales (0.394), and that there is a negative interaction effect between TFP and the input tariff (-1.136). However, the interaction effect between age and the input tariff, our coefficient of interest, is virtually unchanged when TFP is included in the regression. Productivity can also be measured in other ways than total factor productivity. Column 5 shows that also when productivity is measured by sales per worker our results are unchanged.

One other reason why firms respond differently is markups. We measure markups by multiplying the output elasticity with respect to materials with sales divided by material expenditure. We assume a Cobb-Douglas production function within industry such that when we take logs the output elasticity is absorbed by the industry times year fixed effect. Column 6 shows that firms respond differently to changes in tariffs based on their markup but it does not affect the age coefficient.

Next, we study whether differences in capital-labor intensity can explain the age effect. Column 7 shows that the age effect is indeed muted when the capital-labor intensity is included. The coefficient of interest goes from 0.0424 to 0.0307. The capital-labor ratio can thus explain part of the age effect we find, but not all of it. Moreover, given the standard errors which are sizable we cannot say at face value whether the difference between the age coefficient in column 7 and column 1 is statistically significant. Column 8 shows that including the material intensity of production—measured by the materials-labor ratio—leads to a somewhat smaller age effect.

Columns 9 and 10 control for the trade intensity of firms, both in terms of imports of materials and exports. In both cases the effect on the age coefficient is modest. One other reason for why firms might respond differently by age is that young firms are more financially constrained than old firms. Therefore, column 11 controls for a measure of financial frictions as proposed by Whited and Wu (2006). The point estimate of the age coefficient does not change much compared to the baseline, but the coefficient is now insignificant due to an increased standard error. The increased standard error results from a decline in the number of observations due to not all firms reporting on each variable that is needed to construct the financial frictions indicator. Therefore, as an alternative we also measure financial frictions by liabilities over sales. The advantage of this measure is that we observe it for almost all firms. Column 12 shows that this leads to a similar age coefficient as in column 11 but now with smaller standard errors and therefore the coefficient remains statistically significant.

Finally, we study whether differences in quality of the goods produced across firms can explain our result. We recover the quality of goods produced by the firm following Khandelwal (2010), as a measure of the size of the market share of a product-firm conditional on the price charged. Column 13 shows that, once more, this does not lead to a large change in the age coefficient.

The main takeaway from Table 3 is that the age effect is not mediated by any of the variables considered for x. Thus, the differential response by age can for instance not be attributed to differences in size or productivity across age groups. The mediation variable that has the largest effect is the capital-labor ratio. But after taking into account differences in capital intensity, the age input tariff coefficient is still 0.0307.

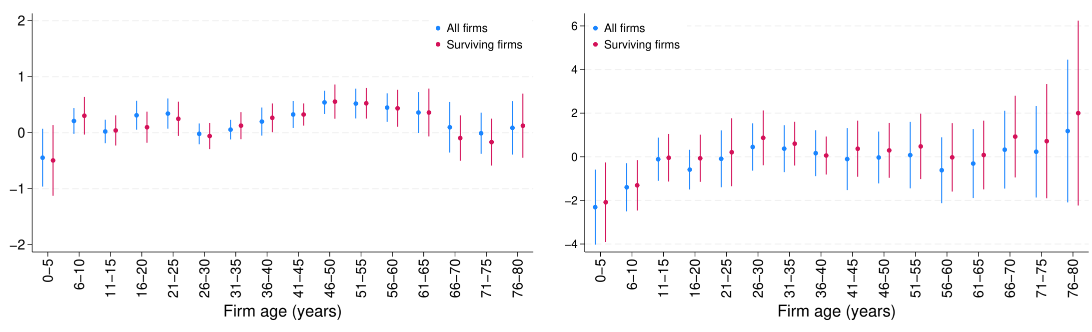
Following a similar procedure, we consider how adding different mediation variables affects the interaction term between age and input tariffs when the outcome variable is product-level quantity. Again, the mediation variables do not remove the age-input tariff interaction coefficient.

Age effect: Selection vs. fundamentals

In the previous section we show that the age effect is not driven by the host of potentially mediating variables we consider there. Next, we ask whether it is age of a firm itself that changes the response of the firm or whether it is driven by selection. For the latter, suppose each firm would react the same to tariffs over its life cycle, but for some reason firms that react more positively to tariffs tend to survive longer. Then older firms react more positively than young firms. However, this would not be because they are older, since they would have reacted the same way when they were younger. Instead, it would be purely due to selection. In a long panel this would be picked up by firm fixed effects. However, we observe each firm over a limited part of their life cycle.

In order to check whether our results are driven simply by selection, or rather, whether age affects firm fundamental characteristics, we compare firms within age groups conditional on survival. Although we consider the trade shock only until 1997, our data continues beyond that year. This allows us to check for how long firms survive after the trade shock, for a period of over 20 years. If firms that survive for an additional 20 years respond similarly to the trade shock as the full set of firms that is present during the trade liberalization, then it suggests that different reactions across age groups to the trade shock are in fact due to the age difference and not due to selection. On the other hand, selection would imply that the effect among all firms of a certain age is different from the effect among the subset of firms of that age which survive at least 20 more years. For example, consider firms of age 10 and of age 30 during the trade reform and suppose they respond differently. Then, consider the subset of firms of age 10 that survive until at least age 30. If the difference between the 10 and 30 year old firms is due to an age effect, then the subset of 10 year old firms surviving until 30 should respond similarly to the full set of 10 year old firms. Conversely, if the difference is due to selection, this subset of firms should instead respond similarly to the 30 year old firms.

Figure 3: Effect of tariffs on log sales for all firms and those that survive at least 20 more years



(a) Output tariff

(b) Input tariff

Figures 3a and 3b show the results of such an exercise in which we compare, within each age bin, the full set of firms to those that survive for at least twenty more years, respectively for output and input tariffs. The effect of both output and input tariffs on sales by age looks very similar comparing the baseline and conditioning on survival for another twenty years. Although in the case of input tariffs the point estimates are higher, they are well within the confidence intervals for the full sample.[4] We conclude that the differences between age groups are not driven by selection.

The identifying assumption in this test is that the selection mechanisms firms faced to reach a certain age in the 1990s are the same as selection mechanisms firms faced afterwards. Or, at least the firms selected in either period should have the same reaction to trade shocks. One can dispute this, in particular the trade shock itself may have changed the survival pressures. Note however, that this would likely lead to a downward bias on the coefficients of the surviving firms. This is because the tariffs were reduced and therefore firms with lower coefficients had better outcomes following the shock. Yet, the coefficients on the surviving firms are not consistently below that of their non-surviving counterparts.

Product entry and exit

So far we have discussed how tariffs affect the sales, prices and quantities of each product firms produce. However, tariffs might also affect whether products are produced in the first place. Here we study the interaction between tariffs and firm age on the extensive margin. Product entry here is a dummy equal to 1 if a product is produced by a certain firm in the present year, but not by the same firm any previous year, and zero otherwise. Product exit is similarly defined as a product that is not produced in the present year, having been produced by the firm in the year prior. Results for product entry and exit follow the similar specifications as used above, and are presented separately in Table 4 and Table 5 respectively.

Table 4: Effect on product entry for incumbent firms

	(1)	(2)
τ^{out}	0.0324	0.0540
	(0.0216)	(0.0438)
τ^{out} x age		-0.000651
		(0.00120)
τ^{in}	0.0278	0.109
	(0.174)	(0.202)
τ^{in} x age		-0.00825*
		(0.00387)
N	31554	26530
R^2	0.066	0.072

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The first column in Table 4 show no statistically significant effect of either the input or the output tariff on product entry for the average firm. However, when we interact the tariffs with age we find that younger firms are less likely to start producing a new product when the input tariff decreases compared to old firms (column 2). A firm that has just started has a 0.011 lower

[4] When we consider firms with a survival horizon of 10 years, the results are even closer to the full sample.

probability to start producing a new product when the input tariff decreases by 10 percentage points, whereas for a 13-year old firm it does not change the likelihood of starting production of a new product when the tariff changes, and for older firms it in fact increases product entry when the input tariff declines.

Table 5 documents the effects of tariffs on product exit. Results parallel those for entry, and indicate the existence of a differential effect by age, where older firms are more likely to reduce their product scope following an increase in input tariffs.

Table 5: Effect on product exit for incumbent firms

	(1)	(2)
τ^{out}	-0.0191	-0.0208
	(0.0154)	(0.0385)
τ^{out} x age		-0.000820
		(0.00154)
τ^{in}	0.0221	-0.0805
	(0.136)	(0.205)
τ^{in} x age		0.00976*
		(0.00491)
N	31105	26145
R^2	0.066	0.073

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5 Conclusions

This paper documents that firm response to trade shocks depends on firm age. We exploit a familiar setting in India's trade liberalization in the 1990's, and find that when tariffs on inputs needed for production change, old firms respond differently than young firms. A decline in input tariffs is followed by an increase in quantities sold, and this reaction is significantly higher in younger firms. There is no differential effect on prices in response to a tariff change, which translates in younger firms experiencing a larger increase in sales, compared to older firms. We do not find evidence of selection as driving our results. Moreover, the age effect is not fully driven by other observables such as firm size, productivity, product scope or quality. While these characteristics typically evolve with age, they cannot fully account for the age effect documented here. This suggests that other features that change with age, and remain unobservable, are relevant when assessing the reaction of firms to trade shocks. Thus, firm age constitutes a valuable statistic that should be included in such evaluations.

The differential response by age to (input) tariffs we find has implications for firm entry and policy. Our results imply that lowering trade tariffs reshapes the revenue stream, which becomes more front loaded, and thus increases the present value of profits over the life cycle. This increased present value makes it more attractive for potential entrepreneurs to enter the market and create new firms. Such an increased firm entry might be favorable for welfare as it increases competitive pressure and leads to a higher variety available for consumers. This provides a new justification for trade liberalization.

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Appendix A Data

We use data on Indian firms from PROWESS, both at the product level and at the firm level. In addition, we use data on Indian output and input tariffs at the product level in the years 1989-2001 from De Loecker et al. (2016).

We consider three inputs into production: labor, capital, and materials. Our measure for labor is the log of compensation to employees. This comprises of salaries and wages and social security contributions (e.g. contribution to an insurance company by an employer to pay for medical care of its employees). It includes paid leaves, profit sharing, bonuses and perquisites and non-monetary benefits (such as medical care, housing, cars, and free or subsidised goods or services) for current employees. It also includes post-employment benefits such as gratuity, pension, provident fund and voluntary retirement benefits.

Our measure for capital is the log of gross fixed assets. The value of gross fixed assets is computed by adding together the historical cost of all fixed assets purchased/constructed, deducting the historical cost of assets sold, and adding or deducting the historical cost of assets coming in or going out at the time of acquisitions, mergers and demergers, etc., as the case may be. This value is thus the sum of gross intangible assets, land & buildings, plant & machinery, computers, electrical installations & fittings, transport infrastructure, transport equipment & vehicles, communication equipment, furniture & fixtures, social amenities and the gross value of any such class of fixed assets.

Our measure for materials is the log of the sum of the expenses incurred on (a) raw materials and on (b) stores, spares and tools consumed. Raw material is the major input for manufacturing companies. Stores and spares aid the production process. These cover sundry supplies, maintenance stores, components, tools, jigs, and other similar equipment.

Other firm-level variables we use are year of incorporation, total sales, export earnings, and the (12-digit 2008) NIC code of the firm's main economic activity. We use the first variable to construct the age of the firm. Note that the incorporation year is the year in which the company came into existence as a distinct legal entity, it is not necessarily the year in which the enterprise came into existence. For example, an enterprise could have existed as a partnership or as a proprietorship for many years before it was incorporated as a company. It could have been a departmental undertaking of the government before privatisation. A company may also have a relatively recent year of incorporation because of a corporate re-structuring. For example, incorporation may result from a demerger or a hive off. While the spun-off business gains a separate legal identity on incorporation, the business did very much exist even prior to incorporation.

Product-level variables we use are production quantity and its unit of measurement, sales quantity and its unit of measurement, and sales value.

Moreover, we consider a host of potential mechanism variables at the firm level. These include size, productivity, markups, the capital/labor ratio, the material/labor ratio, export intensity, import intensity of materials, financial frictions, and quality. Size is measured both as the log of sales and as the log of compensation to employees (our labor measure). For productivity we consider both log labor productivity by dividing sales by labor, and TFP, which is derived assuming a Cobb-Douglas production function. Markups are also derived under the Cobb-Douglas assumption, implying uniform elasticities of substitution. Financial frictions are implemented both as the log of liabilities over sales and as an aggregate index comprised of five indicators, following Whited and

Wu (2006). Finally, quality is the value-weighted average of quality estimations for each product of the firm as in Khandelwal (2010).

Cleaning

We first merge all firm-level data. We drop finance firms from our data as we focus on the manufacturing sector. Data are generally reported over a 12-month period. If the data is reported in the first half of the year, we consider the data as pertaining to the previous year. Most of the time, the reporting date is March 31st, as this is the end of the book year in India. If the data is reported over a different length of time than 12 months, we scale all flow variables to a 'full-year equivalent' before takings logs, if applicable.

It sometimes happens that firms provide multiple reports in the same year, although always at different dates. In this case, we select a single observation per firm-year by going through the following steps in this order: (1) keep the observations with the fewest missings on labor, materials and capital; (2) if at least one observation has 12 reporting months while others do not, drop observations with a different number of reporting months; (3) if at least one observation is reported on March 31st, drop observations reported at a different date; and finally, (4) take the first observation of all remaining duplicates.

The product-level data we also convert to full-year equivalents if applicable. Products have a 20-digit CMIE (Centre for Monitoring Indian Economy) code. We drop observations which do not have a product code or whose product code is not in the 20-digit format.[5] We merge with the firm-level data and only keep observations for which the reporting dates of the product-level and firm-level data matches. We then create two datasets for which observations are selected based on similar conditions but for different variables.

The first dataset contains data on sales value, sales quantity, and prices. Prices are not included in the raw data but we construct them from sales values and quantities at the product level. This means that observations for which both sales values and quantities are missing, carry no relevant information, so we drop them. An important thing to note is that not all quantities are reported in the same units of measurement. When applicable, we convert units to the same metric unit. This goes for the case of weight, length, area, and volume.

Furthermore, there are two issues we have to deal with: bunching and duplicates. Bunching refers to a situation where one observation reports the total sales value or quantity for a set of observations within a firm-year and this data is missing for the other observations in this set. Duplicates refers to a situation in which there are multiple observations of the same product-unit within a firm-year. We deal with these as follows. First, we drop observations which are bunching over different products since there is no way to know the division of the total over the different products. Next, we sum values and quantities over all observations within a firm-year-product-unit set. Finally, we keep only one observation of each duplicate. If, despite the previous steps, an observation does not have data on sales value at this point, we drop it.

The second dataset contains data on production quantities, next to the sales data. In this dataset we use 12-digit product codes by simply removing the last 8 digits of the 20-digit codes. We drop duplicates if none of the observations hold information on one of production quantity, sales quantity, and sales value. Then, we drop duplicate observations for which data on all these

[5]The latter consist exclusively of code "100000000000000000000" (1e20) which we suppose means 'other' or 'unknown'.

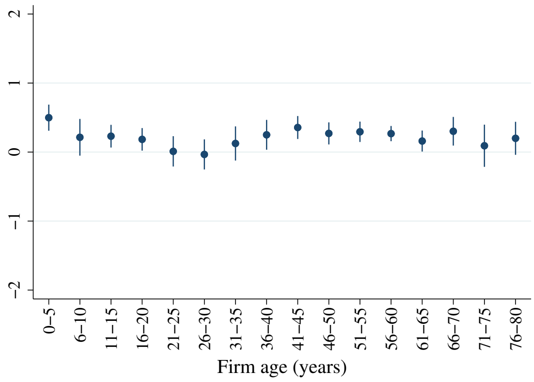
variables and the units of measurement are missing. We again convert metric units to a single unit when applicable. There are a number of cases where one duplicate observation holds data on production and another one on sales. We combine these into a single observation if the units are the same and there is no bunching happening.

Lastly, we deal with bunching and duplicates again. We set data on both production and sales to missing when bunching over different product codes occurs. Then, we sum the production and sales data over all observations within a firm-year-product-unit set. Finally, we keep only one observation of each duplicate.

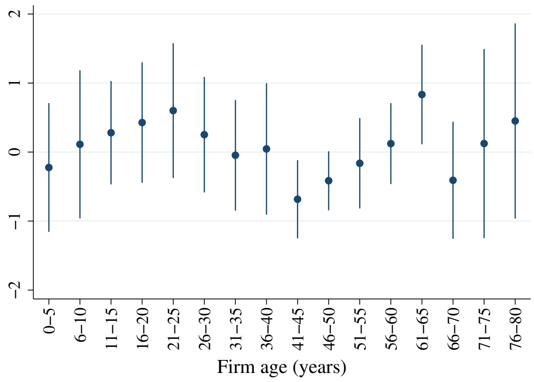
We merge the product-level data from Prowess with the tariff data obtained from De Loecker et al. (2016). The tariff data is reported for an older version of the CMIE product codes, so we map the new codes in our data from PROWESS to these old codes. This was largely straightforward, except that sectors 14, 15, and 16 seem to have been coded "1414", "1415", and "1416", respectively. We remove the leading "14" and add two trailing zeros.

Appendix B   Additional Figures

Figure 4: Differential effect of output tariffs and input tariffs on log price by firm age

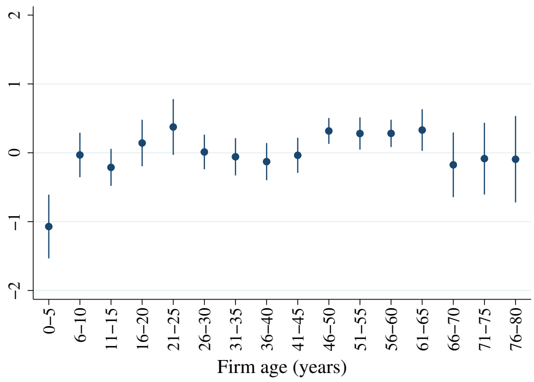


(a) Effect of output tariffs (β_2^b)

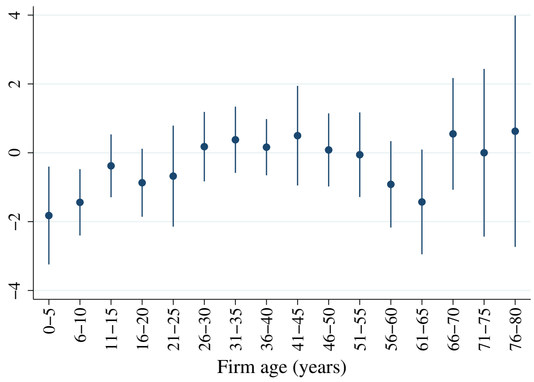


(b) Effect of input tariffs (β_4^b)

Figure 5: Differential effect of output tariffs and input tariffs on log quantity by firm age



(a) Effect of output tariffs (β_2^b)



(b) Effect of input tariffs (β_4^b)