Trade Liberalization, Productivity, and Resource Allocation in Manufacturing Firms in Ethiopia

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Abstract

This paper studies the effect of tariff changes on firm level productivity, firm exit, and industry resource reallocation in Ethiopian manufacturing firms. It uses a new estimation method for production functions to obtain unbiased and efficient estimates of parameters and total factor productivity compared to the "input proxy" approaches, which are common in the empirical trade and productivity literature. We find evidence for increased productivity after liberalization and resource reallocation in several industries as expected from the theoretical literature. However, there are heterogeneous impacts across sectors. We find no evidence for firm exit after tariff reductions due to direct competition effects from lower cost imports but the tariff reductions affect firm decisions to exit via their effect on productivity. Tariff reduction also increase average industry productivity through its influence on market share reallocations from low to high productive firms.

Keywords: Trade Liberalization, Productivity, Firms, Resource Reallocation
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1 Introduction

Exposure to international trade provides the opportunity to increase the total factor productivity of firms through various channels. Heterogenous–firm trade theories describe how aggregate industry productivity can improve through selection and resource reallocation from low to high productive firms within an industry in response to trade liberalization (Melitz 2003). Firms in an open economy will also benefit from productivity enhancing technological spillovers of the R & D investments of their trading partners (Coe and Helpman 1995). Trade allows firms to have access to cheap imported intermediate inputs that are of high quality (Kasahara and Rodrigue 2008).

This paper investigates the impact of unilateral tariff liberalization measures on Ethiopian manufacturing firms. The country has pursued a gradual approach to lift protection for its domestic industries beginning in 1995 by reducing import tariffs in different phases over a period of 20 years. The nation remains one of the twenty countries in the world that is not yet a member of the World Trade Organization (WTO), and it is still negotiating access to the world market. This research uses the gradual tariff change across time and industries for identification in order to study the impact of output and intermediate input tariff reductions on firm level productivity. We will also explore the effect of tariff reduction on firms' decision to exit. Does tariff reduction affect firm exit directly due to competition from low cost imported goods or indirectly through its effect on productivity? We use a firm level panel data collected between 2000 and 2009 from medium and large manufacturing firms. We observe changes in tariff policy twice during this study period.

We also conduct industry productivity decomposition to isolate the contribution of resource reallocation and within firm productivity improvement among surviving firms, new firm entrants, and exiting firms to aggregate industry productivity using dynamic Olley-Pakes productivity decomposition(Melitz and Polanec 2015). We, then, estimate the impact of tariffs on industry resource reallocation and within firm productivity improvements.

This paper uses a two-stage estimation approach to study the effect of trade liberalization on firm productivity following the standard in the literature[1] (Pavcnik 2002, Topalova and Khandelwal 2010, and Amiti and Konings 2007). We will be using a new

[1] Wang and Schmidt (2002) argued against the use of a two-stage estimation procedure for estimating the impact of exogenous variables on technical efficiency of a firm because the results are usually biased downwards. Fernandes (2007) also estimated both one-step and two-step estimation procedure to study the impact of tariff on productivity in Columbian manufacturing firms. She found the magnitude of the effect in one-step estimation to be higher than the two-stage estimation procedure.

method of estimating production function developed by Gandhi, Navarro, and Rivers (2011) — a techniques which improves upon the "input proxy" approaches of Olley and Pakes (1996), Levinsohn and Petrin (2003), and Ackerberg, Caves, and Frazer (2015) which use either investment or intermediate input as proxy for productivity to identify the parameters of production function that most previous empirical trade studies rely on. The method argues that the "input proxy" approaches do not exactly identify the production function(and hence productivity) in the presence of flexible inputs. Instead of using flexible inputs as a proxy for productivity, this method makes use of the information contained in the first order conditions with respect to the flexible input to identify input coefficients and productivity.

This paper contributes to the literature in three ways. First, it uses a new production function estimation technique and compares the result with other methods to see if studies investigating the impact of trade liberalization on productivity are sensitive to the production function estimation method. Second, we will be estimating the impact of tariff on industry resource reallocation in addition to estimating impact on firm level productivity, which is common in the literature. Finally, this paper adds to the limited literature studying the effect of trade liberalization policy on manufacturing firms in Sub-Saharan African region.

The result from our firm level production function estimation shows that there is a high level of heterogeneity in firm productivity within industries where a firm at the 75th percentile distribution of productivity is twice as productive as the firm in a 25th percentile distribution using the same level of inputs. The productivity gap increases to fourfold when we compare the 95th percentile firm to the 5th percentile. We also find that tariff reduction increases the total factor productivity of firms: a 10 percentage point reduction in tariffs increases average firm productivity by approximately 2 percent. This effect of output tariff reduction on productivity of the average firm becomes statistically insignificant when we control for firm heterogeneity based on export or import status of firms or input tariffs. We find that exporting firms benefit more than non-exporting firms in terms of improving their productivity after liberalization. A 10 percentage point reduction in output tariff increases exporters' productivity by 6 percent compared to non-exporting firms. Input tariff reduction has stronger impact on productivity compared to output tariff reduction, bringing a 19 percent TFP improvement for a 10 percentage point reduction in input tariff. We also observe heterogeneity in impact based on the variation in productivity of firms. The result from quantile regression indicates that firms on the higher end of the productivity distribution benefit the most out of tariff reduction compared to firms on the lower distribution. Firm's decision to exit the industry is not directly affected by low cost import competition due to reduced output tariffs. But, tariff indirectly affect firm exit through its effect on productivity.

Aggregate decomposition of industry productivity reveals that reallocation of resources among firms accounts for 73 percent of the improvement in overall manufacturing industry productivity while within firm productivity improvement through increased efficiency contributes for 39 percent. While exit of low productive firms contributes for 11 percent of the improvement over the years, simultaneous entry of small and low productive firms contributes for -23 percent of the aggregate productivity bringing the average industry productivity down. The result from our industry level regression also indicates that lowering tariffs improves resource reallocation contributing positively to aggregate industry productivity.

The rest of the paper is organized as follows. Section 2 reviews related works from the literature and presents background information on Ethiopia's trade liberalization, section 3 presents the theoretical framework for estimating production function, discusses data, and econometric estimation method, section 4 presents the results, and finally section 5 concludes.

2 Background and Literature

Firms display significant variation in efficiency — as measured by Total Factor Productivity(TFP) rather than the intensity of use of a particular input — in production within an industry. Syverson (2011) presents a simple model to explain why such productivity dispersion is sustained in equilibrium within an industry; and discusses what happens to firms when there is an external common productivity shock to the industry. Those firms that take advantage of the shock will grow bigger while others will shrink or even be no longer profitable. Trade liberalization is one such shock that will expose all firms within an industry in the same way but with different results.

According to Melitz (2003), firms incur some fixed cost to operate in an industry but have different productivity levels. This fixed cost implies that firms will continue in business if their productivity is higher than some cutoff productivity level which ensures "zero cutoff profit condition", otherwise they decide to exit. Entry into exporting also has the associated fixed cost that are independent of export volumes[2]. This again implies that firms with productivity higher than some "export productivity cutoff" will be able to profitably enter into export markets. Lowering export trade barriers increases the profit for exporting firms. It also lowers the export productivity cutoff allowing some high productive firms to enter into export. The increased demand for labor by these firms increases the wage making low productive firms unprofitable and forcing them to exit. This reallocation of resources towards more productive firms and exit of low productive firms increases aggregate industry productivity. The unilateral tariff reduction, on the other hand, increases import competition reducing demand and price for domestic produced goods. This leads to low productive firms that are marginal to leave industry. It also results in lower demand for labor resulting in depressed wages. This, in turn, lowers the export productivity cutoff for existing high productive firms enabling them to export to international markets. Again, exit of low productive firms and reallocation of labor from low to high productive firms will improve aggregate industry productivity. Melitz model results in TFP improvement by increasing productivity cutoff for operating as a business and lowing productivity cutoff for exporting regardless of the nature of liberalization (bilateral or unilateral)[3].

[2]Fixed costs associated with exporting include learning about foreign markets, finding buyers, fulfilling exporting standards and other foreign regulations, etc

[3]Ethiopian manufacturing firms enjoy preferential trade agreements with European Union member countries through everything but arms (EBA) treaty and African Growth Opportunity Act (AGOA) with the US which lowers the cost of exporting for firms. Hence, some firms exporting to these markets enjoy benefits that accrues through this preferential treatment. The tariff liberalization policy of the country is done unilaterally.

Increased trade also creates opportunity to access improved technologies that can increase efficiency. Coe and Helpman (1995) found that foreign country investment in research and development can affect the productivity of domestic firms directly or indirectly; and the more open a country is to international trade, the larger will be the benefit from investments of trading partners' R &D. Direct benefits of foreign country's investment in R&D include learning about new technologies, production processes, and organization. Indirect benefits come from import of quality goods and services that are the result of R&D investments. Amiti and Konings (2007), have also used firm-level data to show the benefits of reduced import tariff on TFP in Indonesian manufacturing firms. The found out that firms that use imported inputs are more productive than non-importing firms. They argue that importing firms' benefit arises from their access to high quality foreign input, variety, and learning effects although they did not identify which of these channels are responsible for the TFP improvement. Increased competition from cheap imported goods also forces firms to change managerial organization of the production process (reduce X-inefficiencies) to become more efficient (Syverson 2011).

Researchers have empirically investigated the productivity effect of trade liberalization such as the Ethiopian case examined here using firm level micro data. Topalova and Khandelwal (2010) used data from Indian manufacturing firms to show the heterogeneous impact of trade liberalizations across firms and different economic environments. They showed that the productivity of firms increased after episodes of trade liberalization due to competition from imported goods and access to improved and cheaper intermediate inputs, with the latter having higher impact. Pavcnik (2002) also found evidence of aggregate productivity improvements in Chilean manufacturing firms after liberalization. This study showed that even though there were within plant improvements in productivity in sectors that were exposed to foreign competition, most of the industry productivity improvement comes from reallocation of resources towards more efficient firms after liberalization. These two studies used methods developed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) to estimate firm level productivity in their analyses.

This study contributes to the literature by using a new and improved method to identify production functions and hence productivity of firms. This method does not rely on strong structural assumptions and does not restrict the functional form of the production technology for estimating productivity(Gandhi, Navarro and Rivers 2011). The estimation of value added production function using intermediate inputs as proxy for firm productivity(Ackerberg, Caves, and Frazer 2015) leads to biased estimates of labor and capital coefficients and also the productivity residual. Since the trade and productivity relationship study relies on the estimate from the production function, it is important to get the first stage estimate as accurate as possible.

There are also limited empirical studies conducted in Africa documenting the productivity effects of trade liberalization using information obtained at firm level. A study of changes in productivity of firms that are engaged in exporting in nine different African countries shows that firms with high productivity self-select into international markets(Van Biesebroeck 2005). He also finds that firms continue to increase their productivity over time since their credit and contract enforcement constraints are reduced significantly. The reason for post-export growth of productivity may be because the firms can undertake previously prohibitive costly productivity raising activities. A different study, however, that uses firm level data from Ghana, Kenya, and Tanzania could not find similar evidence for post-export growth in productivity (learning-by-exporting) although it finds a positive correlation between exporting and productivity(Bresnahan et al. 2016). Therefore, although there is evidence showing high productive firms self-selecting into export markets, the evidence for learning-by-exporting is not conclusive.

Researches in Ghana, Kenya, Tanzania, and Ethiopia have also found that export destination of the countries matters to how much productivity improves while exporting. Firms that export to other African countries have lower productivity compared to firms that export to the rest of the world. (Mengistae and Teal 1998; Bresnahan et al. 2016). Studies in Ghana and South Africa, which also includes domestic oriented firms, has shown that a 10% decrease in import tariff improves the average Total Factor Productivity by 1.2% and 1.8%, respectively (Ackah, Ernest Aryeetey, and Morrissey 2012; Jonsson and Subramanian 2001).

Bigsten, Gebreeyesus, and Soderbom (2016) also investigated trade liberalization and productivity in Ethiopian manufacturing firms using data from 1997–2005. They estimated input elasticities using average cost share of inputs assuming a two factor Cobb-Douglas production function. This is a non-econometric approach computed from firms' reported expenditures for labor and capital. They concluded that output tariff has no effect on firm productivity. This paper uses data from 2000 − 2009 and a new production function estimation technique. It also reaches at a different conclusion about the effect of output tariff liberalization on productivity. We analyze heterogenous effect of tariffs on firms based on exposure to international trade and firm's productivity. In addition, we conduct industry productivity decomposition to understand the contribution of surviving, new entrant, and exiting firms to aggregate industry productivity.

This paper will add to the limited literature about trade liberalization and productivity relationship in Africa using a longer panel dataset. It will also be, to the best our knowledge, the first paper to measure resource reallocation using dynamic aggregate productivity decomposition for the manufacturing sector in the region, and investigate how industry resource reallocation is affected by tariff changes.

2.1 Overview of Ethiopia's Trade Liberalization Process

Import substitution industrialization had been pursued as the central policy for growing the manufacturing sector in Ethiopia from the 1960's until 1991. The imperial regime first introduced tariff protections, incentives, and tax relief in the 1960's in order to attract both domestic and foreign firms to establish new industries. In the seventies, a new socialist regime, the Dergue, came to power which continued the import substitution strategies by nationalizing private firms and making industrialization a state-led effort (Zerihun 2008).

In 1991, after the overthrow of the Dergue, a new government started on various economic and trade liberalization measures with the aim of transforming the economy from centrally planned to market oriented; and integrating the country to the world market. It eliminated quantitative restrictions on imports and gradually reduced the level and dispersion of tariff rates. The process of liberalizing the foreign trade regime was conducted more gradually in Ethiopia relative to other African countries that opened their market in the 90s as part of Structural Adjustment Programs and completed their accession to the WTO at the time. The tariff rates for goods in Ethiopia have been reduced and amended eight times in different phases between 1995 and 2014; and the country is still negotiating access to WTO membership. The pre-reform tariff rates were brought down from 0-240 percent to 0-80 percent by 1995. The average unweighted tariff rate was then reduced from 28.9 percent in 1995 to 21.5 percent in 1997, then to 19.5 percent in 1998, and then to 17.5 percent in 2003. Two of the eight tariff reductions fall under our study period of 2000–2009.

We treat tariff reduction as an exogenous policy change although we do not necessarily reject the potential endogeneity of the variable, since tariff reductions could potentially be correlated with firm productivity. There are two reasons, however, to support the treatment of these variable as exogenous in our analysis. First, tax revenue consideration instead of the need to continue protecting some sectors of the economy until they build competitiveness is the main reason for gradual reduction in tariff. The 90s were times when a new government took power and major policy changes were being implemented. Macroeconomic stability with prudent fiscal policy was one of the objectives of the structural adjustment program. It was necessary to ensure that tariff reduction was neutral to government revenue with limitations already in place on domestic borrowing for public finances. It was also necessary that gains from a broadening tax base go to strengthening the fiscal position of the government instead of financing tariff reforms(IMF 2001). Therefore, revenue considerations were higher on the agenda than an industrial policy that aims to continue protection or support of industries in response to some form of lobbying or initial productivity conditions. Second, external pressures by IMF and the World bank that forces the government to liberalize markets were important than industry lobbying (Jones, Morrissey, and Nelson 2011). The inter-temporal and across-industry variation of tariff will also provide us a good identification strategy to study the effect of tariff liberalization.

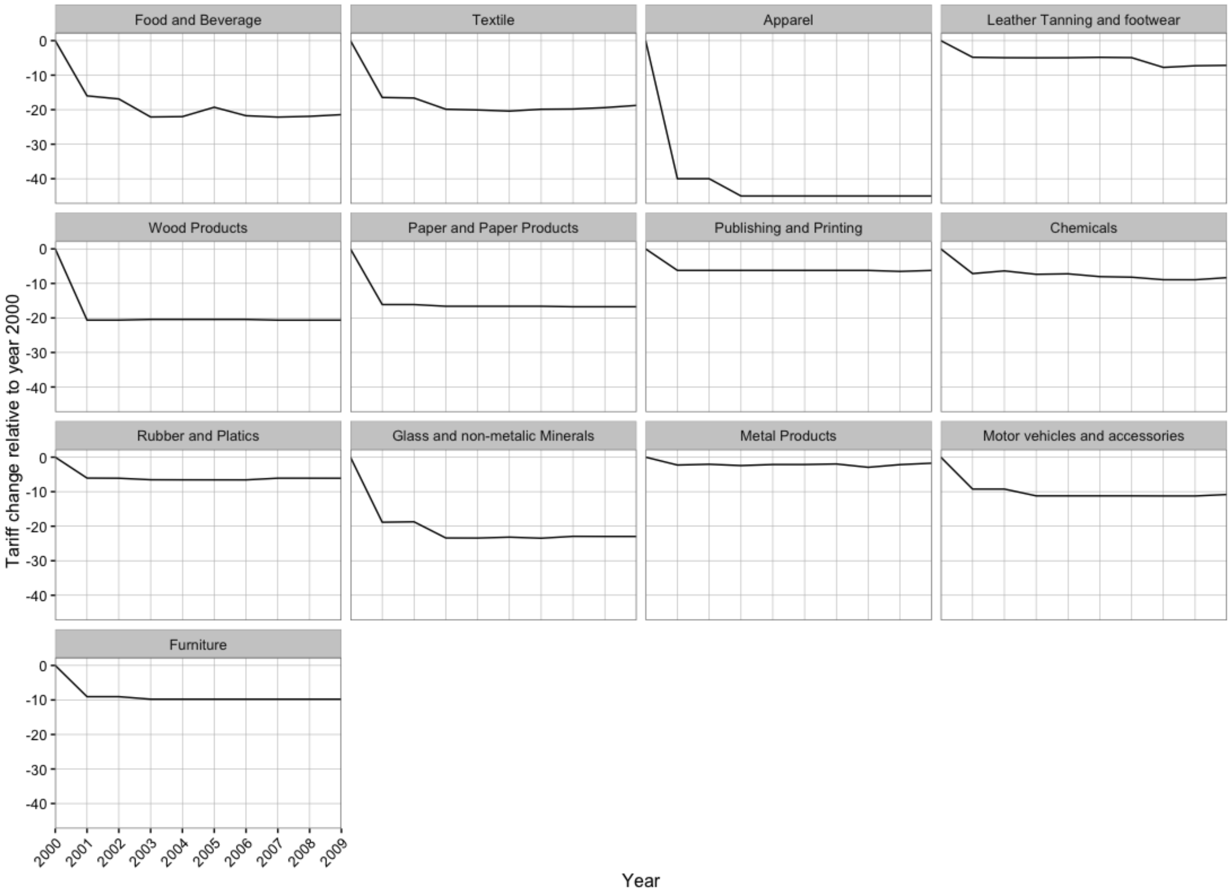
Table 1: Average Industry Tariff Trends

Industry (2-digit ISIC)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Food and Beverage	46.5	30.1	29.9	24.9	24.7	24.8	24.8	25.4	25.2	25.2
Textile	49.2	32.9	33.0	29.5	29.7	29.8	29.5	29.1	28.7	28.3
Apparel	80.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Leather Tanning and footwear	26.7	21.9	21.9	21.8	21.8	21.8	21.8	19.1	19.9	20.1
Wood Products	31.3	10.7	10.7	10.9	10.9	10.9	10.9	10.7	10.7	10.7
Paper and Paper Products	29.5	13.4	13.4	12.9	12.9	12.9	12.9	12.7	12.7	12.7
Publishing and Printing	16.0	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Chemicals	20.7	14.3	13.3	13.2	12.8	13.9	14.3	14.8	14.9	14.5
Rubber and Plastics	20.5	14.4	14.4	14.0	14.0	14.0	14.0	14.5	14.5	14.5
Glass and non-metallic Minerals	46.7	28.1	28.1	23.4	23.5	23.4	23.5	24.3	24.3	24.3
Basic Iron, steel, and casting	6.2	5.5	5.5	6.3	6.3	6.3	6.3	6.8	6.8	6.8
Metal Products	20.9	19.4	18.4	17.6	17.2	17.2	17.0	16.9	15.6	15.0
Machinery and appliances	10.8	9.3	9.3	8.2	8.2	8.2	8.2	8.2	8.2	8.2
Electric motors, cables, and equipments	23.4	18.8	18.8	19.0	19.0	19.0	19.0	18.0	18.0	18.0
Motor vehicles and accessories	28.4	19.2	19.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2
Furniture	37.1	28.0	28.0	27.3	27.3	27.3	27.3	27.3	27.3	27.3
Average	36.8	24.9	24.5	22.1	22.0	20.0	21.0	22.0	22.0	22.6
Minimum	6.2	5.5	5.5	6.3	6.3	6.3	6.3	6.8	6.8	6.8
Maximum	80.0	40.0	40.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0

Table 1 above shows the import tariff rates applied for various industries in the manufacturing sector between 2000 and 2009. We can see from the table that the maximum tariff rate is reduced from 80% to 35%, and the average is reduced by 14.3% percentage points from 36.8% in 2000 to 22.6% in 2009. We observe the largest drop in tariff rates in industries which have the highest protection rate in the first place. We see the largest drop in apparel (45%) followed by food and beverages and textile with about 21% each. We see lowest reduction in tariffs in sectors where there were low tariffs to begin with, such as machinery and appliances (2.6%).

Figure 1 below shows the tariff change relative to base year (2000) for selected industries. It depicts the variation in tariff reduction across industries and time. Sectors that experienced the largest drops in tariff rates are those that had high tariff rates originally.

Figure 1: Tariff change relative to beginning period (Year = 2000)



3 Empirical Strategy

3.1 Estimating Production Function

Identification and estimation of production functions is a challenge because firm's input decisions are a function of productivity shocks, which is not observable in the data but are known to the firm. This productivity shock may represent different variables like managerial talent or practice, quality of labor input such as training and experience that is not captured by standard input measures, quality of capital input that embodies technology which raises total factor Productivity (TFP), and other factors known to the firm but unknown to the econometrician (Syverson 2011). The optimal choice of input decisions in the production process is going to be correlated with these productivity shocks. Therefore, we employ a production function estimation framework that takes into account this endogeneity problem, and produce unbiased estimates of input coefficients and productivity measures.

We use an estimation framework that improves upon the input control approaches (Olley and Pakes 1996; Levinsohn and Petrin 2003; and Ackerberg, Caves, and Frazer 2015) which use investment or intermediate input as a proxy for productivity shocks. This approach uses the information contained in the first order condition of intermediate inputs to correctly identify inputs and hence the productivity measure (Gandhi, Navarro, and Rivers 2011), henceforth GNR.

The input-output relationship as developed by GNR (2011) takes the following time varying form:

$$Y_{it} = F_t(K_{it}, L_{it}, M_{it})e^{\nu_{it}}, \tag{1}$$

where: K_{it}, L_{it}, and M_{it} are capital, labor, and intermediate inputs used by firm i at year t, and ν_{it} is a Hicks neutral productivity parameter that can be decomposed into components

$$\nu_{it} = \omega_{it} + \varepsilon_{it}$$

with ω_{it} being a persistent productivity shock for firm i at year t. This is the component of productivity that is known to the firm while making input decisions but not observable to the econometrician. Meanwhile, ε_{it} is an ex-post shock realized after production decisions (not known to the firm and also not observable). Therefore:

$$E[\varepsilon_{it}|L_{it}, K_{it}, M_{it}] = 0.$$

Let's denote $\mathcal{E} = E[e^{\varepsilon_{it}}]$ and let the persistent shock follow a Markovian structure in its evolution. The current productivity shock depends on information from previous period, in the following way:

$$\omega_{it} = h(\omega_{it-1}) + \eta_{it},$$

where: η_{it} is the "innovation" to the firm's productivity and satisfies $E[\eta_{it}|\omega_{it-1}] = 0$. The intermediate input is assumed strictly monotone in ω_{it}

$$m_{it} = \mathcal{M}(\mathcal{I}_t) = \mathcal{M}(L_{it}, K_{it}, \omega_{it})$$

Labor and capital are assumed to be predetermined at or prior to period *t-1*, while the intermediate input is flexibly determined at period t. This implies that:

$$E[\eta_{it} + \varepsilon_{it}|L_{it}, K_{it}, L_{it-1}, K_{it-1}, M_{it-1}, \ldots] = 0$$

The firm's profit maximization problem with respect to intermediate input will be:

$$\mathcal{M} = arg\, max P_t E[F(K_{it}, L_{it}, M_{it})e^{(\omega_{it}+\varepsilon_{it})}|\mathcal{I}_t] - \rho_{it}M_{it} \tag{2}$$

The first order condition of this problem is

$$P_t \frac{\partial F}{\partial M_{it}}(K_{it}, L_{it}, M_{it})e^{\omega_{it}}\mathcal{E} = \rho_{it} \tag{3}$$

with $\mathcal{E} = E[e^{\varepsilon}_{it}]$. Taking logs of eq. (3) and (1) and taking their difference gives the share of intermediate input in output:

$$s_{it} = ln\mathcal{E} + lnG_t(K_{it}, L_{it}, M_{it}) - \varepsilon_{it}, \tag{4}$$

where: $G_t(K_{it}, L_{it}, M_{it}) = \frac{\partial F(K_{it}, L_{it}, M_{it})}{\partial M_{it}} \frac{M_{it}}{F(K_{it}, L_{it}, M_{it}}$ is the elasticity of the production function with respect to intermediate inputs, and $s_{it} = ln(\frac{\rho_{it}M_{it}}{P_{it}Y_{it}})$ is the share of expenditure on intermediate input in total value of output. Equation 4, which GNR call the share regression identifies the elasticity w.r.t inputs upto a constant and the ex-post shock. It forms the basis for the first stage estimation of the production function.

The intermediate input elasticity also defines a partial differential equation that can be integrated up to identify the part of the production function related to the intermediate input and a constant. By the fundamental theorem of calculus we have

$$\int \frac{G_t(K_{it}, L_{it}, M_{it})}{M_{it}} dM_{it} = lnF_t(K_{it}, L_{it}, M_{it}) + \mathscr{C}(K_{it}, L_{it}). \tag{5}$$

Subtracting eq.(5) from the production function and re-arranging we get:

$$\mathscr{R} = lnY_{it} - \int \frac{G_t(K_{it}, L_{it}, M_{it})}{M_{it}} dM_{it} - \varepsilon_{it} = -\mathscr{C}(K_{it}, L_{it}) + \omega_{it}. \tag{6}$$

Notice that $\mathscr{R}$ is observable as it is a function of data and elasticity and ex-post shocks which are recoverable in the first stage.

Applying the Markov Structure on productivity changes forms the basis for the second stage estimation

$$\mathscr{R} = -\mathscr{C}(K_{it}, L_{it}) + h(\mathscr{R}_{it-1} + \mathscr{C}(K_{it-1}, L_{it-1}) + \eta_{it}. \tag{7}$$

To operationalize this estimation procedure GNR show that we need to approximate the non-parametric functional forms of the elasticity expression, the integration component, and the constant of the integration using second order polynomial series approximation. Then we can easily use a standard sieve GMM estimation to identify the labor, capital, and hence productivity using the following moment condition.

$$E[\eta_{it}|K_{it}, L_{it}, K_{it-1}, L_{it-1}, \mathscr{R}_{it-1}] = 0 \tag{8}$$

Our procedure following GNR uses a non-linear least square regression for a log polynomial approximation of equation (4), estimates equation (5) using second order polynomial approximation, and then recover the capital and labor coefficients using the moment condition in equation (8).

3.2 Data and Estimation Method

3.2.1 Data

The data used in this study comes from a census of medium and large manufacturing firms in Ethiopia between 2000 to 2009 collected by the Central Statistics Agency (CSA). These are firms that employ 10 or more people. We have 738 firms in 2000 that satisfy this definition, and they increase to 1947 in 2009. Import tariff rates for the manufacturing sector are obtained from the World Integrated Trade Solution (WITS) website at HS 8-digit level, which is later aggregated at 2-digit HS level to match with the firm level data from CSA that categorizes firms using a 4-digit International Standard Industry (ISIC) code.

The firm level dataset contains information on value of output, number of permanent employees, capital (fixed assets), raw material and energy costs that will allow us to estimate the production function using the model we suggested in section 3. It also contains data for different firm characteristics such as ownership (private or public), value of export revenue (making it possible to identify exporters), value of imported raw materials(to identify firms' use of foreign input), and year of establishment that we make use of to analyze the effect of trade liberalization on firm productivity.

Table 2: Total Number of Firms by Industry across time

Industry (2-digit ISIC)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Food and Beverage	213	219	266	272	294	213	334	346	439	484
Textile	33	31	34	36	38	38	42	41	25	44
Apparel	25	24	29	32	35	28	31	32	34	37
Leather Tanning and footwear	52	52	52	56	62	60	60	72	75	80
Wood Products	16	14	21	17	20	18	21	33	49	44
Paper and Paper Products	7	5	7	7	7	9	12	12	19	18
Publishing and Printing	56	46	66	66	66	68	74	81	92	87
Chemicals	39	36	41	45	45	51	52	64	70	69
Rubber and Plastics	27	27	37	39	42	47	63	64	80	82
Glass and Non-metalic Minerals	77	81	96	111	119	66	139	273	454	557
Basic Iron, Steel, and Casting	7	10	11	10	13	13	14	13	14	15
Metal Products	50	50	61	73	73	73	99	57	93	109
Machinery and appliances	13	7	7	9	9	6	8	4	3	4
Motor vehicles and accessories	9	6	6	7	7	8	10	42	14	12
Furniture	113	112	147	157	165	63	190	203	271	304
Total	738	721	882	938	996	762	1150	1338	1733	1947

Table 2 above shows the number of firms we have in each industry (2-digit ISIC) across time. The major industries are food and beverage, furniture, glass and non-metallic minerals, metal products, rubber and plastics, leather tanning and footwear, textile, and apparel. We observe more concentration of firms in Food and Beverage, Glass and Non-metallic Minerals, Furniture, and Metal Products. Although we observe a high degree of entry and exit of firms from the data, we have in general a net increase in the number of firms over the years on net basis with the exception of Machinery and Appliances sub-sector where there are fewer firms by the end of 2009 compared to 2000. The degree of increase in number of new firms entering the market varies by industry, from 33% in Textile to 623% in Glass and Non-metallic Minerals.

The dataset used in our analysis contains an unbalanced panel of firms with a total of 11, 217 firm-year observations. Sixty seven percent of the firms in the sample have reported a non-zero value for use of raw materials imported from abroad in their production process. On average, the share of these imported raw materials in total cost of production is 34 percent for these firms[4]. Around five percent of the firms have indicated that they have participated at least once in exporting their produce abroad. Revenue from export accounts for 43 percent of the total income on average for these firms. Twelve percent of firms in our sample ceased their production operation and exited the industry at one point. Most firms are privately owned (almost 90 percent of them). Summary statistics are shown in Table 3 below.

Table 3: Summary Statistics

Variables	Observations	Mean	Std. Dev.
ln(Output)	11,028	13.950	2.132
ln(Capital)	10,733	12.939	2.829
ln(Labor)	10,925	3.293	1.362
ln(Intermediate input)	11,197	13.258	2.219
lnTFP(GNR)	10,289	5.974	0.460
lnTFP_FE(GNR)	10,289	6.550	0.613
lnTFP(ACF): Revenue Function	9,944	2.171	0.501
lnTFP(ACF): Value Added	10,196	7.358	1.468
Output Tariff(%)	11,217	23.428	8.888
Input Tariff(%)	11,216	6.355	4.079
Tariff change(%) (relative to base year)	11,217	-14.303	10.984
Exporter (=1 if export revenue > 0)	11,217	0.045	0.207
Importer (=1 if raw material import>0)	11,217	0.667	0.471
Ownership(=1 if Private, otherwise Public)	11,217	0.887	0.317
Share of Import raw material	8,491	0.338	0.327
Share of Export in Revenue	500	0.432	0.431
Exit (=1 if firm exits at year t+1)	11,217	0.121	0.326

[4]Total cost of production refers the variable cost of production which includes wages for labor and other intermediate input use such as electricity and other raw materials purchased locally.

Table 4 below shows the summary statistics for exporting and non-exporting firms to show the difference between these two group of firms. Exporting firms have higher value of output, capital, and employ higher number of persons on average compared to non-exporting firms. They also have higher TFP. Output tariff rates between these groups is similar but slightly higher for exporting firms. Firm exit among exporters is half of the exit rate we see for non-exporting firms. Eight three percent of exporting firms have used imported raw materials compared to 66 percent for non-exporting firms but the share of imported raw materials in total cost of production is only 20 percent for exporting firms compared to 35 percent for others.

Table 4: Summary statistics by export status group

	Non-Exporting Firms			Exporting Firms		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
ln(output)	10,525	13.806	2.042	503	16.960	1.712
ln(Capital)	10,235	12.778	2.771	498	16.259	1.760
ln(Labor)	10,422	3.197	1.283	503	5.295	1.413
ln(Intermediate Input)	10,694	13.118	2.139	503	16.237	1.744
lnTFP(GNR)	9,791	5.967	0.459	498	6.112	0.454
lnTFP_FE(GNR)	9,791	6.515	0.594	498	7.245	0.562
Output Tariff	10,714	23.371	8.800	503	24.643	10.528
Input Tariff	10,713	6.367	4.051	503	6.112	4.642
Import Input(=1 if import >0)	10,714	0.659	0.474	503	0.829	0.377
Private Firms(=1 if Yes)	10,714	0.900	0.300	503	0.618	0.486
Share of imported raw material	8,041	0.346	0.330	450	0.197	0.223
Exit(=1 if firm exits at year t+1)	10,714	0.123	0.329	503	0.060	0.237

Table 5 shows similar summary statistics to compare firms that use imported raw material to those who do not. Although there are differences between these two groups, it is not as big as the difference that exists between exporters and non-exporters.

Table 5: Summary Statistics of firms by use of imported input use

	Non-importing Firms			Importing Firms		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
ln(Output)	3,654	13.353	1.905	7,374	14.246	2.176
ln(Capital)	3,477	12.362	2.700	7,256	13.216	2.848
ln(Labor)	3,606	2.922	1.219	7,319	3.476	1.391
ln(Intermediate Input)	3,719	12.616	2.100	7,478	13.577	2.207
lnTFP(GNR)	3,278	5.906	0.508	7,011	6.006	0.433
lnTFP_FE(GNR)	3,278	6.386	0.610	7,011	6.627	0.599
Output Tariff	3,739	24.796	7.228	7,478	22.744	9.538
Input Tariff	3,738	4.603	3.451	7,478	7.231	4.087
Exporter(=1 if firm exports)	3,739	0.023	0.150	7,478	0.056	0.229
Private(=1 if Yes)	3,739	0.907	0.291	7,478	0.877	0.328
Share of Export Revenue	84	0.519	0.399	416	0.415	0.436
Exit(=1 if firm exit at year t+1)	3,739	0.136	0.343	7,478	0.113	0.317

3.2.2 Estimation Method

we use the regression specification below in order to estimate the impact of trade liberalization on total factor productivity(ν_{it}). In the first stage, we estimate productivity ν_{it} using the GNR method described section 3.1. Then, we analyze how productivity changes due to tariffs using the following specification:

$$\nu_{it} = \delta + \delta_t + \delta_j + \alpha(OutputTariff)_{jt} + \beta(Inputtariff)_{jt} + X_i'\gamma + \varepsilon_{it}, \tag{9}$$

Where ν_{it} is TFP of firm i at year t estimated by the GNR method[5], δ_t is a time dummy that controls for unobserved macroeconomic shocks that affect all industries, δ_j is industry dummy which controls for time-invariant industry specific characteristics which affect productivity, $OutputTariff_{jt}$ is the average output tariff rate of industry j at year t, $Inputtariff_{jt}$ is the average input tariff of imported raw materials for industry j at time t, and X represents a vector of firm level characteristics that are believed to affect productivity. These variables include, a dummy variable indicating ownership status of the firm (private or public) and firm size. We categorized firms into three groups as large, medium, and small using the number of permanent employees hired by the firm. We treat a firm as large if the number of people employed is greater than the 75th percentile, medium if the number of employees is between the 50th percentile and 75th percentile, and small if it is below 25th percentile. The 75th percentile cutoff point is 191 employees which is considered big in Ethiopian context. The 50th percentile cutoff is 20 employees. We also control for export and import status in some of our specifications. We interact output tariff rate with export dummy to observe heterogenous impact of output tariff on exporters and non-exporters. Similarly, we interact input tariff with a dummy indicating a firm's use of imported input use to see if firms that use imported inputs benefit more than non-importing firms due to tariff reduction.

We calculate the input tariff rates as weighted average of their output tariff following Amiti and Konings (2007). We use the share of imported raw materials in total variable cost of production as weights in this calculation[6]. We generate this variable at industry level although we can calculate the imported raw material share at firm level. The input tariff for industry j at time t is calculated as

$$inputtariff_{jt} = \theta_{jm} * outputtariff_{jt}, \tag{10}$$

[5] We use the TFP estimates from the first stage estimation which accounts for firm fixed effect.

[6] Topalova and Khandelwal (2010) used share of imported raw material in total outputs (instead of total cost) as weights to calculate import tariff rates. This lowers the implied input tariff rates resulting in bigger magnitude for coefficient estimates of input tariff but with qualitatively similar results.

where θ_{jm} is the average share of imported material (m) in total variable cost of production for industry j.

We estimate equation(9) using pooled OLS with bootstrapped standard errors since our TFP variable is obtained using another estimation model in stage one. We expect the coefficient on output tariff rate will be negative since trade liberalization increases competition from imported goods making firms increase their efficiency if they survive. Similarly, we assume the coefficient of input tariff to be negative since liberalization allows firms to have access to cheap intermediate inputs which decreases the competitive pressure from imported final goods. We also report results from a system-GMM estimation technique in appendix (A). SYS GMM estimation takes into account the assumption we made regarding the Markovian evolution of the productivity shock, which calls for a regression having the lag of the TFP as RHS variable. The introduction of a lag of the dependent variable induces endogeneity problem but the SYS-GMM estimator uses deeper lags of the variables themselves as instrument to solve the endogeneity problem. This also takes care of potential endogeneity of tariff by using internal instruments. The results are qualitatively similar to our estimation in equation (9) vis-a-vis to the impact of output tariff on TFP.

Melitz (2003) model outlines how firms at different levels of productivity respond to trade liberalization. We use Quantile Regression to observe the heterogenous effect of tariff on firms with various productivity levels. We estimate (QR) to see the effect of tariff changes on three productivity percentile distributions (10th, 50th, and 90th).

To identify the mechanism of firm exit either through direct (competition from cheaper imports) effects of trade liberalization or indirect (competition with domestic firms in improving productivity) effects, we estimate the following probit models

$$Exit_{it} = \alpha Tariff_{jt-1} + \beta X_{it} + \varepsilon_{it}, \tag{11}$$

$$Exit_{it} = \delta \nu_{jt-1} + \beta X_{it} + \varepsilon_{it}, and \tag{12}$$

$$Exit_{it} = \alpha Tariff_{jt-1} + \delta \nu_{jt-1} + \beta X_{it} + \varepsilon_{it}, \tag{13}$$

where $Exit_{it}$ is an exit indicator($= 1$) if firm i gets out of business at year t and X_{it} is a vector of firm level characteristics such as firm size, age and age square, ownership type, time, and industry dummies.

One of the effects of trade liberalization discussed in heterogenous-firm trade theories is resource reallocation from low to high productive firms. We use dynamic Olley-Pakes productivity decomposition method developed by Melitz and Polanec (2015) in order to measure the effect of resource reallocation and within firm productivity improvements to aggregate industry productivity. This method takes into account the contribution of survivors, new firm entrants, and exiters to aggregate industry productivity. It is an improvement over the cross-sectional method of decomposing industry productivity by Olley and Pakes which does not take into account the effect of new firm entrants and exiters. It does only a simple unweighted average of productivity (showing trend in productivity change over time) and a covariance-term between productivity and market shares that captures resource reallocation among firms(Olley and Pakes 1996). Let the aggregate productivity in an industry ν_t^j be described as follows:

$$\nu_t^j = \bar{\nu}_t^j + cov(s_{it}, \nu_{it}) \tag{14}$$

$$\nu_t^j = \bar{\nu}_t^j + \sum_{i \epsilon j} (s_{it}^j - \bar{s}_t^j)(\nu_{it}^j - \bar{\nu}_t^j)$$

where s_{it}^j is the share of output of firm i at year t in industry j, $\bar{s}_t^j$ is the output share of the average firm at year t in industry j, ν_{it}^j is productivity of firm i at year t in industry j, and $\bar{\nu}_t^j$ is the average unweighted productivity of industry j and year t.

At any given period t, we have surviving (S) firms that were operating in the industry in prior periods before t and new entrant firms (E) that joined the industry between period $t = 2$ and t. Some of the firms that have been operating in prior years are no longer in business at period t, we call this group of firms exiters(E). The aggregate industry productivity at period t and $t-1$ can be expressed as a weighted average of survivor and entrant firms (period t) and survivor and exiter firms(Period $t-1$). Let s_S, s_E, and s_X be the aggregate market shares of survivors(S), Entrants(E) and Exiters(X), respectively. The sum of survivor and entrant market shares at time t or survivor and exiter market shares at $t-1$ is equal to one(Melitz and Polanec 2015). Therefore, aggregate industry productivity at time t becomes:

$$\begin{aligned}\nu_t &= s_{S_t}\nu_{S_t} + s_{E_t}\nu_{E_t} \\ &= \nu_{S_t} + s_{E_t}(\nu_{E_t} - \nu_{S_t}),\end{aligned}$$

and the aggregate industry productivity at $t-1$ is:

$$\begin{aligned}\nu_{t-1} &= s_{S_{t-1}}\nu_{S_{t-1}} + s_{X_{t-1}}\nu_{X_{t-1}} \\ &= \nu_{S_{t-1}} + s_{X_{t-1}}(\nu_{X_{t-1}} - \nu_{S_{t-1}}).\end{aligned}$$

The change in productivity between period t and $t-1$ can be interpreted as percentage change in productivity since we measure productivity in logarithms. The difference in productivity between the periods ($\Delta\nu = \nu_t - \nu_{t-1}$) will give us:

$$\Delta\nu = \nu_{S_t} - \nu_{S_{t-1}} + s_{E_t}(\nu_{E_t} - \nu_{S_t}) + s_{X_{t-1}}(\nu_{S_{t-1}} - \nu_{X_{t-1}}). \tag{15}$$

The first term in equation 14 gives us the contribution of surviving firms to aggregate industry productivity. Entrant firms' contribution to aggregate productivity, $s_{E_t}(\nu_{E_t} - \nu_{S_t})$, will be positive if new firms have higher productivity compared to surviving firms at the time of entry. If firms that exit the industry have lower productivity, $s_{X_{t-1}}(\nu_{S_{t-1}} - \nu_{X_{t-1}})$, compared to surviving firms at the time of exit, then aggregate productivity increases, and vice versa. We can apply the Olley-Pakes decomposition shown in equation (13) for the change in productivity among surviving firms between two periods.

$$\Delta\nu = \Delta\bar{\nu}_s + \Delta cov_s + +s_{E_t}(\nu_{E_t} - \nu_{S_t}) + s_{X_{t-1}}(\nu_{S_{t-1}} - \nu_{X_{t-1}}) \tag{16}$$

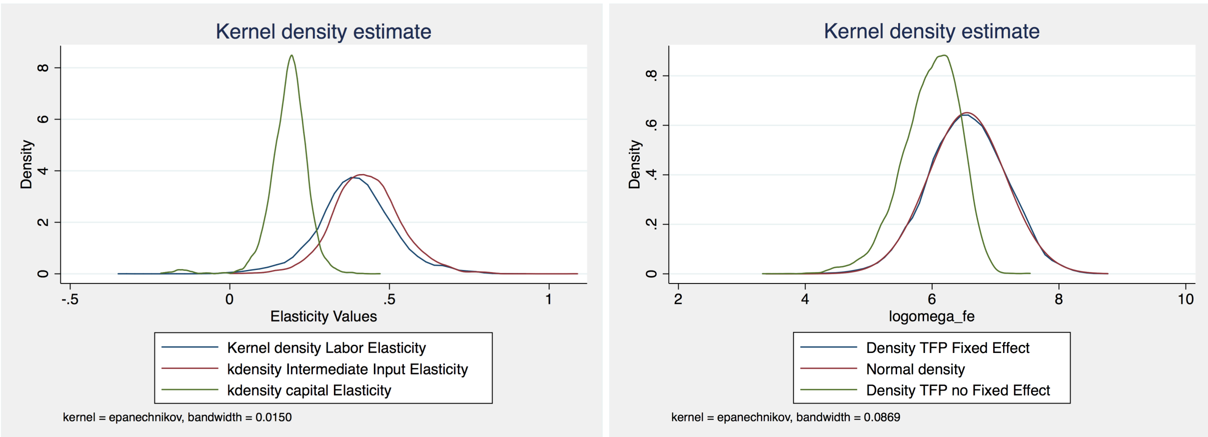
The Olley-Pakes decomposition for the surviving firms shows us the shift in productivity distribution over time (unweighted mean change in productivity) and market share-productivity reallocation among surviving firms(covariance term).

4 Results

4.1 Productivity Heterogeneity

As we discussed in Section 3, our production function estimates vary across time and firms, essentially producing a distribution of input elasticity and productivity estimates for each firm. Figures 2 below shows the distributions of input elasticity and TFP estimates. We estimated the production function with and without fixed effects generating two TFP estimates. We plotted the two types of TFP estimates (with and without fixed effects) in the graph below. We superimposed a normal distribution on the TFP distribution plots which coincided with the TFP estimate with firm fixed effects. We use the TFP estimate obtained after accounting for unobserved firm heterogeneity using firm fixed effects in stage one for our stage two regression for tariff and productivity relationship. While these are not the main focus of our work, they are useful to demonstrate the heterogeneity of production in Ethiopian manufacturing.

Figure 2: Elasticity and TFP Distributions from GNR estimation



(a) Distributions of input elasticity estimates.

(b) TFP: with and without fixed effect.

Table 6 below shows elasticity estimates from the GNR production function estimation. It presents the average elasticity of inputs for selected industries at 2-digit ISIC classification level along with their standard errors. We also show the factor intensity of inputs for each industry, which is a simple ratio of the elasticity of capital to labor, and the sum of elasticities as a measure of returns to scale. We observe that overall, the manufacturing sector has constant returns to scale but the result varies by sector. The elasticity of capital does not vary by much from sector to sector, which on average is 0.2. Most of the variation across sectors is in the elasticity of labor and intermediate inputs. Labor input elasticities range from a low of 0.37 in Food and Beverage to 0.5 in Textile while the intermediate input elasticity ranges from 0.38 in textile and apparel to 0.47

in Chemicals industry. The capital intensity ratio shows that metal products, food and beverage, chemical, publishing and printing, and rubber and plastics have above industry average capital intensity.

Table 6: Elasticity Estimates

Industry (ISIC 2 digit)	**Elasticity**	**mean**	**se**
Food and Beverage (15)	Labor	0.37	0.12
	Capital	0.18	0.07
	Intermediate	0.45	0.11
	Sum	1.01	0.11
	Capital Intensity (K/L)	0.51	1.22
Textile (17)	Labor	0.50	0.18
	Capital	0.18	0.09
	Intermediate	0.38	0.15
	Sum	1.06	0.14
	Capital Intensity (K/L)	0.39	0.32
Apparel (18)	Labor	0.49	0.14
	Capital	0.19	0.07
	Intermediate	0.38	0.10
	Sum	1.05	0.12
	Capital Intensity (K/L)	0.41	0.18
Basic Iron and steel and casting metals (27)	Labor	0.27	0.14
	Capital	0.18	0.04
	Intermediate	0.60	0.13
	Sum	1.05	0.05
	Capital Intensity (K/L)	0.93	5.36
Furniture (36)	Labor	0.39	0.09
	Capital	0.17	0.06
	Intermediate	0.40	0.08
	Sum	0.96	0.10
	Capital Intensity (K/L)	0.44	0.20
Total	Labor	0.39	0.12
	Capital	0.18	0.06
	Intermediate	0.43	0.11
	Sum	1.00	0.11
	Capital Intensity (K/L)	0.46	3.92

Table 8 below summarizes the productivity(TFP) statistics for each firm the same way we recover the elasticity estimates. We measure productivity dispersion within industry by reporting the ratio of percentiles of the productivity measure. The results show that there is a lot of heterogeneity in productivity across firms within an industry. The firm that is on the 75 percentile distribution of productivity is on average twice as productive than firm on the 25th percentile distribution. The 90/10 ratio varies from a low 2.8 for furniture to a high of approximately 4 in textile. There is a high productivity heterogeneity in both the textile and apparel sector, where the most productive firms can produce 5 or 6 times more than the lower productive firms using the same amount of inputs. The lowest heterogeneity is found in furniture. The ranges of values of this ratios in different sectors also indicates the presence of heterogeneity not only across firms within a sector but also across sectors.

Table 7: Productivity Percentile ratios showing dispersion within industry

ISIC 2 Digit classification	**Productivity Ratio**	**mean**
	75/25	1.80
Food and Beverage (15)	90/10	3.02
	95/5	4.13
	75/25	2.04
Textile (17)	90/10	3.96
	95/5	5.82
	75/25	1.84
Apparel (18)	90/10	3.24
	95/5	5.02
	75/25	1.70
Leather Tanning and footwear (19)	90/10	2.95
	95/5	3.93
	75/25	1.79
Metal Products (28)	90/10	3.31
	95/5	4.85
	75/25	1.71
Furniture (36)	90/10	2.81
	95/5	3.78
	75/25	1.79
Total	90/10	3.05
	95/5	4.21

4.2 Effects of trade liberalization on Productivity

Table 8 below presents the results from estimation of the model in equation (9) for the effects of tariffs on firm productivity. Bootstrapped standard errors after 1000 replication are reported in parenthesis. In column 1 we look at the impact of output tariff only on TFP after controlling for some firm level characteristics. We find that tariff reduction is negatively correlated with average firm productivity as expected from theory. The result is statistically significant at 10 percent level of significant. The tariff coefficient shows that a 10 percentage point reduction in tariff rates will lead to a 1.8 percent improvement in productivity. This result is consistent with similar studies, for example, in Indonesia where Amiti and Konings (2007) found the effect to be 2.1 percent.

We introduced tariff variable interacted with export status of firms and a dummy variable indicating whether a firm has exporter status or not in column 2. The coefficient on tariff variable remains negative although it is not statistically significant anymore.

Insignificant tariff variable in all the remaining columns may suggest omitted variable bias in column 1. The coefficient on the interaction term indicates that tariff reduction benefits exporting firms more than non-exporting firms and it is strongly significant. A 10 percent reduction in tariff increases the productivity of exporting firms by 6.4 percent compared to non-exporting firms. The exporter dummy coefficient also indicates that exporting firms are 48 percent more productive than non-exporting firms. This result is similar across different specifications in column 5 and 6. Exporting firms represent 5 percent of the firms in our sample but they employ 4 times more people than non-exporting firms and have 3 times more capitalization. Despite the low performance of Ethiopian manufacturing firms in international export markets, trade liberalization boosted the productivity of firms that engage in exporting.

Table 8: Results: Tariffs and Productivity

Dependent variable: lnTFP	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	-0.00176*	-0.000586	-0.000376	-0.0007	-0.000362	0.00216
	(0.00107)	(0.00112)	(0.00146)	(0.001425)	(0.00140)	(0.00197)
Input Tariff			-0.00607**	-0.0194***	-0.0154***	-0.0211***
			(0.00251)	(0.00353)	(0.0034)	(0.00473)
Export Tariff Interaction		-0.00636***			-0.00703***	-0.00628***
		(0.00208)			(0.00214)	(0.00239)
Exporter Dummy		0.475***			0.478***	0.507***
		(0.0579)			(0.0586)	(0.0706)
Import Tariff Interaction				0.0153***	0.0164***	0.0152***
				(0.00295)	(0.00292)	(0.00415)
Input Imports Dummy				0.0292	0.0144	0.00821
				(0.0183)	(0.0191)	(0.0284)
Ownership Dummy	-0.0105	-0.0870***	-0.0985***	-0.0971***	-0.0866***	-0.0758***
	(0.0158)	(0.0186)	(0.0195)	(0.0182)	(0.0184)	(0.0208)
Firms Size controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,289	10,289	10,289	10,289	10,289	4,417
R-squared	0.995	0.995	0.995	0.995	0.995	0.996

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

In column 3, we introduced input tariff. Tariff reduction increases the availability of high quality and variety of imported inputs that can increase efficiency. The point estimate for input tariff coefficient is over three times higher in magnitude compared to the magnitude on output tariff in column 1, which shows that a 10 percent reduction in input tariff increases productivity by 6.1 percent. In column 4, we added a dummy indicating imported raw material use by the firm and tariff interacted with this same dummy variable. Accounting for this firm heterogeneity based on imported input use has increased the magnitude on the input tariff coefficient significantly, indicating a 10 percent reduction in input tariff leading to improvement in productivity by 19 percent. On the other hand, the coefficient on the interaction term shows that non-importing firms benefit more than importing firms from the input tariff reduction, contrary to expected result. The net effect of a 10 percent input tariff reduction is 4.1 percent improvement in productivity for importing firms. We normally expect the coefficient on the interaction term to be negative indicating that firms that use imported raw materials will benefit more than non-importing firms since they will have access to efficiency enhancing quality raw materials. According to Amiti and Konings (2007), this inverse relationship may happen because low cost raw material inputs may have reduced incentives for firms to pursue productivity increasing measures. The statistically insignificant coefficient on imported input dummy also shows that firms that import raw materials are not necessarily more productive than non-importing firms, indicating absence of technology externality through imported input use. The empirical literature on the effect of input tariff reduction on productivity has mixed results. For example, Van Biesebroeck (2003) in Columbian manufacturing firms and Muendler (2004) in Brazil found no effect of intermediate input tariff reduction on productivity while Amiti and Konings (2007) found not only that input tariff reduction result in overall increases to productivity similar to what we found above but importing firms reap more benefits compared to non-importing firms due to the reduction.

Columns 5 and 6 show results which include both exporting and imported input use heterogeneity across firms in the specification. In column 6, we run the model only on the balanced sample of firms to account for selection effect due to firm exit. The results are qualitatively similar with the previous columns. The magnitude on input tariff is higher on the balanced sample indicating a net effect of 6 percent productivity improvement for a 10 percent input tariff reduction on importing firms. Controlling for size of firms, privately owned companies are 8–10 percent less productive compared to public owned firms on average in all specifications.

We learned from the heterogenous-firm trade theories that firms with different levels of productivity respond differently to trade liberalization. It is, thus, important that we test for the empirical validity by studying the impact of tariff reduction on firms with different levels of productivity. Figure 3 below shows the quantile plot of total factor productivity in log scale. This scatter plot shows the distribution of log TFP, each point in the graph plotted against the fraction of the data with values less than that fraction.

In table 9, we report results from a quantile regression specification using three

Figure 3: Quantile plots of Total Factor Productivity

different productivity percentile cutoffs: 10th, 50th, and 90th percentiles[7]. It contains results from three different specifications. The first column looks at the effect of output tariff only, followed by addition of input tariff in the second column, and finally we add exporting and importing status of firms. We control for firm size, year, and industry fixed effects in all three specification. In column 1, we see that firms in the 90 percentile productivity distribution show an increase in productivity(4%) which is twice the size we see for the median productivity firm (2%) for a 10 percent tariff reduction. We observe no statistically significant effect of tariff coefficient on productivity for firms at 10th percentile distribution. When we add input tariff rate in column 2, we find similar result to our previous analysis for firms at the 90th and 50th percentile distributions. The coefficient on output tariff is not statistically significant any more but we find a larger magnitude and statistically significant coefficient for input tariff. A 10 percent reduction in input tariff leads to around 16 and 10 percent productivity improvement for firms in the 90th and 50th percentile distribution, respectively. For firms in the 10 percentile productivity distribution, a similar change in input tariff reduction increases productivity by 20 percent. On the other hand, out tariff reduction leads to a decline in productivity improvement for the low productive firms. A 10 percent reduction in output tariff results in 11 percent reduction in productivity.

The results in column 3 are all qualitatively similar to what we find in column 2 for

[7]We also run the model for the 25th and 75th percentile cutoff. The result is qualitatively similar.

Table 9: Quantile Regression: Tarriff impact across heterogenous Productivity Distribution

Dependent Variable: lnTFP	(1)	(2)	(3)
Q10			
Tariff	0.00370	0.0110***	0.00832**
	(0.00303)	(0.00327)	(0.00351)
Input Tariff		-0.0201***	-0.0152***
		(0.00631)	(0.00473)
Exporter Dummy			0.177***
			(0.0400)
Input Imports Dummy			0.115***
			(0.0231)
Ownership Dummy	0.0749**	0.0721**	0.0820**
	(0.0334)	(0.0311)	(0.0327)
Firm Size	Yes	Yes	Yes
Time Dummy	Yes	Yes	Yes
Industry Dummy	Yes	Yes	Yes
Q50			
Tariff	-0.00203*	0.00169	0.00139
	(0.00110)	(0.00155)	(0.00133)
Input Tariff		-0.00982***	-0.00879***
		(0.00247)	(0.00226)
Exporter Dummy			0.107***
			(0.0269)
Input Imports Dummy			0.0763***
			(0.0130)
Ownership Dummy	-0.0307*	-0.0295	-0.0118
	(0.0178)	(0.0182)	(0.0194)
Firm Size	Yes	Yes	Yes
Time Dummy	Yes	Yes	Yes
Industry Dummy	Yes	Yes	Yes
Q90			
Tariff	-0.00402***	0.00187	0.000656
	(0.00134)	(0.00177)	(0.00187)
Input Tariff		-0.0157***	-0.0130***
		(0.00313)	(0.00326)
Exporter Dummy			0.131***
			(0.0442)
Input Imports Dummy			0.00681
			(0.0119)
Ownership Dummy	-0.0621***	-0.0527***	-0.0640***
	(0.0166)	(0.0171)	(0.0159)
Firm Size	Yes	Yes	Yes
Time Dummy	Yes	Yes	Yes
Industry Dummy	Yes	Yes	Yes
Observations	10,289	10,289	10,289

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

the effect of output and input tariff on productivity. The export dummy which captures technological spillovers from export status is consistently positive and significant across all productivity distributions. The result on the imported input use dummy, however, is different for firms at the top of the distribution compared to others. In table 9, we find no statistically significant effect for imported input use dummy on productivity similar to the high productive firms.

4.3 Effects of trade liberalization on Firm Exit

We estimated a probit model to measure the likelihood of firm exit given the level of firm productivity and the tariff changes. In table 7 below, we report the marginal effects from this probit regression[8]. We controlled for firm level characteristics such as age and its square, firms size, and ownership type in addition to unobservable time and industry effects. We found that there is no evidence for a decision by a firm to exit the industry due to changes in tariff per se, implying that increased competition from cheap imported goods is not a factor affecting firm exit. On the other hand we see that a firm's decision to exit is significantly affected by its level of productivity. A 1% increase in productivity reduces the likelihood of exit decision by around 3.5%. Therefore, competition with domestic firms in adjusting to trade liberalization is more important than competition from cheaper imported goods when it comes to firm's decision to exit.

Table 10: Tariff, productivity, and firm decision to exit: Probit regression

	Marginal Effects Reported		
Dependent Variable:Exit Indicator			
lag productivity	-0.0348***		-0.0349***
	(0.0104)		(0.0104)
Tariff		-0.000372	-0.000482
		(0.000960)	(0.000981)
Observations	5,612	6,139	5,612

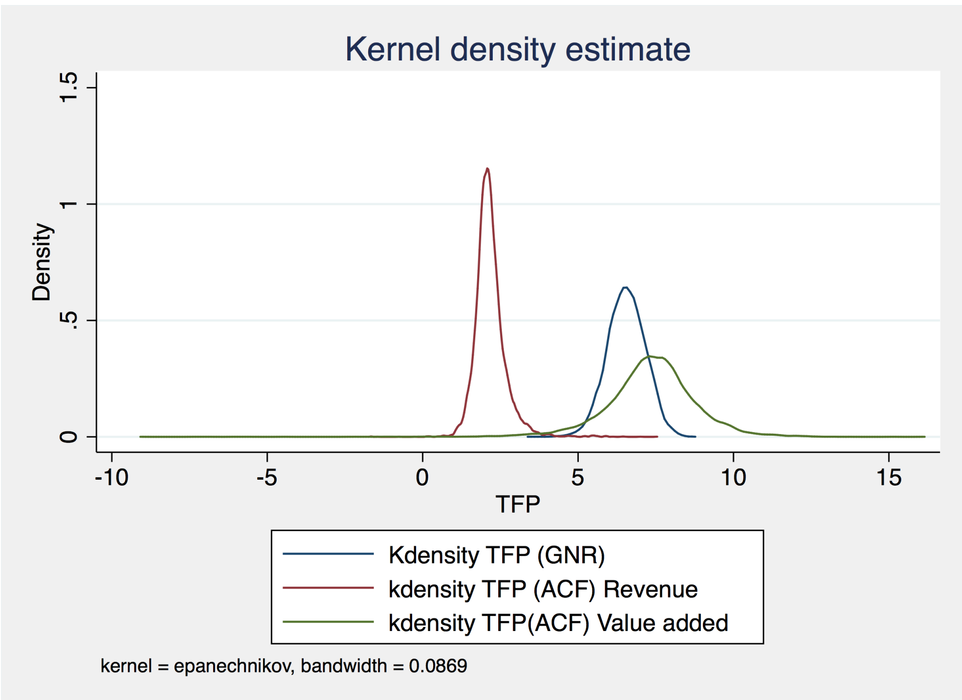
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[8]We also estimated a linear probability model (LPM) and found qualitatively the same and quantitatively close results. The LPM estimates yield a co-efficient value of -0.033 on lag productivity, a mere 0.06 difference from probit model. See Appendix B

4.4 Robustness Check

Kealey, Pujolas, and Sosa-Padilla (2016) investigated if the choice of the production function matters in studying the relationship between trade reform and firm-level productivity. They used data from Colombian manufacturing firms and estimated production function using three methods developed by Levinsohn and Petrin (2003), Ackerberg, Caves, and Frazer (2015), and Gandhi, Navarro, and Rivers (2011). The found out that the productivity estimates from the three methods are different although ACF and GNR estimates are closer to each other compared to LP estimates. We also estimated the ACF production function model for the Ethiopia data and we find significant variations in the distribution of TFP estimates. Figure 4 below shows the TFP distributions from GNR, value added ACF, and revenue ACF models. The average TFP from value added ACF estimation is relatively closer to the GNR estimate but the distribution is more dispersed. We also estimated equation 9 using TFP estimates from the ACF model (See tables in appendix C). We find that the coefficient on output tariff changes signs depending on what variables we add in the right hand side. Output tariff and productivity have a positive relationship at first contrary to the prediction from trade theory but this changes when add input tariff into the regression equation. However, the effect of input tariffs reduction on productivity becomes negative.

Figure 4: TFP Estimates Distributions from ACF and GNR Methods



4.5 Aggregate Industry Productivity Decomposition

Tables 11 and 12 below present the aggregate productivity decomposition for the overall manufacturing sector and some selected industries within manufacturing following the model specified by equation (15) in section 3. The survivors column in the tables show the shift in productivity distribution over the years (within firm productivity improvement) relative to the first year of observation. The covariance column in Olley-Pakes productivity decomposition indicates the extent of allocative efficiency of the industry. A large and positive covariance between productivity and market share shows that more productive firms produce a larger portion of the industry output, and industry productivity will be higher. This reallocation of output from low to high productive firms also indicates the underlying reallocation of factors of production. The entrants column shows the difference between productivity of new entrants and surviving firms weighted by the aggregate market share of entrants. A positive entrant column implies that higher productive firms are entering the industry compared to surviving firms which contributes positively to aggregate industry productivity. A positive exiter column indicates that those firms that cease to produce and leave the industry have lower productivity compared to surviving firms. The last column in both tables indicates the aggregate productivity change relative to the base year (2000), which is the sum the contribution by survivors, entrants, and exiters. Since these productivity changes are reported in logs, they can be interpreted as percentage changes.

Table 11: Aggregate Productivity Decomposition for Overall Manufacturing

Aggregate Productivity Decomposition relative to 2000 (T=1)					
T=2	Survivors	Covariance	Entrants	Exiter	Aggregate
2001	1.15	-3.81	-0.88	0.29	3.26
2002	0.88	-2.94	-0.68	0.90	-1.83
2003	1.19	-0.49	-0.25	0.97	1.42
2004	5.09	-6.43	-0.28	0.41	-1.22
2005	6.90	-1.56	-0.05	0.05	5.35
2006	6.78	-4.71	-0.09	0.23	2.21
2007	6.75	-7.34	-1.86	0.17	-2.28
2008	5.91	-3.56	-0.72	-0.19	1.44
2009	5.29	10.04	-3.17	1.52	13.68

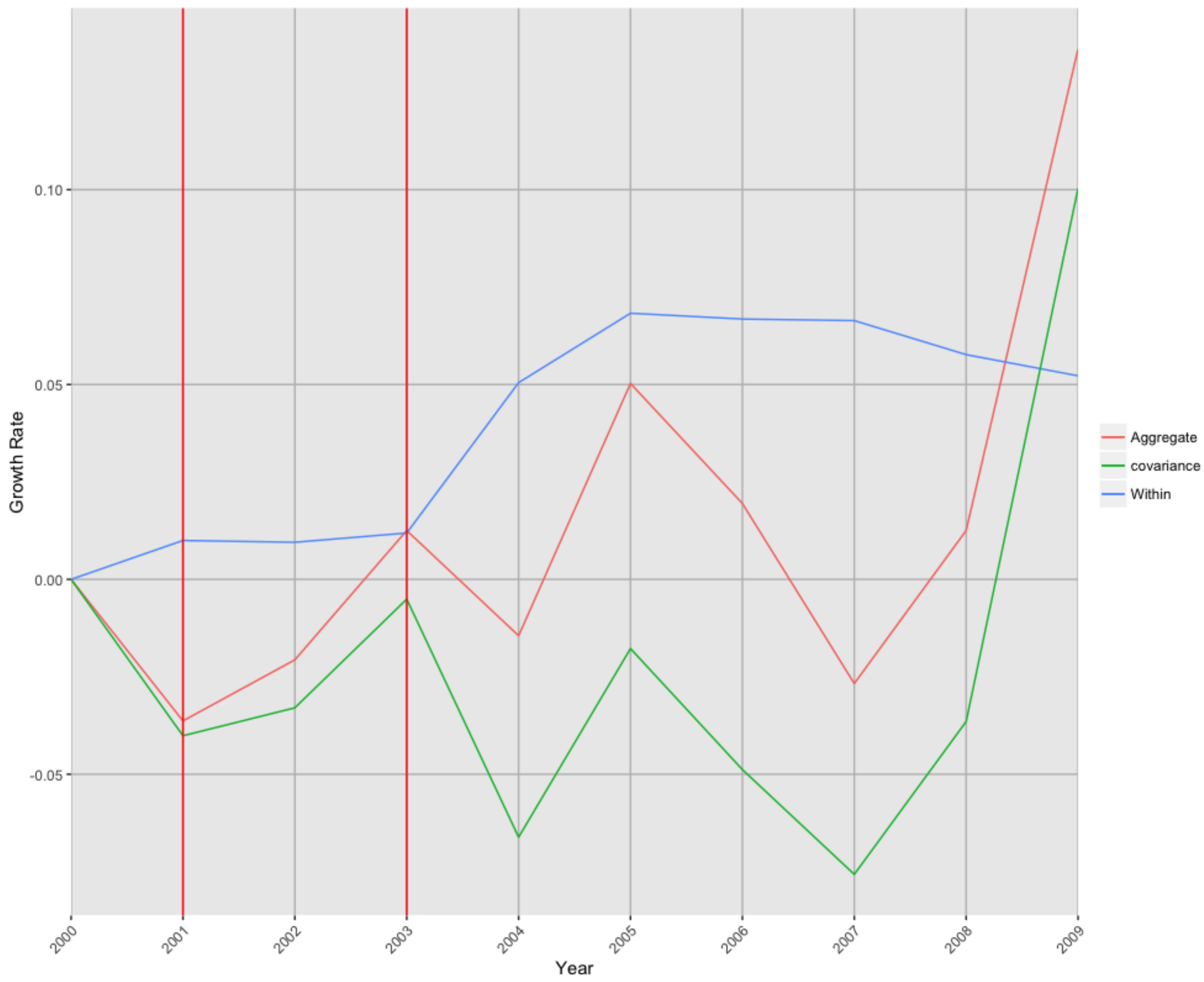
The aggregate productivity change for the overall manufacturing sector (table 8) registers an increase of about 14% in 2009 relative to 2000. We see a consistent increase in the within productivity improvement among the surviving firms indicating a shift in productivity distribution over time. The covariance term that captures market share reallocations among the surviving firms indicates a negative growth rate in the correlation between market shares and productivity except in the final year. Although we have a positive covariance term for all years indicating higher productive firms producing a larger portion of the industry output, the magnitude of this term declines in the intermediate years before we see a significant improvement in the final year. The year-to-year variation in the covariance term indicates an improving allocative efficiency trend compared to the comparison to the base year, which may be the reason for observing the large improvement in the final year(See graph in the appendix for a comparison of year-to-year change against change relative to the base year). This also shows that there were better market reallocation of resources in the base year (2000) compared to intermediate years. In the final year, the major contribution for aggregate productivity improvement comes from allocative efficiency which contributes for 73% of the aggregate productivity improvement for the overall manufacturing sector.

Firms that cease operation and exit the industry have lower productivity compared to surviving firms in all years ($s_{X_{t-1}}(\nu_{S_{t-1}} - \nu_{X_{t-1}})$). This selection effect is responsible for 11% of the aggregate improvement in industry productivity. On the other hand, the contribution of new firm entrants to the aggregate productivity is negative through out showing no sign of improvement in the entire period. The new firm entrants do not necessarily have higher productivity compared to surviving firms at the time of entry ($s_{E_t}(\nu_{E_t} - \nu_{S_t})$). The entry of low productive firms brings the aggregate productivity down by almost 19% in 2009. Unilateral tariff reduction leads to increased import competition resulting in exit of low productive firms which in turn raises the productivity cut-off for entry into the industry. Melitz's theory posits that high productive new firms entering the market as one of the channels through which aggregate industry productivity improves. The evidence from Ethiopian manufacturing suggests otherwise. Although, it is true that lower productive firms exit the industry, new firm entrants do have high productivity compared to surviving firms. New entrants are also smaller in size on average compared to existing firms in the industry. The median number of employees for a new firm is 13 which is only one-third of the median number of employees at surviving firms (45). The graph below shows the trend for all components of the decomposition.

Table 12 below shows the disaggregated productivity decomposition by industry within manufacturing[9]. We see some patterns that are similar to the story we see above for the overall manufacturing sector but there are also industries that show a different

[9] We present here the change in productivity between the first year and final year only for space consideration. We included the detailed table that compares productivity growth in each period relative the base year in the appendix. The information in the table above is representative of the overall trend for the full table in the appendix except for some sectors where we observe very high fluctuations

Figure 5: Productivity Change relative to beginning period (Year = 2000)



Note: The vertical lines indicate the two years when the tariff reduction took place.

pattern. A consistent within firm improvement in productivity for survivors is also evident in all industries similar to the trend we see in overall manufacturing. The covariance term, however, tells us two opposite stories depending on which industry we are looking at. We see a positive correlation between market shares and productivity in most of the industries except in Textile, Rubber and Plastics, and Furniture indicating that more productive firms produce more of the industry output contributing positively to aggregate industry productivity improvement. On the other hand, those three industries with a negative covariance term show that less productive firms still continue to produce more of the industry output. The magnitude of misallocation of resources in these industries is so high that the overall aggregate industry productivity growth is negative compared to its level in 2000 erasing the impact of positive within firm productivity improvement by surviving firms. We see a consistent decline in Furniture and Rubber and Plastics industries when we also compare productivity during intermediate years to the base year(see appendix).

The textile sector showed a positive aggregate productivity growth in the intermediate years despite the presence of some degree of resource misallocation except in the final year.

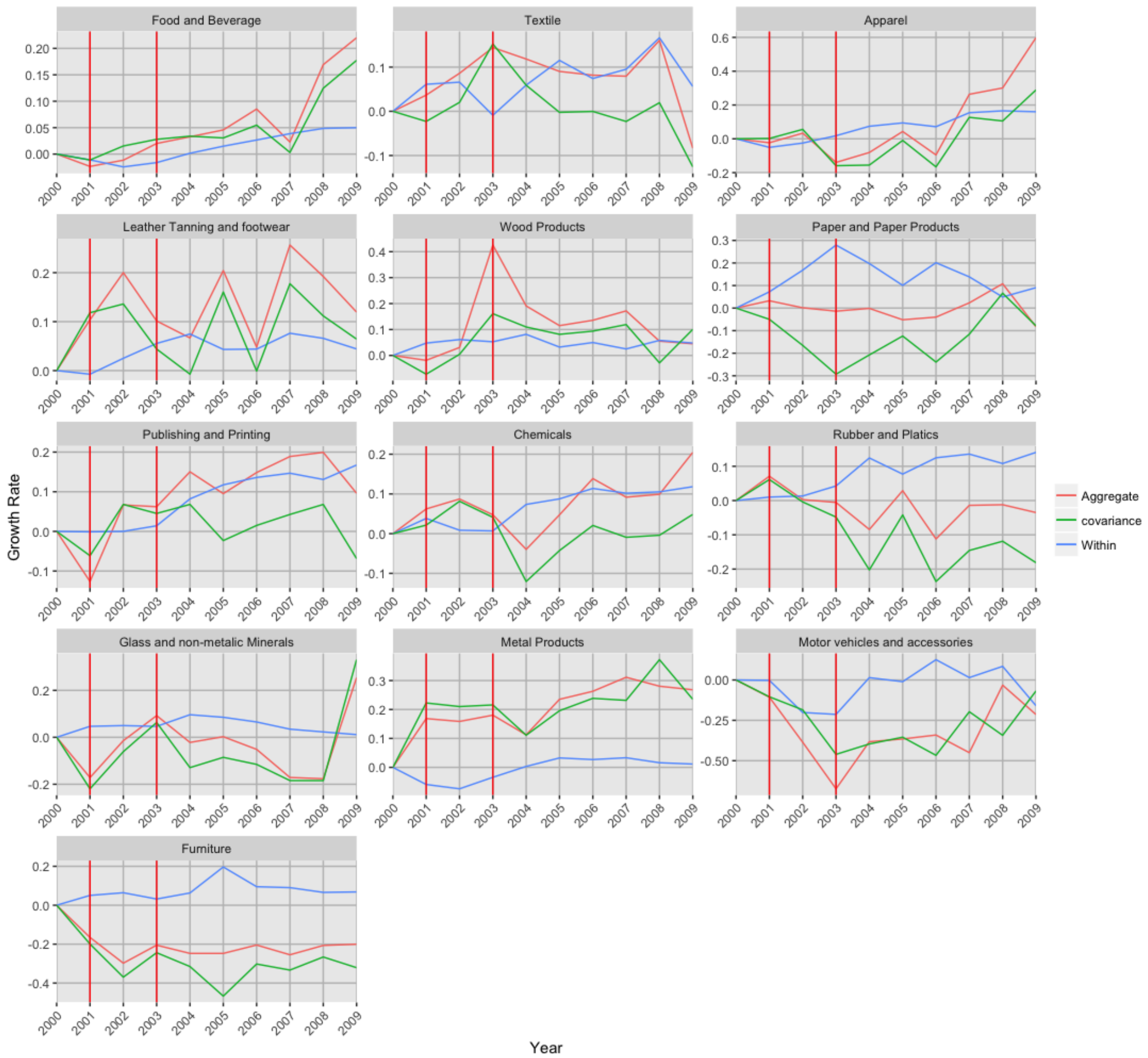
Table 12: Aggregate Productivity Decomposition by Industry (2-digit ISIC)

Aggregate Productivity Decomposition relative to 2000(T=1)						
	T=2	Survivors	covariance	Entrant	Exiter	Aggregate
Food and Beverage	2009	5.00	17.74	-1.96	1.23	22.01
Textile	2009	5.61	-12.57	2.26	-3.64	-8.35
Apparel	2009	16.02	28.89	0.40	14.46	59.78
Leather Tanning and footwear	2009	4.42	6.43	-0.41	1.50	11.95
Wood Products	2009	4.79	10.06	-6.33	-4.01	4.50
Chemicals	2009	11.83	4.85	-0.13	3.92	20.47
Rubber and Plastics	2009	14.06	-18.13	-0.48	1.05	-3.49
Glass and non-Metallic Minerals	2009	1.15	33.08	-9.70	0.89	25.43
Furniture	2009	6.84	-32.10	1.08	4.16	-20.02

The Textile industry experienced one of the largest drops in tariff rates of approximately 20% between 2000 and 2009, which did not necessarily induce market reallocation among the survivors nor lead to the exit of low productive firms. Exiters are also relatively more productive compared to survivors. The Textile industry aggregate productivity is negatively affected by exiting firms. Sixty percent of these surviving firms in the textile sector in Ethiopia are large state owned enterprises that are not necessarily productive but are usually able to secure government contracts for part of their market. These state owned firms could be a factor in explaining the negative correlation between productivity and market share reallocation.

The contribution of new firm Entrants to aggregate productivity are negative for most industries except for textile, apparel, and furniture industries. Exits of low productive firms contributes positively to aggregate industry productivity except for textile and wood products. Figure 2 shows a graph of the overall changes in productivity for selected thirteen 2-digit ISIC industries for all categories of decomposition.

Figure 6: Growth rate of Aggregate Productivity



In most industries the trend for aggregate industry productivity follows the trend for the covariance term indicating that allocative efficiency of the industry is the important driver of productivity followed by within firm productivity improvement. We exclude the trend lines for entrants and exiters for better visibility since these two lines are flat around the zero line in most industries indicating their insignificant contribution to aggregate productivity improvement.

4.6 Tariff Reduction and Aggregate Industry Productivity

We saw from productivity decomposition in the previous section that within productivity improvement and market reallocation among firms are important components that contribute the most for aggregate industry productivity. In this section, we will look at how tariff reduction affects the components of industry productivity. We will specifically look at the impact on aggregate industry productivity, within productivity improvement in industries, and market reallocation. We will make use of the following difference in productivity regression framework to investigate the impact of tariff.

$$\Delta Y_{ijt} = \alpha + \beta \Delta Tariff_{jt} + \delta Time_t + \varepsilon_{ijt} \tag{17}$$

Where ΔY_{ijt} is the change in aggregate productivity, within firm improvement in productivity, and covariance term from base year levels for firm i, industry j, and time t, respectively. $\Delta Tariff_{jt}$ is also the change in industry tariff relative to tariff level in 2000. Industry fixed effect disappears since it is time invariant. Table 13 below shows two versions of the result from the regression in equation 17. The OP Cross-section represents results using Olley-Pakes productivity decomposition which does not track new firm entrants and exiters. The results are presented in first three columns. The last three columns show results using components of the productivity decomposition from the dynamic Olley-Pakes which track new firm entrants and exiters. However, since we have already established in the previous section that entrants' and exiters' contribution to aggregate productivity is negligible, we ignore them in this regression. Instead, we see impact on within firms improvement and market share reallocation among surviving firms.

Table 13: Regression for the effect of tariff change on aggregate and within firm industry productivity and market reallocation

	OP Cross Section			Survivors Only:Dynamic OP		
VARIABLES	Aggregate	Within	Covariance	Aggregate	Within	Covariance
Tariff Change	8.69e-06	0.00186***	-0.00185***	-0.000850***	0.000412***	-0.00147***
	(0.000152)	(9.58e-05)	(0.000119)	(0.000204)	(0.000118)	(0.000137)
Constant	0.424***	0.248***	0.176***	0.141***	0.0720***	0.0758***
	(0.00503)	(0.00267)	(0.00452)	(0.00706)	(0.00346)	(0.00577)
Observations	11,217	11,217	11,217	11,217	4,550	4,550
Year FE	Y	Y	Y	Y	Y	Y
R-squared	0.568	0.533	0.284	0.085	0.072	0.107

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The result in the first three columns shows that a 10 percentage point decrease in tariff changes will improve the growth rate of market reallocation by 2% among all firms in the industry while it has equal but opposite effect on the improvement of the average industry productivity which captures within-firm productivity gains and selection effect in OP decomposition. The net effect on aggregate industry productivity is zero. The last three columns that track surviving firms from the dynamic OP decomposition indicate that a 10 percentage point decrease in tariff changes will improve the growth rate in the covariance term by 1.5 percent. Given the approximately 15 percent decrease in average tariff rate for the manufacturing sector between 2000 and 2009, it implies that we have a 2.25 percent growth rate in the covariance term due to the unilateral tariff reduction. We have seen in Table 11 that the overall increase in the covariance term between 2000 and 2009 is 10.04 percent. Therefore, we can conclude that the overall tariff reduction in the manufacturing sector is responsible 23 percent of the market allocative efficiency we observed in the same period. On the other hand, the within component indicates a positive relationship with tariff change indicating that a reduction in tariff will reduce the rate at which firms improve their productivity over time. A 10 percentage point reduction in tariff change reduces the growth rate of within-firm productivity improvement by 0.4 percent. In aggregate, the same amount of reduction in tariff change will increase the manufacturing sector's productivity by 0.9 percent. We know from Table 11 that the aggregate industry productivity increased by 14% for the manufacturing sector as a whole. Trade liberalization accounts for 13 percent of this overall in manufacturing sector productivity. Appendix F contains a table that accounts for industry heterogeneity by interacting tariff rate with industry dummies.

5 conclusion

This paper used a new production estimation technique that generates distributions of elasticity and productivity parameters that vary by time and industry to account for the heterogeneous productivity of firms in Ethiopian Manufacturing industry. A dynamic decomposition of aggregate industry productivity shows that we observe a shift in productivity distribution across time among surviving firms across all industries in manufacturing. While we observe reallocation of resources from low to high productive firms in some industries, we find misallocation in others as witnessed by the negative productivity and market share relationship. New firms that join industries also do not necessarily have higher productivity compared to firms that are already operating. Although the contribution of exiting firms towards aggregate industry productivity is negligible due to their lower market share weight, we have evidence that exiting firms have low level of productivity compared to surviving firms. In general, we found both within productivity improvement and selection effect as predicted by trade literature theory.

Trade liberalization in Ethiopia is shown to improve firm productivity, although the effect varies by the level of productivity prior to trade reform. Firms with relatively high level of productivity benefit the most from liberalization suggesting a differential benefit to globalization. Firms' decision to exit does not seem to be impacted directly due to competition from cheaper imports but through the indirect effect of tariff on productivity. We can concluded that domestic competition with other firms due to liberalization is a more important factor for exit decision rather than competition with cheaper imports from abroad.

The results from this paper indicate that trade liberalization measures are successful in improving average industry productivity although they are taken unilaterally without expecting reciprocal measures from trading partners. The existence of sectors where low productive firms produce a larger share of output represents a resource misallocation that needs to be addressed. There are barriers in some industries that prevent free movement of labor and capital which need to be identified.

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6 Appendix

Appendix: A: Comparison with SYS GMM and FGLS result

Table 14: Output Tariff Comparison Pooled OLS vs SYS GMM

Dependent variable: lnTFP	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	-0.00161*	-0.000586	-0.000606	-0.00463**	-0.00551***	-0.00619***
	(0.00099)	(0.00117)	(0.00159)	(0.00210)	(0.00185)	(0.00222)
Export Tariff Interaction		-0.00636***	-0.00610**		0.00153	0.00318
		(0.00223)	(0.00242)		(0.00398)	(0.00400)
Exporter Dummy		0.475***	0.526***		0.0809	0.0538
		(0.0614)	(0.0694)		(0.101)	(0.105)
Observations	10,289	10,289	4,417	6,703	6,703	3,727
R-squared	0.105	0.446	0.468			
Number of Firms				1,781	1,781	490
Hansen(p-value)				0.173	0.220	0.356
AR(1)p-value				0	0	0
AR(2)(p-value)				0.0418	0.0745	0.0878

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Controls: Firm Size, ownership, Time, and Industry Dummies

Table 15: Input Tariff: Pooled OLS vs SYS GMM

Dependent Variable: ln TFP	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	-0.00127	-0.000362	0.00216	-0.00276	-0.00456***	-0.00492***
	(0.00190)	(0.00140)	(0.00190)	(0.00171)	(0.00147)	(0.00166)
Input Tariff	-0.00240	-0.0154***	-0.0211***	0.00356	-0.000596	-0.00618
	(0.00329)	(0.00347)	(0.00466)	(0.00281)	(0.00448)	(0.00488)
Export Tariff Interaction		-0.00703***	-0.00628***		0.00182	0.00275
		(0.00227)	(0.00239)		(0.00382)	(0.00405)
Import Tariff Interaction		0.0164***	0.0152***		0.00196	0.0101
		(0.00298)	(0.00400)		(0.00642)	(0.00700)
Exporter Dummy		0.478***	0.507***		0.0632	0.0613
		(0.0618)	(0.0685)		(0.0933)	(0.0985)
Input Imports Dummy		0.0144	0.00821		-0.00571	-0.0490
		(0.0187)	(0.0276)		(0.0513)	(0.0524)
Observations	10,289	10,289	4,417	6,703	6,703	3,727
R-squared	0.213	0.452	0.475			
Number of Firms				1,781	1,781	490
Hansen(p-value)				0.0601	0.161	0.320
AR1(p-value)				0	0	0
AR2(p-value)				0.0389	0.0616	0.0789

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Controls: Firm Size, ownership, Time, and Industry Dummies

Table 16: FGLS Result

Dependent Variable : lnTFP	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	-0.00125**	0.00133**	0.000154	-7.74e-05	0.000404	0.00218**
	(0.000549)	(0.000599)	(0.000665)	(0.000596)	(0.000567)	(0.00102)
Input Tariff			-2.26e-05	-0.00122	-0.00155	-0.00619**
			(0.00111)	(0.00150)	(0.00142)	(0.00240)
Export Tariff Interaction		-0.00749***			-0.00345***	-0.00333***
		(0.00105)			(0.000862)	(0.00106)
Import Tariff Interaction				0.000205	0.00140	0.000283
				(0.00122)	(0.00114)	(0.00211)
Input Imports Dummy				0.0449***	0.0356***	0.0303*
				(0.00745)	(0.00639)	(0.0158)
Exporter Dummy		0.327***			0.174***	0.147***
		(0.0293)			(0.0259)	(0.0323)
Ownership Dummy	-0.0243***	-0.00386	-0.0540***	-0.0457***	-0.0384***	-0.0450***
	(0.00923)	(0.00927)	(0.0118)	(0.0117)	(0.0118)	(0.0142)
Firm Size Control	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,103	9,103	9,103	9,103	9,103	4,417
Number of Firms	1,832	1,832	1,832	1,832	1,832	492

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B: Linear Probability model

Table 17: Linear Probability Model (LPM) for firm exit regression

Dependent Varible: Exit indicator	(1)	(2)	(3)
lag productivity	-0.0288***		-0.0289***
	(0.00856)		(0.0100)
Tariff		-0.000350	-0.000405
		(0.000818)	(0.000881)
Time Dummy	Yes	Yes	Yes
Industry Dummy	Yes	Yes	Yes
Firm Size	Yes	Yes	Yes
Ownership Dummy	Yes	Yes	Yes
Observations	7,284	7,995	7,284
R-squared	0.127	0.128	0.127

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix C: Robustness Check with ACF production Function estimates

Table 18: Tariff and Productivity: ACF estimation using Revenue Function

Dependent Variable: lnTFP	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	0.00397***	0.00393***	-0.00538***	-0.00539***	-0.00581***	-0.00861***
	(0.00133)	(0.00134)	(0.00177)	(0.00164)	(0.00173)	(0.00264)
Export Tariff Interaction		0.00360			0.00138	0.00233
		(0.00282)			(0.00274)	(0.00257)
Exporter Dummy		0.0396			0.137**	0.125
		(0.0727)			(0.0691)	(0.0774)
Input Tariff			0.0245***	0.0246***	0.0269***	0.0376***
			(0.00274)	(0.00349)	(0.00378)	(0.00493)
Import Tariff Interaction				-0.000356	-0.000285	-0.00704
				(0.00312)	(0.00312)	(0.00460)
Input Imports Dummy				0.0143	0.00846	0.0932***
				(0.0218)	(0.0211)	(0.0359)
Ownership Dummy	-0.129***	-0.123***	-0.134***	-0.134***	-0.126***	-0.0943***
	(0.0205)	(0.0215)	(0.0198)	(0.0217)	(0.0212)	(0.0231)
Firm Size	Y	Y	Y	Y	Y	Y
Time Dummy	Y	Y	Y	Y	Y	Y
Industry Dummy	Y	Y	Y	Y	Y	Y
Observations	9,944	9,944	9,944	9,944	9,944	4,343
R-squared	0.953	0.953	0.953	0.953	0.953	0.953

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

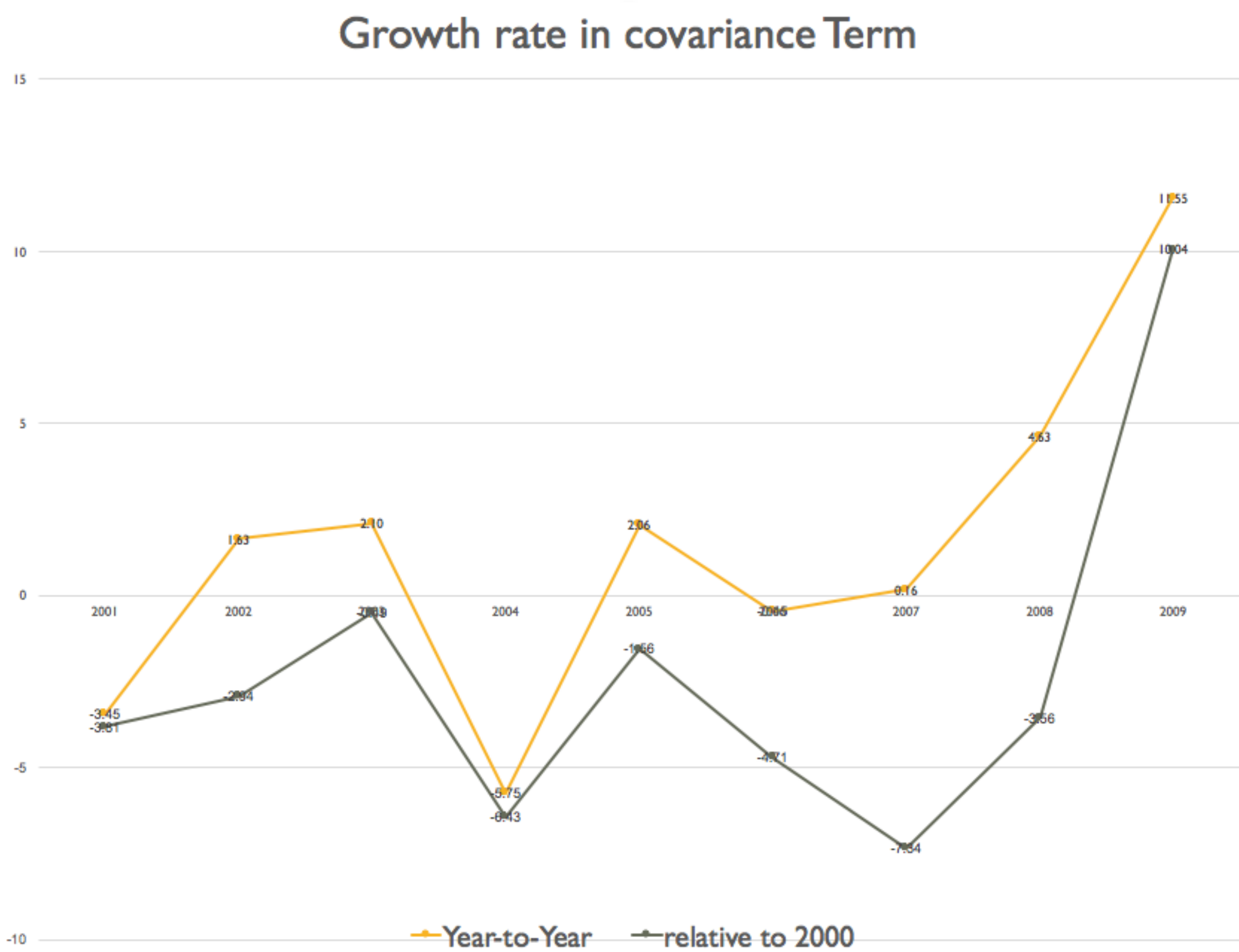
Table 19: Trade and Productivity: ACF estimation using value added production Function

Dependent Variable:lnTFP	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	0.00862***	0.00845**	-0.00994**	-0.0104**	-0.0107**	-0.00820
	(0.00335)	(0.00350)	(0.00469)	(0.00432)	(0.00426)	(0.00591)
Export Tariff Interaction		0.00556			-0.000158	0.0152**
		(0.00665)			(0.00649)	(0.00726)
Exporter Dummy		0.0297			0.246	-0.0156
		(0.180)			(0.187)	(0.222)
Input Tariff			0.0487***	0.0265***	0.0296***	0.0361***
			(0.00740)	(0.00935)	(0.00933)	(0.0122)
Import Tariff Interaction				0.0274***	0.0278***	0.00837
				(0.00787)	(0.00825)	(0.0107)
Input Imports Dummy				-0.0676	-0.0773	0.0469
				(0.0575)	(0.0575)	(0.0845)
Ownership Dummy	-0.00584	0.00316	-0.0160	-0.0171	-0.00725	0.0740
	(0.0515)	(0.0527)	(0.0499)	(0.0512)	(0.0510)	(0.0595)
Firm Size	Y	Y	Y	Y	Y	Y
Time Dummy	Y	Y	Y	Y	Y	Y
Industry Dummy	Y	Y	Y	Y	Y	Y
Observations	10,196	10,196	10,196	10,196	10,196	4,391
R-squared	0.966	0.966	0.966	0.966	0.966	0.969

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix D: Growth rate of covariance term

Figure 7: Year-to-Year change Vs change relative to base year in Covariance Term



Appendix E: Productivity Decomposition of 2 digit-level ISIC industries

Table 20: Dynamic Olley Pakes Decomposition by 2 Digit ISIC Industry Code

Aggregate Productivity Decomposition relative to 2000(T=1)						
	T=2	Survivors	covariance	Entrant	Exiter	Aggregate
Food and Beverage	2001	-1.10	-1.12	-0.31	0.19	-2.34
	2002	-2.42	1.53	-0.46	0.20	-1.16
	2003	-1.61	2.79	-0.04	0.87	2.00
	2004	0.16	3.39	-0.34	0.07	3.27
	2005	1.49	3.05	-0.15	0.17	4.57
	2006	2.66	5.48	0.34	0.04	8.52
	2007	3.87	0.31	-0.40	-1.49	2.29
	2008	4.86	12.46	-0.42	0.02	16.92
	2009	5.00	17.74	-1.96	1.23	22.01
Textile	2001	6.12	-2.29	-0.15	-0.01	3.67
	2002	6.59	2.03	-0.02	0.00	8.60
	2003	-0.89	15.24	0.06	0.02	14.43
	2004	5.93	5.90	0.00	0.00	11.83
	2005	11.52	-0.24	-0.17	-2.09	9.03
	2006	7.42	-0.03	0.18	0.60	8.17
	2007	9.52	-2.29	0.09	0.64	7.95
	2008	16.64	1.95	-0.70	-1.84	16.05
	2009	5.61	-12.57	2.26	-3.64	-8.35
Apparel	2001	-5.05	0.21	-2.13	4.64	-2.33
	2002	-2.51	5.58	-0.78	1.05	3.34
	2003	1.84	-15.89	0.00	0.08	-13.97
	2004	7.42	-15.53	0.04	0.00	-8.08
	2005	9.42	-0.95	-0.23	-3.91	4.33
	2006	7.17	-16.61	0.00	-0.09	-9.53
	2007	15.44	12.71	-2.04	0.23	26.34
	2008	16.54	10.55	-2.72	5.71	30.08
	2009	16.02	28.89	0.40	14.46	59.78
Leather Tanning and footwear	2001	-0.73	11.82	-0.84	0.14	10.38
	2002	2.51	13.60	-0.11	4.00	20.01
	2003	5.55	4.40	-0.09	0.28	10.14
	2004	7.48	-0.72	-0.09	0.02	6.68
	2005	4.33	16.05	-0.13	0.18	20.42
	2006	4.39	-0.07	-0.15	0.63	4.79
	2007	7.63	17.74	-0.29	0.55	25.64
	2008	6.59	11.17	0.05	1.42	19.23
	2009	4.42	6.43	-0.41	1.50	11.95
Wood Products	2001	4.76	-7.22	-0.02	0.61	-1.87
	2002	6.12	0.44	-2.97	-0.51	3.08
	2003	5.28	16.11	-4.21	25.38	42.55
	2004	8.14	10.97	-0.03	0.00	19.08
	2005	3.23	8.15	-0.01	0.12	11.49
	2006	4.98	9.38	-0.86	0.06	13.57
	2007	2.51	11.90	2.74	-0.02	17.13
	2008	5.81	-2.86	2.56	0.00	5.51
	2009	4.79	10.06	-6.33	-4.01	4.50
Paper and Paper Products	2001	7.21	-4.98	0.00	1.02	3.26
	2002	16.81	-16.54	-0.15	0.00	0.13
	2003	27.94	-29.31	0.00	0.00	-1.36
	2004	19.74	-20.76	0.88	0.00	-0.14
	2005	10.08	-12.39	1.25	-4.12	-5.18
	2006	20.12	-23.94	-0.13	-0.05	-3.99
	2007	13.84	-11.58	0.07	0.00	2.33
	2008	4.93	6.61	-0.75	0.00	10.78
	2009	9.05	-7.87	-0.03	-9.41	-8.25
Publishing and Printing	2001	-0.11	-6.14	-0.01	-6.37	-12.64
	2002	0.01	6.80	-0.17	0.04	6.67
	2003	1.41	4.53	-0.05	0.33	6.22
	2004	8.20	6.80	0.00	0.03	15.03
	2005	11.74	-2.31	0.02	0.08	9.53
	2006	13.61	1.50	0.01	-0.28	14.84
	2007	14.67	4.28	0.11	-0.05	19.01
	2008	13.09	6.79	0.04	0.00	19.93
	2009	16.74	-6.87	-0.01	-0.25	9.60
Chemicals	2001	3.83	2.15	0.18	0.06	6.22
	2002	0.87	8.15	-0.29	0.00	8.72
	2003	0.69	4.12	-0.07	0.02	4.75
	2004	7.36	-12.05	-0.02	0.75	-3.96
	2005	8.76	-4.25	-0.06	0.29	4.74
	2006	11.38	2.06	-0.17	0.59	13.87
	2007	10.18	-0.92	-0.22	0.14	9.18
	2008	10.52	-0.40	-0.21	0.00	9.92
	2009	11.83	4.85	-0.13	3.92	20.47
	2001	1.01	6.13	-0.21	0.17	7.10
Rubber and Platics	2002	1.33	-0.41	-0.70	0.05	0.27
	2003	4.25	-4.82	-0.03	0.04	-0.55
	2004	12.43	-20.22	-0.76	0.12	-8.44
	2005	7.72	-4.19	-0.66	0.02	2.89
	2006	12.48	-23.62	-0.28	0.21	-11.20
	2007	13.55	-14.56	-0.36	-0.04	-1.41
	2008	10.80	-11.87	-0.15	0.00	-1.22
	2009	14.06	-18.13	-0.48	1.05	-3.49

Table 21: Dynamic Olley Pakes Decomposition by 2 Digit ISIC Industry Code...

Aggregate Productivity Decomposition relative to 2000(T=1)						
	T=2	Survivors	covariance	Entrant	Exiter	Aggregate
Glass and non-metalic Minerals	2001	4.68	-21.94	-0.18	0.29	-17.15
	2002	5.00	-6.12	-0.80	0.48	-1.44
	2003	4.66	6.31	-2.35	0.63	9.24
	2004	9.63	-12.91	-0.21	1.31	-2.18
	2005	8.53	-8.53	-0.02	0.27	0.25
	2006	6.53	-11.53	-0.18	0.05	-5.13
	2007	3.47	-18.43	-1.91	-0.25	-17.11
	2008	2.30	-18.45	-1.49	0.00	-17.64
	2009	1.15	33.08	-9.70	0.89	25.43
Basic Iron,steel,and casting	2001	12.87	11.84	0.39	0.00	25.09
	2002	6.60	18.21	-0.28	0.00	24.53
	2003	10.44	6.61	-0.08	0.00	16.97
	2004	10.88	-1.72	0.48	0.00	9.64
	2005	12.98	6.94	-0.80	0.00	19.12
	2006	15.69	4.71	0.00	0.00	20.40
	2007	14.35	10.53	0.00	2.21	27.09
	2008	16.83	8.50	-0.29	-6.38	18.65
	2009	6.72	19.09	-0.56	-3.20	22.06
Metal Products	2001	-5.91	22.25	0.11	0.41	16.85
	2002	-7.41	21.01	1.33	0.93	15.87
	2003	-3.43	21.57	-0.29	0.18	18.03
	2004	0.33	11.11	-0.24	0.05	11.25
	2005	3.26	19.58	0.66	0.02	23.51
	2006	2.70	23.85	-0.26	0.01	26.29
	2007	3.33	23.16	0.84	3.82	31.14
	2008	1.60	37.22	-1.95	-8.83	28.04
	2009	1.14	23.51	0.84	1.31	26.81
Machinery	2001	-1.68	-7.24	0.00	-0.34	-9.26
	2002	-16.79	7.32	0.57	-6.44	-15.34
	2003	-9.08	-7.11	17.14	0.08	1.02
	2004	1.30	5.14	0.00	0.00	6.45
	2005	5.38	6.78	0.00	4.91	17.07
	2006	8.62	0.02	-0.21	0.00	8.42
	2007	18.38	6.92	0.00	2.35	27.66
	2008	27.40	-9.26	0.00	1.65	19.80
	2009	24.69	-8.58	-0.15	0.00	15.96
Motor vehicles and accessories	2001	-0.24	-10.42	0.00	0.01	-10.66
	2002	-20.12	-18.50	0.00	0.07	-38.55
	2003	-21.31	-46.07	-0.01	0.00	-67.39
	2004	1.46	-39.61	-0.07	0.00	-38.23
	2005	-1.06	-35.44	-0.04	0.00	-36.53
	2006	12.58	-46.66	0.00	0.00	-34.09
	2007	1.49	-19.66	-26.84	0.00	-45.01
	2008	8.44	-34.27	-0.11	22.72	-3.22
	2009	-15.92	-6.82	-0.01	1.37	-21.38
Furniture	2001	5.05	-19.94	-4.15	2.49	-16.54
	2002	6.43	-36.96	-2.30	3.06	-29.77
	2003	3.18	-24.39	-0.05	0.74	-20.52
	2004	6.32	-31.50	-0.69	1.13	-24.75
	2005	19.66	-46.70	-0.04	2.33	-24.76
	2006	9.52	-30.21	-0.59	0.83	-20.45
	2007	9.04	-33.32	-3.48	2.30	-25.46
	2008	6.61	-26.60	-0.67	0.00	-20.67
	2009	6.84	-32.10	1.08	4.16	-20.02

Appendix F: Industry level regression of tariff and productivity accounting for heterogeneity of industries

Table 22: Tariff and industry Productivity regression: Accounting for Industry Heterogeneity

	OP cross Section			Dynamic OP		
Dep. Variables	Aggregate	Within	Covariance	Aggregate	Within	Covariance
Tariff Change	0.0128***	-0.00835***	0.0212***	0.0496***	0.00693***	0.0377***
	(0.000396)	(0.000300)	(0.000261)	(0.000464)	(0.000347)	(0.000231)
Food and Beverage*tariff	-0.00916***	0.0111***	-0.0203***	-0.0478***	-0.00644***	-0.0380***
	(0.000262)	(0.000213)	(0.000182)	(0.000381)	(0.000259)	(0.000187)
Textile*tariff	-0.00615***	0.00893***	-0.0151***	-0.0473***	-0.00845***	-0.0351***
	(0.000430)	(0.000212)	(0.000327)	(0.000593)	(0.000351)	(0.000273)
Apparel*tariff	-0.0151***	0.00651***	-0.0216***	-0.0483***	-0.00770***	-0.0367***
	(0.000390)	(0.000262)	(0.000322)	(0.000551)	(0.000419)	(0.000273)
Leather and Footwear*tariff	-0.00899***	0.0156***	-0.0246***	-0.0559***	-0.0139***	-0.0423***
	(0.000932)	(0.000460)	(0.000568)	(0.00111)	(0.000740)	(0.000383)
Wood*tariff	-0.0113***	0.00210***	-0.0134***	-0.0481***	-0.00778***	-0.0378***
	(0.000523)	(0.000290)	(0.000451)	(0.000609)	(0.000434)	(0.000260)
Paper*tariff	-0.00756***	-8.59e-05	-0.00747***	-0.0367***	-0.00611***	-0.0276***
	(0.00102)	(0.000490)	(0.000788)	(0.00100)	(0.000451)	(0.000657)
Publishing*tariff	0.00935***	0.00422***	0.00513***	-0.0478***	-0.0159***	-0.0314***
	(0.000712)	(0.000194)	(0.000782)	(0.00104)	(0.000733)	(0.000371)
Chemicals*tariff	-0.00548***	0.00987***	-0.0153***	-0.0430***	-0.00799***	-0.0329***
	(0.000344)	(0.000178)	(0.000376)	(0.000592)	(0.000474)	(0.000283)
Rubber* tariff	0.0141***	0.00859***	0.00547***	-0.0125***	-0.00581***	-0.00848***
	(0.000685)	(0.000255)	(0.000711)	(0.000995)	(0.000613)	(0.000625)
Glass*tariff	-0.0120***	0.00881***	-0.0208***	-0.0421***	-0.00487***	-0.0351***
	(0.000252)	(0.000199)	(0.000196)	(0.000392)	(0.000244)	(0.000288)
Iron and Steel*tariff	-0.000453	0.0926**	-0.0931***	-0.104***	-0.00599	-0.0263
	(0.0428)	(0.0379)	(0.0127)	(0.0388)	(0.0346)	(0.0173)
Metal Products*tariff	-0.0551***	-0.00648***	-0.0486***	-0.0950***	-0.0148***	-0.0788***
	(0.00206)	(0.000968)	(0.00165)	(0.00277)	(0.00207)	(0.00156)
Machinery*tariff	-0.167***	-0.0751***	-0.0920***	-0.0234***	-0.00467	-0.0123***
	(0.0121)	(0.0104)	(0.0169)	(0.00901)	(0.00948)	(0.00388)
Electric Motors*tariff	-0.0259	0.0122	-0.0381***	-0.0536***	-0.00912**	-0.0358***
	(0.0331)	(0.0320)	(0.00899)	(0.0106)	(0.00385)	(0.00412)
Motor Vehicles*tariff	0.0298***	0.0275***	0.00222**	0.00246	0.0123***	-0.00802***
	(0.00107)	(0.000502)	(0.00106)	(0.00243)	(0.00169)	(0.00102)
Time Dummy	Y	Y	Y	Y	Y	Y
Observations	11,217	11,217	11,217	11,217	11,217	11,217
R-squared	0.773	0.801	0.647	0.642	0.215	0.580

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$