The Impact of Input and Output Tariffs on Firms’ Productivity: Theory and Evidence

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Abstract

This paper studies the impact of trade liberalization on productivity. I show that when intermediate inputs are not highly differentiated, lowering input tariffs leads to a rise in within-firm productivity and wages, and lowering output tariffs has the opposite effect. When intermediate inputs are highly differentiated, the conclusions reverse. These predictions are supported by the data, given by the industrial survey from INEGI (Mexico’s Instituto Nacional de Estadística Geografía e Informacion) in the period 1984-1990. The paper yields estimates for the elasticity of substitution among intermediate inputs, which are useful in determining the direction of the impact of trade liberalization. These estimates can be used to assess the gains from trade liberalization.

I Introduction

The effects of trade reform on productivity have been thoroughly studied. However the results both theoretical and empirical have been ambiguous. The proponents of protectionism claim that imposing tariffs for a period of time allows domestic firms to grow in size, enabling them to exploit the economies of scale and become more efficient. Moreover, the incentive to invest in superior technology might increase with market size (Rodrik 1988). In contrast,

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the supporters of trade liberalization claim that trade liberalization will raise productivity through two channels. The first channel is the selection effect (Melitz 2003) where the most productive firms survive and thrive after trade liberalization, the inefficient ones have to exit. As a result, the average productivity across firms increases. Individual firms can also experience improved productivity through a second channel: trade liberalization provides more access to foreign technology (Grossman and Helpman 1991).

Consistent with the second channel, recent work has focused on the role of intermediate inputs. Trade liberalization brings more access to foreign markets. Therefore domestic firms can import higher quality inputs, leading to higher productivity. There are other ways to improve productivity through the use of intermediate inputs. The love of variety approach, outlined in the Dixit-Stiglitz (1977) model, implies that the firm is more productive when using more varieties of intermediate inputs (Feenstra, Markusen and Zeile 1992, Acemoglu and Zilibotti 2001, Koren and Tenreyro 2007). Ethier (1982) attributes this effect as “higher specialization in production”. In line with Ethier’s argument, I address the following question: How do import tariffs, in particular input tariffs and output tariffs, affect firms’ productivity through the import of intermediate inputs?

This question has been partially addressed in the literature. Pavcnik (2002) finds that in Chile, plants in the import-competing sectors are on average more productive than those in non-traded sectors. By comparing the performance of the firms in those sectors during the period of trade liberalization, she suggests that the plants in the import-competing sectors will have to close their inefficient parts due to greater foreign competition. Fernandes (2007) shows that in Colombia, tariffs have a negative effect on productivity. She also finds evidence for the prediction that more imports of intermediate inputs lead to productivity gains. However she does not distinguish between the types of tariffs, in particular input tariffs and output tariffs, which may be an important distinction. Indeed Amiti and Konings (2007) take the analysis one step further, showing that in Indonesia, tariffs on intermediate inputs have a significant negative effect on productivity, while the effects of output
tariffs are much smaller, even insignificant. In contrast to these studies, Tybout (1991) finds little productivity improvement after trade liberalization in Chile in the 1970s. Muendler (2004) shows that in Brazil, although trade liberalization brings high quality intermediate inputs from abroad, it contributes little to productivity since high quality inputs come with high prices.

The closest papers to this one are Halpern, Koren and Szeidl (2006) and Kasahara and Rodrigue (2008). The former provides a model in which the productivity of a firm increases with the quality and the number of varieties of intermediate inputs that the firm uses. Since the authors do not observe tariffs, they have to rely on counterfactual experiments to study the impact of trade reforms. Moreover, since they have to approximate the change in the number of varieties as a function of tariffs so that they can link trade policy with productivity improvement, their experiments can only applied to reforms in which the change in tariffs is small, which is rarely the case when countries pursue trade liberalization. Kasahara and Rodrigue (2008) show that in Chile, a higher share of foreign intermediate inputs implies a larger variety of intermediate inputs which brings productivity improvement. Their study however does not link the share of foreign intermediate inputs to economic policy, we therefore do not know how policy makers should implement trade reforms.

This paper shows that trade liberalization can have a negative or positive effect on productivity depending on which markets are liberalized and the degree of differentiation of the intermediate inputs. Trade liberalization in the final market and trade liberalization in the intermediate markets have opposite impacts on the performance of the firms. Only few studies distinguish input tariffs (applied in the intermediate markets) and output tariffs (applied in the final market). Corden (1971) claims that output tariffs act as a protection for the value-added product while input tariffs behave like a tax on this product. For example, trade protection in the car industry (the final market) helps the auto makers, while high tariffs in the auto parts markets (the intermediate markets) reduce profit. Empirically, besides the study of Amiti and Konings (2007) that we mentioned above, the only study that explicitly distinguishes be-
tween input and output tariffs is Schor (2004), who finds that in Brazil, including input tariffs in the estimation reduces the effects of output tariffs. I develop a model that explicitly considers the role of input and output tariffs. I also test the model using the data from Mexico which seems to support my model.

The effects of trade liberalization will also depend on the degree of differentiation of intermediate inputs, captured by the elasticity of substitution among these inputs. The intuition is simple: Depending on how differentiated these inputs are, the marginal revenue of intermediate inputs increases or decreases with the number of varieties of these inputs. When inputs are highly differentiated, adding one more variety will greatly increase the efficiency of the firm. Hence, the marginal revenue is an increasing function of the number of varieties. In contrast, when these inputs are less differentiated, or in the extreme case when they are perfect substitute, having one extra variety is equivalent to increasing the quantity of the same inputs. This will decrease the efficiency, or the marginal revenue of intermediate inputs. In this case, the marginal revenue of intermediate inputs decreases with the number of varieties. Output tariffs increase with output price, hence, increase with the marginal revenue of intermediate inputs. Therefore, lowering output tariffs leads to a decline in the number of varieties if intermediate inputs are not highly differentiated, and a rise in the number of varieties otherwise. Input tariffs however increase with the marginal cost of intermediate inputs, which has to be equal to the marginal revenue in equilibrium. Therefore, lowering input tariffs implies a fall in the marginal revenue of intermediate inputs, which leads to a rise in the number of varieties if the degree of differentiation is not high, and a decline otherwise. By the love of variety approach described above, an increase (decrease) in the number of varieties due to the changes in input and output tariffs implies a rise (fall) in productivity. The degree of differentiation dependence motivates our empirical exercise as it provides the estimates of the elasticity of substitution which tells us how differentiated the intermediate inputs are.

Besides productivity, trade liberalization can affect wages: After the country liberalizes, wages might decline (Goldberg and Pavcnik 2005, Revenga 1997), stay unchanged (Pavcnik et al 2004, Trefler
2004) or even increase (Amiti and Davis 2008). My model proves that each of these contrasting scenarios is possible depending on which markets trade liberalization affects and the degree of differentiation of the intermediate inputs. Which scenario applies to Mexico in the 1980s is an empirical question which motivates, in part, the empirical analysis in the second part of the paper.

I also show that the effects of trade liberalization on productivity and on wages in the long run are always higher than in the short run, when labor is immobile. In other words, the mobility of labor makes the responses of productivity and wages to trade reforms more pronounced, which means the gains from trade liberalization can be bigger. This result calls for more labor market deregulation.

Finally, this paper provides estimates for the elasticity of substitution. Not many studies in the literature provide these, and they focus on the consumption side, i.e. they estimate the elasticity of substitution among consumption goods. My paper however provides estimates for the intermediate inputs, which are useful in determining the direction of the impact of trade liberalization on productivity, and also helps us to quantify the gains from trade.

The organization of the paper is as follows: Section 2 present my model. Section 3 discusses the variety effect. In Section 4, I examine how trade policy can change the economic outcomes such as imports of intermediate inputs, measured productivity and wages. Section 5 tests these predictions and estimates the structural parameters in the model. The results are summarized in Section 7. Proofs are given in the Appendix.

II The Small Open Economy

We consider a modified Ricardo-Viner model applied to a small, developing country. There are two sectors, A and M, employing a common factor which will be denoted as labor. This factor is supplied inelastically. Sector A, considered to be the numeraire, uses only labor whereas sector M will combine labor and imported intermediate goods to produce a final product. Most of the action will take place in this sector M, therefore we will assume that trade pol-
icy, set by the country, only applies to sector M and the intermediate sector which we will denote as X. Sector M is assumed to be duty free.\textsuperscript{1} Implicitly we assume that sector M is the import-competing sector while sector A is the export-competing one to balance trade. It is consistent with the fact that the country is less developed than the rest of the world and sector M is presumably more capital intensive than sector A. For the notations, as the imported intermediate goods will be used as one of the inputs for the goods in sector M, the tariff applied to these intermediate goods will be called input tariff while the one imposed on sector M will be called output tariff. Also since the country is small, the prices in sector M and sector X will be the world prices plus the tariffs. In particular, if we call $p^w$ and $r^w$ the world prices in sector M and X, $p, r$ the corresponding effective prices and $\tau_i, \tau_o$ the corresponding tariffs then we have:

\[
p = p^w(1 + \tau_o) \\
r = r^w(1 + \tau_i)
\]

As $p^w$ and $r^w$ are fixed, $p$ and $r$ can substitute for $\tau_o$ and $\tau_i$. To save the notations, we now discuss the effects of $p$ and $r$ as a proxy for trade policy. The price in sector A is always 1.

\section*{II.1 Sector A}

As mentioned above, our model is a modified Ricardo-Viner. Since sector A plays a minor role in our model and we do not intend to discuss the effects on the specific factors, we assume that this sector uses only a common factor $L$, as labor\textsuperscript{2}. We can think of this sector as Agriculture. The production function is assumed to be as follows:

\[
A = L^\gamma - (L - L_A)^\gamma
\]

$L$ is the supply of labor and $L_A$ is the quantity of labor used in sector A. This set up is arguably ad-hoc. However it satisfies the

\textsuperscript{1}We can also think of the trade policy in sector A to be unchanged during the studying period. Think about Agriculture (sector A) and Manufacture (sector M). One might raise the concern that the reciprocal tariff, set by the trade partners, might affect the productivity of the country in question. In our model since we assume that the trade policy in sector A does not change, we can focus on the case where trade policy is unilateral. I thank Marc for this comment.

\textsuperscript{2}Later in the empirical part, this common factor labor will regarded as domestic factor, since the intermediate inputs have to be imported.
conventional constraints, namely the concavity (when $\gamma$ is bigger than 1) and when labor used is zero, the quantity produced in the sector is also zero. When $\gamma$ is equal to 1, we have a linear production function. This form of function helps us to solve for an analytical solution in equilibrium, which proves to be useful for our estimations, as we will see in the later parts. The decision in this sector is simply to equate the marginal product of labor with the wage:

$$w = \gamma (L - L_A)^{\gamma - 1} \tag{1}$$

This condition tells us that there is constant price elasticity of supply of labor: the elasticity is simply $\frac{1}{\gamma - 1}$ when $\gamma$ is bigger than 1.

II.2 Sector M

Assume there is one representative firm that combines labor and imported intermediate inputs to produce a final homogenous good as follows:

$$M = L_M^\alpha \left( \int_0^nx(j)^{\epsilon}dj \right)^{\frac{1-\alpha}{\epsilon}} \tag{2}$$

where $L_M$ is the number of workers hired, $x(j)$ is the amount of intermediate input $j$ used and $n$ is the number of varieties chosen by the firm. The elasticity of substitution among intermediate inputs is computed as $\sigma = \frac{1}{1-\epsilon}$. Therefore a high $\epsilon$ indicates that intermediate inputs are more easily substituted, while a low $\epsilon$ corresponds to greater input differentiation within the sector. We assume that there is no fixed cost of using intermediate input varieties. As output grows with the number of varieties and there is no cost of increasing this number, it is obvious that the firm will use all available varieties. Therefore it remains for the firm to choose optimally labor and the quantity of each intermediate input variety. The two optimal conditions are then:

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3This assumption is contrast to Halpern, Koren and Szeidl (2006) where they have heterogeneous fixed cost to explain a feature in their Hungarian data that firms use different number of varieties. As we don’t have data on the number of varieties, assuming a homogeneous fixed cost will create a natural monopoly since the small firms can not afford to pay this fixed cost, only the biggest firm can.
or equivalently we have:

\[ \frac{\partial \Pi}{\partial L_M} = 0 \]
\[ \frac{\partial \Pi}{\partial x(j)} = 0 \]

\[ \alpha p L_M^{\alpha-1} \left( \int_0^n x(j)^{\sigma} dj \right)^{\frac{1-\alpha}{\sigma}} = w \] (3)

\[ (1 - \alpha)p L_M^\alpha \left( \int_0^n x(j)^{\sigma} dj \right)^{\frac{1-\alpha-\varepsilon}{\varepsilon}} x(j)^{\sigma-1} = r(j) \] (4)

The first and second equations tell us that the marginal revenue of using one extra unit of input, be labor or intermediate input \( j \), must be equal to the cost of purchasing that unit, be wage or the intermediate input price.

II.3 Sector X

There are no domestic producers in sector X (the intermediate sector). Instead there are only foreign producers, each of them will provide a differentiated intermediate input and has to pay a fixed cost, acting as set up cost. With the small country assumption, the world price of the intermediate inputs will not be affected by whatever happens in the Home country. In other words, the price of these inputs that the domestic users have to pay, which is the world price plus the ad valorem tariff, will be treated as exogenous variable. Acting as a monopolistic competitor, a foreign supplier has a profit which is proportional to its revenue. Indeed, this profit will be equal to the revenue divided by the elasticity of substitution among intermediate input varieties. Call the fixed set up cost \( c \), the free entry condition implies:

\[ \frac{rx}{\sigma} = c \] (5)

III The variety effect in measured productivity

To discuss productivity changes, we need a measure of productivity. The most common ones are labor and total factor produc-
tivity (TFP). Since there is no reason to prefer one to another, one should consider both of them.

Total factor productivity is defined as follows:

$$\Omega = \frac{M}{L^{\alpha}K^{1-\alpha}}$$

$$= n^{(1-\alpha)(1-\epsilon)}$$

where $$K = \int_0^n x(j) dj$$. The variety effect appears clearly here. Total factor productivity $$\Omega$$ is an increasing function of $$n$$, the number of intermediate input varieties. The higher $$1 - \alpha$$ and the lower $$\epsilon$$, the higher the effect. The intuition is straightforward. Measured productivity responds highly to the number of intermediate input varieties change when those inputs are more important (high $$1 - \alpha$$) and when they are more substitutable (low $$\epsilon$$).

Another measure is labor productivity. In our set up, this measure of productivity is proportional to the wage in sector M. Therefore instead of discussing another measure of productivity, we can study the effects of tariffs on TFP and wages. Henceforth, we denote productivity as TFP.

**IV The effects of trade policy**

Here we discuss two scenarios: the short run and the long run. In the short run scenario, labor is assumed to be immobile. This situation is more likely to arise in the developing countries when the labor market is imperfect, highly regulated, or when the moving cost is high or the unions are powerful. Moreover, distinguishing these two scenarios is interesting because I will show that trade policy has bigger effects in magnitude in the long run than in the short run. This result helps policy makers to think about whether we should regulate the labor market.
IV.1 Labor market friction: short term equilibrium

In this case, labor is immobile. In other words, $L_M$ is fixed, we will have the wage in sector A fixed, whereas that in sector M depends only on the intensive and extensive margin of import of intermediate inputs, according to (3). In this case, we have a system of equations:

$$\alpha pL_M^{\alpha - 1} \left( \int_0^n x(j)^{\epsilon} dj \right)^{\frac{1}{\alpha - 1}} = w$$

$$(1 - \alpha) pL_M^\alpha \left( \int_0^n x(j)^{\epsilon} dj \right)^{\frac{1}{\alpha - 1}} x(j)^{\epsilon - 1} = r(j)$$

where $n, x, w$ are the unknowns. From the second and third equations, we can get the intensive margin of imports:

$$x = \frac{1}{1 - \epsilon} \frac{c}{r}$$

Given that $L_M$ is fixed, we can derive the extensive margin of imports $n$, from either the second or the third equation:

$$n = (1 - \alpha)^{\frac{\epsilon}{\alpha + \epsilon - 1}} \left( \frac{\epsilon}{1 - \epsilon} \right)^{\frac{\alpha \epsilon}{\alpha + \epsilon - 1}} L_M^{\frac{\alpha \epsilon}{\alpha + \epsilon - 1}} c^{\frac{\alpha \epsilon}{\alpha + \epsilon - 1}} p^{\frac{\epsilon}{\alpha + \epsilon - 1}} r^{\frac{(1 - \alpha) \epsilon}{\alpha + \epsilon - 1}}$$

Finally the wage in sector M is given by:

$$w = \alpha pL_M n^{\frac{\epsilon}{\alpha - 1}} x^{1 - \alpha}$$

Remember that the producer prices are linked with the tariffs by the following formulas:

$$p = p^w (1 + \tau_o)$$
$$r = r^w (1 + \tau_i)$$

where $p^w, r^w$ are the given world price of the final good in sector M and the intermediate inputs (sector X). Hence we can rewrite the above formulas as follows:

$$x = \frac{1}{1 - \epsilon} \frac{c}{(1 + \tau_i) r^w}$$
\[ n = A_1 c^{\frac{\alpha}{\alpha+\epsilon-1}} (p^w(1 + \tau_o))^\frac{\epsilon}{\alpha+\epsilon-1} (r^w(1 + \tau_i))^\frac{-(1-\alpha)}{\alpha+\epsilon-1} \]  

where \( A_1 = (1 - \alpha)^{\frac{\alpha}{\alpha+\epsilon-1}} \left( \frac{\epsilon}{1-\epsilon} \right)^{\frac{\alpha}{\alpha+\epsilon-1}} L_M^{\frac{\alpha}{\alpha+\epsilon-1}} \)

\[ w = A_2 c^{\frac{(1-\alpha)(1-\epsilon)}{\alpha+\epsilon-1}} (p^w(1 + \tau_o))^{\frac{1-\alpha}{\alpha+\epsilon-1}} (r^w(1 + \tau_i))^{\frac{(1-\alpha)\epsilon}{\alpha+\epsilon-1}} \]  

Total factor productivity is given by:

\[ \Omega = A_1 (p^w(1 + \tau_o))^{\frac{(1-\alpha)(1-\epsilon)}{\alpha+\epsilon-1}} (r^w(1 + \tau_i))^{\frac{-(1-\alpha)\epsilon}{\alpha+\epsilon-1}} \]  

We can see that the effects of output tariff \( \tau_o \) and input tariff \( \tau_i \) on productivity and wages depend on the signs of \( \frac{\epsilon}{\alpha+\epsilon-1} \). In particular when \( \frac{\epsilon}{\alpha+\epsilon-1} > 0 \), productivity and wages increase when \( \tau_o \) is higher and \( \tau_i \) is lower. When \( \frac{\epsilon}{\alpha+\epsilon-1} < 0 \), productivity and wages increase when \( \tau_o \) is lower and \( \tau_i \) is higher. To understand why this is the case, we need to analyze that condition, which can be rewritten as follows:

\[ \sigma = \frac{1}{1-\epsilon} > \frac{1}{\alpha} \]

As the elasticity of substitution \( \sigma \) captures the degree of differentiation among intermediate inputs, a low \( \sigma \) means these inputs are highly differentiated. In this case, adding one more variety will greatly increase the efficiency of the firm, hence the marginal revenue is an increasing function of the number of varieties. In contrast, when these inputs are less differentiated (high \( \sigma \)), or in the extreme case when they are perfect substitute, adding one extra variety implies more of the similar inputs. This will decrease the efficiency, or the marginal revenue of intermediate inputs. In this case, the marginal revenue of intermediate inputs decreases with the number of varieties. Now as output tariffs increase with the marginal revenue of intermediate inputs, lowering output tariffs implies a decline in the number of varieties if intermediate inputs are not highly differentiated, and a rise in the number of varieties otherwise. Input tariffs however increase with the marginal cost of intermediate inputs, which has to be equal to the marginal revenue in equilibrium. Therefore lowering input tariffs implies a fall in the marginal revenue of intermediate inputs, which leads to a rise in the number of varieties if the degree of differentiation is not high, and a decline otherwise. We also know from section III that productivity is an
increasing function of the number of varieties, and so are wages. Therefore we have the following result:

**Proposition 1.** When labor is immobile between sector,

- if intermediate inputs are not highly differentiated, trade liberalization in the final market decreases the extensive margin of imports, i.e. less intermediate input varieties will be imported. As a result, productivity and wages decline. Trade liberalization in the intermediate market, by contrast, increases both the intensive margin and the extensive margin of imports, improves domestic firms’ productivity and the wage in the final sector.

- if intermediate inputs are highly differentiated, we have the opposite conclusions. In particular, trade liberalization in the final market boosts productivity while trade liberalization in the intermediate markets leads to a fall in productivity.

As our predictions depend on the degree of differentiation among intermediate inputs, one might think of a natural, empirical analysis to assess which case arises. However, before doing the empirical analysis, we can have some prior about the likelihood of the predictions. Recall that input the second scenario (intermediate inputs being highly differentiated) arises when \( \sigma < \frac{1}{\alpha} \). In general, we would expect \( \alpha \) to be around two-third, which means \( \sigma \) has to be smaller than 1.5. This is a low value for \( \sigma \), since it leads to a mark-up of 300%. Therefore we would expect the first scenario to apply in our empirical analysis.

**IV.2 The effects in the long run**

We need to solve the system of equations (1),(3),(4) and (5) with the unknowns \((w, L_M, n, x(j))\). Assume that intermediate inputs are symmetric, i.e. they have the same price \( r \), the demand for each intermediate input variety will be identical. From (5) we have:

\[
x = \frac{1}{1 - \epsilon r} \frac{c}{1 - \epsilon r} \tag{10}
\]

From (4) and (10) we have:
\[ L_M = (1 - \alpha)^{\frac{1}{\gamma - \alpha}} \frac{\epsilon}{1 - \epsilon} c p^{\frac{1}{\gamma - \alpha}} n^{\frac{\alpha + \epsilon - 1}{\alpha}} r^{\frac{1 - \alpha}{\gamma - \alpha}} \]  

Equating wages in both sectors, we have:
\[ \gamma(L - L_A)^{\gamma - 1} = \alpha p L_M^{\alpha - 1} n^{\frac{1 - \alpha}{\epsilon}} x^{1 - \alpha} \]

Remember that \( L - L_A = L_M \) then:
\[ L_M = \left( \frac{\alpha}{\gamma} \right)^{\frac{1}{\gamma - \alpha}} \left( \frac{\epsilon}{1 - \epsilon} \right)^{\frac{1 - \alpha}{\gamma - \alpha}} c^{\frac{1 - \alpha}{\gamma - \alpha}} p^{\frac{1}{\gamma - \alpha}} n^{\frac{1 - \alpha}{\gamma - \alpha}} r^{\frac{1 - \alpha}{\gamma - \alpha}} \]  

Then from (11) and (12) the number of variety bought by the Southern firm in sector M, up to a constant, is given by:
\[ n = p^{-\gamma \epsilon} \left( \frac{1 - \alpha}{\gamma - \alpha} \right)^{\gamma - 1} p^{\frac{1 - \alpha}{\gamma - \alpha}} \]  

Then from (10),(11) and (13) we have:
\[ L^M = p^{-\gamma \epsilon} \left( \frac{1 - \alpha}{\gamma - \alpha} \right)^{\gamma - 1} p^{\frac{1 - \alpha}{\gamma - \alpha}} \]  

From (1) and \( L^M = L - L_A \) we have:
\[ w = p^{-\gamma \epsilon} \left( \frac{1 - \alpha}{\gamma - \alpha} \right)^{\gamma - 1} p^{\frac{1 - \alpha}{\gamma - \alpha}} \]  

Total factor productivity is given by:
\[ \Omega = p^{-\gamma \epsilon} \left( \frac{1 - \alpha}{\gamma - \alpha} \right)^{\gamma - 1} p^{\frac{1 - \alpha}{\gamma - \alpha}} \]  

In the special case when \( \gamma = 1 \), we can see that wages are fixed at 1, so there is no effect on wages. However, input tariffs and output tariffs still can affect the number of varieties as follows:
\[ n = p^{\frac{1 - \alpha}{1 - \epsilon}} r^{\frac{\epsilon}{1 - \epsilon}} \]  

From equations (16) and (15) we can see that similar to the short run scenario, here the effects of output and input tariffs on productivity and wages depend on the structural parameters. In particular, when \( \alpha \epsilon - \gamma(\alpha + \epsilon - 1) < 0 \), lowering input tariffs increases productivity and wages while lowering output tariffs decreases these two variables. We can rewrite this condition as follows:
\[ \sigma - 1 > \frac{\gamma - 1}{\gamma} \frac{1 - \alpha}{\alpha} \]
This condition is similar to that in the short run scenario. In fact, it is a weaker condition, as the condition in the short run scenario is equivalent to the following:

\[ \sigma - 1 > \frac{1-\alpha}{\alpha} \]

With the same intuition that we use in the short run scenario, we have the following result:

**Proposition 2.** When labor is mobile,
- if intermediate inputs are not highly differentiated, trade liberalization in the final market decreases the extensive margin of imports, i.e. less intermediate input varieties will be imported. As a result, productivity and wages decline. Trade liberalization in the intermediate market, by contrast, increases both the intensive margin and the extensive margin of imports, improves domestic firms’ productivity and the wage in the final sector.
- if intermediate inputs are highly differentiated, we have the opposite conclusions. In particular, trade liberalization in the final market boosts productivity while trade liberalization in the intermediate markets leads to a fall in productivity.

We can also show that the magnitude of the effects are different in these two cases.

**Proposition 3.** The effects of trade policy on the extensive margin of imports, firms’ productivity and labor wage is always greater in the long run than in the short run.

Proof See Appendix.

V Empirics

V.1 Data

V.1.1 Mexico trade liberalization in the ’80s

In the 1980s, Mexico began a process of structural reform that fundamentally changed the economic environment facing productive enterprises. The centerpiece of structural reforms was trade liberalization. Its initiative was created in 1983 with the implementation
of the temporary import regime for exporters but the first serious attempt occurred in July 1987 when the government began to cut significantly the coverage of quantitative restrictions and tariff rates.

Figure 1: Tariffs in Mexico

V.1.2 Data description

The data is an industrial survey provided by Mexico’s Instituto Nacional de Estadistica Geografia e Informacion (INEGI). This survey covers about 3200 largest firms in Mexico for the period 1984-1990. Firms are required to answer by law. They report in this dataset their value of production, their inputs use, including the subcontracting work in Mexico as in Grether (1996). In the survey that we use, this maquila service can involve two domestic firms as well as a foreign firm. As our model focuses on domestic firms producing for the domestic market, the problem can lie on the fact that one part of the production o the firms will serve the foreign firms (i.e. they will count as export). Fortunately as Grether (1996) notes that the output and input uses associated with the maquila service are recorded for the plant that ordered the job, therefore the domestic firms that provide the service for foreign firms will not count that
Table 1: Summary statistics

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<th>87</th>
<th>88</th>
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<td>4412.40</td>
<td>6304.60</td>
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<td>(34999.12)</td>
<td>(48721.69)</td>
<td>(81104.16)</td>
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</tbody>
</table>

The numbers in parentheses are the standard errors.
Unit: Thousand peso

Table 2: Summary statistics

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<th>85</th>
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<td>2</td>
<td>3</td>
<td>7</td>
<td>9</td>
<td>7</td>
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<tr>
<td>Maximum output</td>
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<td>336224</td>
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Unit: Thousand peso

use of intermediate inputs, among others. These variables allow us to study the firms’ behavior.

Besides, we also have in the data set the price indices (both output and input prices) and tariffs (both output and input tariffs) at the 4-digit level. These data are provided by Mexico’s Secretary of Commerce and Industrial Development (SECOFI).

V.1.3 Imports of intermediate inputs

Mexico in the 80’s experienced a consistent increase in imports of intermediate inputs. As reported in figure 2, from 1986 to 1990, those imports increase by 7 times. Not only the absolute value but also the relative terms as the share of imports grows from 13% to 21%. Finally the import per worker also goes up by 10 times.

V.1.4 How do tariffs change overtime

Figures 3 and 4 show input and output tariffs in the Food sector. We can see that there is variation within this sector, which allows us to study the responses of the firms within each sector. More importantly, the variation is smaller overtime, which is driven
Figure 2: Imports of intermediate inputs in the 80’s

by trade liberalization. This stylized fact supports the claim that firms’ responses are due to trade liberalization.

V.2 Is there evidence that the growth of imported input spending goes up with input tariff and goes down with output tariff?

The main feature in our model is that trade policy affects the decision of the plants regarding the import of intermediate inputs. In particular, when intermediate inputs are not highly differentiated,
a decrease (increase) in input (output) tariffs leads to a higher level of imported intermediate inputs. Therefore our first task is to test if there is a correlation as we predict between tariffs and the import of intermediate inputs, which suggests the following estimation:
\[ y_{it} = \beta_J' + \beta_t + \beta_p' \cdot IT_{jt} + \beta_p' \cdot OT_{jt} + \beta_s \cdot s_{it} + u_{it} \]

The dependent variable is the log of imported raw materials, the independent variables are input tariff (IT) and output tariff (OT) at the 4-digit level, \( s \) is firm \( i \)'s output, \( u_{it} \) are the error terms, \( i \) indexes the firm, \( j \) indexes the 4-digit industry and \( J \) indexes the 2-digit industry in which firm \( i \) operates, \( t \) indexes the time period. I also allow for sector fixed effect and time fixed effect. Results are reported in Table 3. We see that the effect of input tariff is significantly negative, while that of output tariffs on import of intermediate inputs is also negative, although not significant.

Table 3: Evidence for the effects of trade policy on imports of intermediate inputs

<table>
<thead>
<tr>
<th>Dependent variable: log of import of raw materials</th>
</tr>
</thead>
</table>
| Input tariff | -.028***  
|             | (.007)     |
| Output tariff | -.0066    
|              | (.0046)   |
| Output      | .93***     |
|             | (.018)     |
| Number of Observations | 4832       |

The numbers in parentheses are the standard errors

V.3 Is there evidence that input and output tariffs affect TFP through the import of intermediate inputs?

V.3.1 TFP correlation

In the first part of the paper, I claim that depending on how differentiated the intermediate inputs are, trade liberalization in the intermediate and final markets can lead to a rise or a fall in productivity. Therefore an interesting empirical question is which scenario applies, especially in Mexico in the 80s where data is available. Since it is more likely that intermediate inputs are not so highly differentiated as we discuss in the previous section, we expect trade liberalization in the intermediate market to improve productivity while trade liberalization in the final market implies a productivity decline. Following Amiti and Konings (2007), I will regress a measured productivity on tariffs. However the way we estimate productivity is controversial. In order to estimate TFP, we need to estimate the
production function and the residual between the actual production and the estimated value is TFP. The easiest way to estimate the production function is using factor share. This methodology requires perfect competition. The most common way is using OLS. However, this method encounters the simultaneity bias, as Olley and Pakes (1996) point out: the use of inputs, especially capital, might be correlated with the productivity shocks that are observed by the firms but not by the econometricians. They propose a methodology that we call henceforth OP which is used recently by Pavcnik (2002), Fernandes(2003), Topalova (2007) and Amiti and Konings (2007). Again this method is not perfect yet as Ackerberg, Caves and Frazer (2008), De Loecker (2008) have found. The discussion of how to estimate productivity is beyond the scope of this paper; I will use these 3 measures for robustness check.

Having estimated productivity, we can now regress this value on tariffs. However, I explicitly show that changes in tariffs can lead to an increase in the import of intermediate inputs, which implies productivity improvement. Therefore what we want to test is not simply the correlation between productivity and tariffs, but between productivity and the tariffs interacted with an indicator that captures the import intensity. A none zero interaction term implies that firms in sectors that import relatively more intermediate inputs will have a higher changes in productivity due to trade liberalization. To compute that indicator, I calculate the weighted ratio between import of raw materials and total output for each sector. Then I establish a ratio ranking : a sector with high rank, say 10, has a higher ratio than a sector with low rank, say 1. The ranking is reported in Table 4.

I run the following regression:

$$\log(TFP_{it}) = \rho_i + \rho_t + \rho_1 \ast OT_{jt} + \rho_2 \ast IT_{jt} + \rho_o \ast OT_{jt} \ast rank_J + \rho_3 \ast IT_{jt} \ast rank_J + \rho_s \ast s_{it} + u_{it}$$

The dependent variable is the log of productivity of firm i (calculated using labor productivity method, factor share method, OLS and OP). The independent variables are input tariff(IT), output tariff(OT) at the 4-digit level industry j in which firm i operates. I also include the time fixed effect, the sector fixed effect and firms’ characteristics \(s_{it}\), here it is the share of Mexican investor. Results
Table 4: Import exposure ranking

<table>
<thead>
<tr>
<th>Sector</th>
<th>rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Food product</td>
<td>10</td>
</tr>
<tr>
<td>2. Beverages</td>
<td>1</td>
</tr>
<tr>
<td>3. Tobacco</td>
<td>7</td>
</tr>
<tr>
<td>4. Textiles</td>
<td>8</td>
</tr>
<tr>
<td>5. Clothing and Apparel</td>
<td>11</td>
</tr>
<tr>
<td>6. Leather Products and Footwear</td>
<td>2</td>
</tr>
<tr>
<td>7. Wood Products and Furniture</td>
<td>4</td>
</tr>
<tr>
<td>8. Pulp and Paper</td>
<td>15</td>
</tr>
<tr>
<td>9. Chemicals</td>
<td>13</td>
</tr>
<tr>
<td>10. Plastic and Rubber Products</td>
<td>12</td>
</tr>
<tr>
<td>11. Glass</td>
<td>3</td>
</tr>
<tr>
<td>12. Other non-Metallic Mineral Products</td>
<td>6</td>
</tr>
<tr>
<td>13. Iron and Steel</td>
<td>5</td>
</tr>
<tr>
<td>14. Non-Ferrous base Products</td>
<td>9</td>
</tr>
<tr>
<td>15. Metal Products</td>
<td>14</td>
</tr>
<tr>
<td>16. Non-Electrical Machinery</td>
<td>18</td>
</tr>
<tr>
<td>17. Electrical Machinery</td>
<td>16</td>
</tr>
<tr>
<td>18. Transport Equipment</td>
<td>17</td>
</tr>
<tr>
<td>19. Other Manufacturing Industries</td>
<td>19</td>
</tr>
</tbody>
</table>

are reported in Table 5.

Table 5: The effects of trade policy on productivity

<table>
<thead>
<tr>
<th>Dependent variable: log of TFP</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor share</td>
<td>.97***</td>
<td>-.14</td>
<td>.54***</td>
</tr>
<tr>
<td>Input tariff</td>
<td>(.20)</td>
<td>(.35)</td>
<td>(.16)</td>
</tr>
<tr>
<td>Output tariff</td>
<td>-.38***</td>
<td>-.16</td>
<td>-.39***</td>
</tr>
<tr>
<td>Input tariff*Rank</td>
<td>(.096)</td>
<td>(.16)</td>
<td>(.079)</td>
</tr>
<tr>
<td>Output tariff*Rank</td>
<td>(.017)</td>
<td>(.032)</td>
<td>(.014)</td>
</tr>
<tr>
<td>Input tariff*Rank</td>
<td>-.071***</td>
<td>-.044</td>
<td>-.073***</td>
</tr>
<tr>
<td>Output tariff*Rank</td>
<td>(.009)</td>
<td>(.015)</td>
<td>(.0072)</td>
</tr>
<tr>
<td>domestic share</td>
<td>-.0014***</td>
<td>-.007***</td>
<td>-.0012***</td>
</tr>
<tr>
<td>Sector FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Time FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Observations</td>
<td>11817</td>
<td>15841</td>
<td>14173</td>
</tr>
</tbody>
</table>

The numbers in parentheses are the standard errors
We can see that $\rho_s$ is negative, implying that having more foreign investors improves productivity. This is the usual spill-over effect when foreign investment can bring new technology and new expertise to the domestic firms. But more importantly are $\rho_i$ and $\rho_o$. The theory tells us that input and output tariffs should have opposite effects on productivity, which are confirmed by the opposite signs that we see in the table. Moreover, as discussed above in the first part, we expect intermediate inputs to be not highly differentiated. In other words, we should see the interaction of input tariffs with the import intensity rank has a negative impact on productivity while the interaction of output tariffs with the import intensity rank has a positive impact on productivity. Again, this prediction is supported by the data in all 3 specifications. And the coefficients are stable.

After seeing the evidence that firms in sectors that import relatively more intermediate inputs experience more effects on productivity from trade liberalization, one might be concerned that even in sectors with high import intensity, the productivity improvement that we see in the data might come from the firms that do not adjust at all or even adjust the import of intermediate inputs in the opposite way that we predict (lower import corresponds to higher productivity). We can address this concern by doing a simple test: we look at the firms whose TFP and tariffs go in the predicted direction (i.e. TFP goes up with output tariffs and goes down with input tariffs) and ask how many of them having TFP and import of intermediate inputs adjustment go together. In other words, we ask the question of how big (in terms of market share) is the fraction of firms that actually adjust their import of intermediate inputs in response to changes in tariffs. This tests gives us a satisfying result: Among the firms that see TFP and output tariffs go in the same direction, 87% of them (in terms of market share) increase (or reduce) their import of intermediate inputs, which increases (or reduces) their TFP. And among the firms that see TFP and input tariffs go in the opposite direction, 89% of them increase (or reduce) their import of intermediate inputs, which therefore increases (or reduces) their TFP. This result is similar to Fernandes’s (2007) where she finds that in Colombia, more than 80% plants with TFP gains under trade liberalization increase their intermediate inputs.
import-to-output ratio. This test brings the evidence that most of the productivity improvements are effectively from the firms that adjust the import of intermediate inputs in the predicted way.

V.3.2 Explain Amiti-Konings (2007)

Amiti and Konings (2007) find that in Indonesia, trade liberalization in the intermediate markets has a large negative effect on productivity of the firms, while trade liberalization in the final market has a much smaller, even insignificant impact. However, they have no theory to explain their findings. This paper can provide a possible explanation.

Indeed, what we have done above is reconfirming the Amiti and Konings (2007) result with the Mexican data. Input tariffs have a negative impact on firms’ productivity. Regarding output tariffs, we find a positive impact on productivity. Remember that we ignore the import competition effect which leads to a negative correlation between output tariffs and productivity. Therefore our effect will mitigate, or even cancel out the usual import competition one which explains why output tariffs have a small, sometimes insignificant effect on productivity.

V.4 How are wages affected by trade policy?

One of the important questions in international economics is how wages are affected after trade liberalization. The answers we have from the literature are mixed. Goldberg and Pavcnik (2005) find that the wage at the industry level goes down with output tariff in Colombia. At the firm level, Revenga (1997) finds a similar result in Mexico. However, a insignificant or near zero effect is also found both in the industry level by Pavcnik et al (2004) and the firm level by Trefler (2004).

Amiti and Davis (2008) show that these contrasting answers may be due to the heterogeneity of the firms and the markets that trade liberalization occur. Indeed, they show that the importing firms experience a rise in wages when input tariffs are lower, while firms that do not import intermediate input see a fall in wages. Also
the wages in the exporting firms rise after trade liberalization in the final market while those in the firms that do not export drop.

Their results are based on the fair wage constraint that assumes a high profitable firm pays high wages. This assumption is actually the rent sharing argument when firms in lucrative sectors will pay high wages. I show in the first part of the paper that even without the effect that Amiti and Davis (2008) discuss, the fact that wages might rise or fall after trade liberalization is still possible, depending on which markets are liberalized and how differentiated the intermediate inputs are. When those inputs are not highly differentiated, trade liberalization in the intermediate markets leads to a rise in wages, while trade liberalization in the final market leads to a fall in wages. If the intermediate inputs are highly differentiated, trade liberalization in the intermediate markets leads to a drop in wages, while trade liberalization in the final market leads to an increase in wages. To test our predictions, we run the following estimation:

$$\ln(w_{it}) = \phi_i + \phi_t + \phi_1 \times IT_{jt} + \phi_2 \times OT_{jt} + \phi_1 \times rank_{it} \times IT_{jt} + \phi_2 \times rank_{it} \times OT_{jt} + \phi_s \times s_{it} + \mu_{it}$$

The dependent variable is the log of the wage of a firm i at time t, defined as the wage bill divided by the number of workers. The variable s is the firm characteristics. More specifically, it contains the wage share of blue collar workers and the profit sharing in the firm. We expect a lower share of blue collar workers relative to white collar workers implies a high skill composition of labor, which should lead to a high wage. Also a high profit sharing means a more powerful union, which may increase the wage. The two tariffs variables IT and OT are input and output tariffs at the 4-digit industry level, respectively. What are important are the interaction terms when our tariffs are interacted with the sector rank. A high rank sector is a sector that imports more of intermediate inputs relative to other sectors.

Our model predicts that lowering input tariffs leads to a rise in import of intermediate inputs when those inputs are not highly differentiated and a fall in import of intermediate inputs otherwise. We also discuss in the first part that the former case is more likely
to arise. A rise in import of intermediate inputs then implies a rise in wages. Therefore we expect a negative coefficient for input tariffs interacted with the sector’s rank. This tells us that a firm in a sector that imports more of intermediate inputs sees a higher increase in wages after trade liberalization in the intermediate markets. We also know from our model that the effect of output tariffs on wages is always the opposite of that of input tariffs, therefore we expect the coefficient of output tariffs interacted with the sector’s rank to have a positive sign. Results are reported in Table 6.

Table 6: The effects of trade policy on wages

| Dependent variable: the total wages | (1)       | (2)       | (3)       | (4)  
---|-----------------|----------|----------|--------
| Input tariff   | -2.06***    | -.20**   | -1.38*** | .86***
|                | (.18)      | (.09)    | (.23)   | (.12)
| Output tariff  | -3.18***    | -.39***  | -3.73*** | -.76***
|                | (.10)      | (.045)   | (.11)   | (.06)
| rank*Input tariff | -.23***   | -.03***  | -.48***  | -.034***
|                | (.015)     | (.009)   | (.02)   | (.011)
| rank*Output tariff | .09***   | .006     | .16***   | .03***
|                | (.009)     | (.004)   | (.01)   | (.005)
| blue collar share | -1.02*** | -1.04*** | -1.09*** | -1.99***
|                | (.04)      | (.02)    | (.04)   | (.02)
| profit sharing | .70***      | .19*     | .28      | .19*
|                | (.22)      | (.10)    | (.21)   | (.11)
| Sector FE      | NO         | NO       | YES      | YES
| Time FE        | NO         | YES      | NO       | YES
| Number of Observations | 20268   | 20268    | 20268    | 20268

The numbers in parentheses are the standard errors

We can see that the signs of our coefficients are consistent with what expect. A higher share of the blue collar workers signifies a lower skill of the composition of labor, which should lower the wage. A higher profit sharing firm should imply a higher wage. And the data confirms what we predict: firms in sectors that import more of intermediate inputs (higher rank) see a rise in wages after lowering input tariffs and a fall in wages after lowering output tariffs.

V.5 Estimating the structural parameters

In the theoretical part of the paper, I show that the effects of trade policy depend on the structural parameters. Our prior belief
is that intermediate inputs are not highly differentiated. Therefore trade liberalization in the intermediate markets leads to a rise in productivity and wages. Productivity and wages drop when the final market is liberalized. These predictions are confirmed in the previous sections. We then want to test if intermediate inputs are effectively not highly differentiated by estimating the structural parameters.

One point I want to make here is the estimation that we will do will yield the estimates for the elasticity of substitution. There are not many studies, which I will discuss later on, that provide these estimates, especially for the intermediate inputs. These estimates however are useful in assessing the gains from trade liberalization as we know that having more variety due to opening the markets is more beneficial if the goods are more differentiated.

V.5.1 The domestic inputs share

In our setup, $\alpha$ is the share of labor. However, labor is the only domestic factor. Therefore we can imagine labor as a proxy for domestic inputs. In this case, $\alpha$ will be the share of domestic inputs and $1 - \alpha$ is the share of imported intermediate inputs. This leads us to the following way of estimating $\alpha$:

$$\alpha_J = \frac{\sum_{i \in J,t} \text{domestic input}_{it} \times \text{output}_{it}}{\sum_{i,t} \text{output}_{it}}$$

Here $i$ indexes the firm in the 2-digit sector $J$, and $t$ is the time. Result are reported in table 7.

V.5.2 The short run scenario

The formula we use here to estimate $\epsilon$ is that of spending on imported intermediate inputs, which is given by:

$$M = nrx = A_1 C_{\alpha+\epsilon-1} p^{\epsilon} r^{1-\alpha+\epsilon}$$
Table 7: The share of domestic inputs

<table>
<thead>
<tr>
<th>Sector</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Food product</td>
<td>.69</td>
</tr>
<tr>
<td>2. Beverages</td>
<td>.51</td>
</tr>
<tr>
<td>3. Tobacco</td>
<td>.36</td>
</tr>
<tr>
<td>4. Textiles</td>
<td>.67</td>
</tr>
<tr>
<td>5. Clothing and Apparel</td>
<td>.61</td>
</tr>
<tr>
<td>6. Leather Products and Footwear</td>
<td>.83</td>
</tr>
<tr>
<td>7. Wood Products and Furniture</td>
<td>.73</td>
</tr>
<tr>
<td>8. Pulp and Paper</td>
<td>.64</td>
</tr>
<tr>
<td>9. Chemicals</td>
<td>.60</td>
</tr>
<tr>
<td>10. Plastic and Rubber Products</td>
<td>.59</td>
</tr>
<tr>
<td>11. Glass</td>
<td>.68</td>
</tr>
<tr>
<td>12. Other non-Metallic Mineral Products</td>
<td>.54</td>
</tr>
<tr>
<td>13. Iron and Steel</td>
<td>.54</td>
</tr>
<tr>
<td>14. Non-Ferrous base Products</td>
<td>.78</td>
</tr>
<tr>
<td>15. Metal Products</td>
<td>.67</td>
</tr>
<tr>
<td>16. Non-Electrical Machinery</td>
<td>.47</td>
</tr>
<tr>
<td>17. Electrical Machinery</td>
<td>.58</td>
</tr>
<tr>
<td>18. Transport Equipment</td>
<td>.48</td>
</tr>
<tr>
<td>19. Other Manufacturing Industries</td>
<td>.59</td>
</tr>
</tbody>
</table>

In log terms, we have:

$$m = a + \frac{\epsilon}{\alpha + \epsilon - 1} \ln p - \frac{(1 - \alpha)\epsilon}{\alpha + \epsilon - 1} \ln r$$ \hspace{1cm} (19)

I then run the following regression:

$$\ln m_{jt} = \beta_0 + \beta_p \ln p_{jt} + \beta_r \ln r_{jt} + \eta_{jt}$$

The dependent variable is the log of spending on imported intermediate materials at the 4-digit industry level at year $t$. The explanatory variables are the log of output price index and of input price index, also at the 4-digit industry level. To address the concern that the price indices might not be exogenous as assumed in the model, I instrument them by input and output tariffs at the 4-digit level. Our model predicts that:

$$\beta_r = -\frac{(1-\alpha)\epsilon}{\alpha + \epsilon - 1}$$

$$\beta_p = -\frac{\epsilon}{\alpha + \epsilon - 1}$$

These formulas help me to estimate $\epsilon$. Indeed I have 2 specifications to estimate $\epsilon$ as follows:
Specification 1: \[ \epsilon = - \frac{\beta_p (1 - \alpha)}{1 - \beta_p} \]

Specification 2: \[ \epsilon = \frac{\beta_r (1 - \alpha)}{\beta_r + 1 - \alpha} \]

As \[ p = p^w (1 + \tau_o) \] and \[ r = r^w (1 + \tau_i) \] I have another estimation: Here the dependent variable is the same as above, and the independent variables are input and output tariffs, at the 4-digit level. The model predicts that \( \beta_o = \beta_p \) and \( \beta_i = \beta_r \). I then have 2 more specifications to estimate \( \epsilon \):

Specification 3: \[ \epsilon = - \frac{\beta_o (1 - \alpha)}{1 - \beta_o} \]

Specification 4: \[ \epsilon = \frac{\beta_i (1 - \alpha)}{\beta_i + 1 - \alpha} \]

These 4 specifications are used for robustness check. The standard error of \( \epsilon \) can be computed using the Delta-method:

\[
\sigma_\epsilon = \frac{(1 - \alpha)^2}{(\beta_r + 1 - \alpha)^2} \sigma_{\beta_r} \\
= \frac{(1 - \alpha)^2}{(\beta_i + 1 - \alpha)^2} \sigma_{\beta_i} \\
= \frac{(1 - \alpha)^2}{(\beta_p - 1)^2} \sigma_{\beta_p} \\
= \frac{(1 - \alpha)^2}{(\beta_o - 1)^2} \sigma_{\beta_o}
\]

Results are reported in Table 8.

V.5.3 The long run scenario

In this scenario, I use the same strategy as in the short run scenario. Here I have another parameter to estimate, \( \gamma \), which means I need another equation. The two equations I use are that of import of intermediate inputs and that of labor:

\[
M = p^{\alpha - \gamma \epsilon - \gamma (\alpha + \epsilon - 1)} r^{\alpha - \gamma \epsilon - \gamma (\alpha + \epsilon - 1)}
\]

\[
L^M = p^{\alpha - \gamma (\alpha + \epsilon - 1)} r^{\alpha - \gamma (\alpha + \epsilon - 1)}
\]
Table 8: Estimate of ϵ in the short term

<table>
<thead>
<tr>
<th>Sector</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.Food product</td>
<td>.33***</td>
<td>.35***</td>
<td>.32***</td>
<td>.21***</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.03)</td>
<td>(.005)</td>
<td>(.09)</td>
</tr>
<tr>
<td>2.Beverages</td>
<td>.41***</td>
<td>.28</td>
<td>.52***</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td>(.097)</td>
<td>(.25)</td>
<td>(.07)</td>
<td>(.73)</td>
</tr>
<tr>
<td>3.Tobacco</td>
<td>.62***</td>
<td>.61***</td>
<td>.63***</td>
<td>.63***</td>
</tr>
<tr>
<td></td>
<td>(.01)</td>
<td>(.01)</td>
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<td>(.003)</td>
</tr>
<tr>
<td>4.Textiles</td>
<td>.37</td>
<td>.44*</td>
<td>.20</td>
<td>.30***</td>
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<tr>
<td></td>
<td>(.38)</td>
<td>(.24)</td>
<td>(3.68)</td>
<td>(.02)</td>
</tr>
<tr>
<td>5.Clothing and Apparel</td>
<td>.37***</td>
<td>.34***</td>
<td>.40***</td>
<td>.73</td>
</tr>
<tr>
<td></td>
<td>(.02)</td>
<td>(.03)</td>
<td>(.008)</td>
<td>(.97)</td>
</tr>
<tr>
<td>6.Leather Products and Footwear</td>
<td>.17***</td>
<td>.17***</td>
<td>.17***</td>
<td>.18***</td>
</tr>
<tr>
<td></td>
<td>(.006)</td>
<td>(.006)</td>
<td>(.001)</td>
<td>(.01)</td>
</tr>
<tr>
<td>7.Wood Products and Furniture</td>
<td>.26</td>
<td>.22</td>
<td>.31</td>
<td>.22***</td>
</tr>
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<td></td>
<td>(.19)</td>
<td>(.21)</td>
<td>(.86)</td>
<td>(.06)</td>
</tr>
<tr>
<td>8.Pulp and Paper</td>
<td>.35***</td>
<td>.34***</td>
<td>.32</td>
<td>.33***</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.05)</td>
<td>(.47)</td>
<td>(.02)</td>
</tr>
<tr>
<td>9.Chemicals</td>
<td>.46***</td>
<td>.53***</td>
<td>.41***</td>
<td>.47***</td>
</tr>
<tr>
<td></td>
<td>(.07)</td>
<td>(.06)</td>
<td>(.01)</td>
<td>(.07)</td>
</tr>
<tr>
<td>10.Plastic and Rubber Products</td>
<td>.43***</td>
<td>.46***</td>
<td>.45***</td>
<td>.31</td>
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<tr>
<td></td>
<td>(.09)</td>
<td>(.09)</td>
<td>(.14)</td>
<td>(.16)</td>
</tr>
<tr>
<td>11.Glass</td>
<td>.33***</td>
<td>.35***</td>
<td>.31***</td>
<td>.30***</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.04)</td>
<td>(.04)</td>
<td>(.01)</td>
</tr>
<tr>
<td>12.Other non-Metallic Mineral Products</td>
<td>.46***</td>
<td>.47***</td>
<td>.47***</td>
<td>.56***</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.05)</td>
<td>(.008)</td>
<td>(.21)</td>
</tr>
<tr>
<td>13.Iron and Steel</td>
<td>.47***</td>
<td>.47***</td>
<td>.47***</td>
<td>.43***</td>
</tr>
<tr>
<td></td>
<td>(.02)</td>
<td>(.02)</td>
<td>(.02)</td>
<td>(.01)</td>
</tr>
<tr>
<td>14.Non-Ferrous base Products</td>
<td>.24***</td>
<td>.29***</td>
<td>.22***</td>
<td>.22***</td>
</tr>
<tr>
<td></td>
<td>(.07)</td>
<td>(.05)</td>
<td>(.001)</td>
<td>(.008)</td>
</tr>
<tr>
<td>15.Metal Products</td>
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<td>.38***</td>
<td>.34***</td>
<td>.26***</td>
</tr>
<tr>
<td></td>
<td>(.14)</td>
<td>(.11)</td>
<td>(.02)</td>
<td>(.08)</td>
</tr>
<tr>
<td>16.Non-Electrical Machinery</td>
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<td>.53***</td>
<td>.58***</td>
<td>.49***</td>
</tr>
<tr>
<td></td>
<td>(.04)</td>
<td>(.04)</td>
<td>(.07)</td>
<td>(.01)</td>
</tr>
<tr>
<td>17.Electrical Machinery</td>
<td>.40***</td>
<td>.36***</td>
<td>.43***</td>
<td>.48***</td>
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<tr>
<td></td>
<td>(.04)</td>
<td>(.04)</td>
<td>(.009)</td>
<td>(.07)</td>
</tr>
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<td>18.Transport Equipment</td>
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<td></td>
<td>(.65)</td>
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<td>(.23)</td>
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<td>19.Other Manufacturing Industries</td>
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<td>.41***</td>
<td>.40***</td>
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<td>(.003)</td>
<td>(.003)</td>
<td>(.002)</td>
<td>(.002)</td>
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</tbody>
</table>

These two equations lead to the following regressions:

\[
\ln(\text{import}_{jt}) = \alpha_1 + \alpha_p \times p_{jt} + \alpha_r \times r_{jt} + \eta_{jt} \quad (20)
\]
\[ \ln(\text{import}_{jt}) = \beta_1 + \beta_p \times p_{jt} + \beta_r \times r_{jt} + \mu_{jt} \]  
(21)

The dependent variables are the log of the weighted average import, defined as the sum of imports of raw materials and the log of the weighted average number of hours working\(^6\). The explanatory variables are the log of input and output price indices, instrumented by input and output tariffs to address the concerns that the price indices might not be exogenous. As predicted by the model, the coefficients \(\alpha_p, \alpha_r, \beta_p, \beta_r\) are given by:

\[
\begin{align*}
\alpha_r &= \frac{\gamma \epsilon}{\alpha - \gamma (\alpha + \epsilon - 1)} \\
\beta_r &= \frac{\gamma \epsilon}{\alpha - \gamma (\alpha + \epsilon - 1)} \\
\alpha_p &= -\frac{\gamma \epsilon}{\alpha - \gamma (\alpha + \epsilon - 1)} \\
\beta_p &= -\frac{\gamma \epsilon}{\alpha - \gamma (\alpha + \epsilon - 1)}
\end{align*}
\]

I therefore have 2 specifications to estimate \(\gamma\) and \(\epsilon\):

\[
\begin{align*}
\text{Specification 1:} & \quad \gamma = \frac{\alpha_p}{\beta_p (1-\alpha) \alpha_p} \\
& \quad \epsilon = \frac{\alpha p - \alpha R}{\alpha - \alpha p - 1} \\
\text{Specification 2:} & \quad \gamma = \frac{\alpha_r}{\beta_r (1-\alpha) \alpha_r} \\
& \quad \epsilon = \frac{\alpha r - \alpha I}{1-\alpha + \alpha r - \alpha I}
\end{align*}
\]

As \(p = p^w(1 + \tau_o)\) and \(r = r^w(1 + \tau_i)\), \(p^w\) and \(r^w\) are fixed, we can rewrite the above equations as follows:

\[
\begin{align*}
M &= (1 + \tau^O) \frac{-\gamma \epsilon}{\alpha - \gamma (\alpha + \epsilon - 1)} (1 + \tau^I) \frac{(1-\alpha) \gamma \epsilon}{\alpha - \gamma (\alpha + \epsilon - 1)} \\
L^M &= (1 + \tau^O) \frac{-\gamma \epsilon}{\alpha - \gamma (\alpha + \epsilon - 1)} (1 + \tau^I) \frac{(1-\alpha) \gamma \epsilon}{\alpha - \gamma (\alpha + \epsilon - 1)}
\end{align*}
\]

These two equations lead to the following regressions:

\[
\ln(\text{import}_{jt}) = \alpha_0 + \alpha_O \times \ln(1 + OT_{jt}) + \alpha_I \times \ln(1 + IT_{jt}) + \eta_{jt}
\]

\[
\ln(\text{labor}_{jt}) = \beta_0 + \beta_O \times \ln(1 + OT_{jt}) + \beta_I \times \ln(1 + IT_{jt}) + \mu_{jt}
\]

---

\(^6\)One may claim that it is not consistent with the way we calculate \(\alpha\) where we use domestic input instead of labor. However, when we compute \(\alpha\) we need the nominal value of domestic inputs and \(\alpha\) close to two-third as we compute seems conventional. Here we need the real value of \(L\), therefore using the number of hours working seems more appropriate.
Again the dependent variables are the log of the weighted average import, defined as the sum of imports of raw materials and the log of the weighted average number of hours working. The independent variables are however the log of input and out tariffs. All the variables are taken at the 4-digit level. As the model predicts $\alpha_O = \alpha_p, \alpha_I = \alpha_r, \beta_O = \beta_p, \beta_I = \beta_r$ I have 2 more specifications to estimate $\gamma$ and $\epsilon$:

**Specification 3:**
\[
\begin{align*}
\gamma &= \frac{\alpha_I}{\beta_I(1-\alpha_\alpha)} \\
\epsilon &= \frac{\alpha_O}{1-\alpha+\alpha_\alpha-\alpha_\beta}
\end{align*}
\]

**Specification 4:**
\[
\begin{align*}
\gamma &= \frac{\alpha_O}{\beta_O(1-\alpha_\alpha)} \\
\epsilon &= \frac{\alpha_I}{1-\alpha+\alpha_\alpha-\alpha_\beta}
\end{align*}
\]

As in the short run scenario, the standard errors are computed using the Delta method:

**Specification 1:**
\[
\begin{align*}
\sigma_\gamma^2 &= \sigma_{\alpha_p}^2 + \sigma_{\beta_p}^2 + \sigma_{\alpha_r}^2 + \sigma_{\beta_r}^2 + \sigma_{\alpha_I}^2 + \sigma_{\beta_I}^2 + \sigma_{\alpha_O}^2 + \sigma_{\beta_O}^2 \\
\sigma_\epsilon^2 &= \frac{(1-\alpha)^2}{\sigma_{\alpha_p}^2 + \sigma_{\beta_p}^2 + \sigma_{\alpha_r}^2 + \sigma_{\beta_r}^2 + \sigma_{\alpha_I}^2 + \sigma_{\beta_I}^2 + \sigma_{\alpha_O}^2 + \sigma_{\beta_O}^2}
\end{align*}
\]

**Specification 2:**
\[
\begin{align*}
\sigma_\gamma^2 &= \sigma_{\alpha_r}^2 + \sigma_{\beta_r}^2 + \sigma_{\alpha_I}^2 + \sigma_{\beta_I}^2 + \sigma_{\alpha_O}^2 + \sigma_{\beta_O}^2 \\
\sigma_\epsilon^2 &= \frac{(1-\alpha)^2}{\sigma_{\alpha_r}^2 + \sigma_{\beta_r}^2 + \sigma_{\alpha_I}^2 + \sigma_{\beta_I}^2 + \sigma_{\alpha_O}^2 + \sigma_{\beta_O}^2}
\end{align*}
\]

**Specification 3:**
\[
\begin{align*}
\sigma_\gamma^2 &= \sigma_{\alpha_I}^2 + \sigma_{\beta_I}^2 + \sigma_{\alpha_O}^2 + \sigma_{\beta_O}^2 \\
\sigma_\epsilon^2 &= \frac{(1-\alpha)^2}{\sigma_{\alpha_I}^2 + \sigma_{\beta_I}^2 + \sigma_{\alpha_O}^2 + \sigma_{\beta_O}^2}
\end{align*}
\]

**Specification 4:**
\[
\begin{align*}
\sigma_\gamma^2 &= \sigma_{\alpha_O}^2 + \sigma_{\beta_O}^2 + \sigma_{\alpha_r}^2 + \sigma_{\beta_r}^2 + \sigma_{\alpha_I}^2 + \sigma_{\beta_I}^2 + \sigma_{\alpha_p}^2 + \sigma_{\beta_p}^2 \\
\sigma_\epsilon^2 &= \frac{(1-\alpha)^2}{\sigma_{\alpha_O}^2 + \sigma_{\beta_O}^2 + \sigma_{\alpha_r}^2 + \sigma_{\beta_r}^2 + \sigma_{\alpha_I}^2 + \sigma_{\beta_I}^2 + \sigma_{\alpha_p}^2 + \sigma_{\beta_p}^2}
\end{align*}
\]

where $\sigma_{\alpha_p}, \sigma_{\beta_p}, \sigma_{\alpha_r}, \sigma_{\beta_r}, \sigma_{\alpha_I}, \sigma_{\beta_I}, \sigma_{\alpha_O}, \sigma_{\beta_O}$ are the standard errors of $\alpha_p, \beta_p, \alpha_r, \beta_r, \alpha_I, \beta_I, \alpha_O, \beta_O$ respectively. Results are reported in Table 9.
Table 9: Estimate of $\epsilon$ in the long term

<table>
<thead>
<tr>
<th>Sector</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Food product</td>
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<td>.43***</td>
<td>.36***</td>
<td>.30***</td>
</tr>
<tr>
<td></td>
<td>(.14)</td>
<td>(.15)</td>
<td>(.04)</td>
<td>(.13)</td>
</tr>
<tr>
<td>2. Beverages</td>
<td>-.10</td>
<td>-.04</td>
<td>.75</td>
<td>.13</td>
</tr>
<tr>
<td></td>
<td>(.52)</td>
<td>(.21)</td>
<td>(.51)</td>
<td>(.58)</td>
</tr>
<tr>
<td>3. Tobacco</td>
<td>.62***</td>
<td>.61***</td>
<td>.62***</td>
<td>.62***</td>
</tr>
<tr>
<td></td>
<td>(.01)</td>
<td>(.01)</td>
<td>(.007)</td>
<td>(.005)</td>
</tr>
<tr>
<td>4. Textiles</td>
<td>.45</td>
<td>.51</td>
<td>-1.33</td>
<td>.33***</td>
</tr>
<tr>
<td></td>
<td>(.44)</td>
<td>(.49)</td>
<td>(105.8)</td>
<td>(.05)</td>
</tr>
<tr>
<td>5. Clothing and Apparel</td>
<td>.34***</td>
<td>.30***</td>
<td>.40***</td>
<td>.58</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.06)</td>
<td>(.03)</td>
<td>(.51)</td>
</tr>
<tr>
<td>6. Leather Products and Footwear</td>
<td>-.40</td>
<td>-.30</td>
<td>.20***</td>
<td>.59</td>
</tr>
<tr>
<td></td>
<td>(5.28)</td>
<td>(3.36)</td>
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<td>(1.1)</td>
</tr>
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<td>7. Wood Products and Furniture</td>
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<td>-.08</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>(.31)</td>
<td>(.37)</td>
<td>(.53)</td>
<td>(.11)</td>
</tr>
<tr>
<td>8. Pulp and Paper</td>
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<td>-1.67</td>
<td>-4.56</td>
<td>.57</td>
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<tr>
<td></td>
<td>(12.82)</td>
<td>(12.75)</td>
<td>(327.1)</td>
<td>(.41)</td>
</tr>
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<td>9. Chemicals</td>
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<td>.78</td>
<td>.71</td>
<td>.71</td>
</tr>
<tr>
<td></td>
<td>(.37)</td>
<td>(.50)</td>
<td>(.41)</td>
<td>(.61)</td>
</tr>
<tr>
<td>10. Plastic and Rubber Products</td>
<td>.28</td>
<td>.31</td>
<td>-.47***</td>
<td>.29</td>
</tr>
<tr>
<td></td>
<td>(.44)</td>
<td>(.49)</td>
<td>(1.53)</td>
<td>(.26)</td>
</tr>
<tr>
<td>11. Glass</td>
<td>-.64</td>
<td>-.72</td>
<td>.21***</td>
<td>.27***</td>
</tr>
<tr>
<td></td>
<td>(7.67)</td>
<td>(8.89)</td>
<td>(.09)</td>
<td>(.03)</td>
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<tr>
<td>12. Other non-Metallic Mineral Products</td>
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<td>.55</td>
<td>.41***</td>
<td>.36***</td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
<td>(1.08)</td>
<td>(.04)</td>
<td>(.14)</td>
</tr>
<tr>
<td>13. Iron and Steel</td>
<td>.41***</td>
<td>.43***</td>
<td>.87</td>
<td>.41***</td>
</tr>
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<td></td>
<td>(.12)</td>
<td>(.12)</td>
<td>(.82)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>14. Non-Ferrous base Products</td>
<td>.24***</td>
<td>.33**</td>
<td>.20***</td>
<td>.22***</td>
</tr>
<tr>
<td></td>
<td>(.09)</td>
<td>(.15)</td>
<td>(.03)</td>
<td>(.02)</td>
</tr>
<tr>
<td>15. Metal Products</td>
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<td>.35***</td>
<td>.50*</td>
<td>.27***</td>
</tr>
<tr>
<td></td>
<td>(.12)</td>
<td>(.13)</td>
<td>(.27)</td>
<td>(.10)</td>
</tr>
<tr>
<td>16. Non-Electrical Machinery</td>
<td>.52***</td>
<td>.52</td>
<td>1.83</td>
<td>.48***</td>
</tr>
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<td>(.10)</td>
<td>(3.6)</td>
<td>(.04)</td>
</tr>
<tr>
<td>17. Electrical Machinery</td>
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<td>.38**</td>
<td>.51***</td>
<td>.51***</td>
</tr>
<tr>
<td></td>
<td>(.17)</td>
<td>(.17)</td>
<td>(.07)</td>
<td>(.14)</td>
</tr>
<tr>
<td>18. Transport Equipment</td>
<td>.24</td>
<td>-.05</td>
<td>5.37</td>
<td>.24</td>
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<tr>
<td></td>
<td>(.38)</td>
<td>(.80)</td>
<td>(45.3)</td>
<td>(.28)</td>
</tr>
<tr>
<td>19. Other Manufacturing Industries</td>
<td>.37***</td>
<td>.38***</td>
<td>.38***</td>
<td>.40***</td>
</tr>
<tr>
<td></td>
<td>(.14)</td>
<td>(.13)</td>
<td>(.04)</td>
<td>(.04)</td>
</tr>
</tbody>
</table>

V.5.4 Discussion of the estimates

The love of variety gives rise to the interest of estimating the elasticity of substitution. The literature however focuses mainly on
the consumption side, namely they study how differentiated the final goods are. This helps to assess the gains from trade liberalization for the consumers. Little is known about the differentiation of intermediate inputs, which predicts how much the firms gain due to trade liberalization in terms of productivity. The estimates that I compute above can bridge this gap.

Since there is little guidance on how the elasticity of substitution among intermediate inputs should be, I will compare my estimates with the elasticity of substitution among final goods that I find in other studies. The most notable result is Broda and Weinstein (2006) where they estimate the elasticity of substitution of US imports. They find that at the 3-digit level, the mean of the elasticity of substitution is 4 in the period 1990-2001, while the median is 2.2. This means that it is more likely that the elasticity of substitution is between 1 and 4. A similar result for the period 1972-1988 when the median is 2.5 confirms this result. With my higher aggregated data (at the 2-digit level) when the elasticity of substitution should be lower than in Broda and Weinstein (2006), the estimates are from 1.2 (for Foodwear) to 2.7 (for Tobacco). Another similarity between my result and Broda and Weinstein’s is that Footwear is the sector with the lowest elasticity of substitution which is 1.2 in both studies.

Other studies in the literature beside Broda and Weinstein (2006) suggest the elasticity of substitution be from 2 to 10 (see Feenstra (1994), Acemoglu and Ventura (2002), Hummels and Klenow (2005)). Therefore our range of value is in the lower end of the suggested interval. It should not be a surprising result because as I discussed above, the literature mainly provides estimates for the consumption goods, whereas my paper provides estimates for the intermediate goods. Marshall (1925) and Hicks (1946) suggest that the elasticity of substitution of intermediate goods should be lower than that of final goods as the demand for intermediate inputs of firms tend to be governed by a choice among complementary sets of factors, while the consumer’s budget tend to be choice among mild substitutes.
VI Conclusion

In this paper, I show that the impact of trade liberalization on productivity depends on which markets are liberalized and the degree of differentiation of intermediate inputs. In particular, when intermediate inputs are highly differentiated, trade liberalization in the final market helps improve productivity, while trade liberalization in the intermediate markets makes productivity decline. When intermediate inputs are less differentiated, the conclusions reverse: trade liberalization in the final market decreases productivity, while trade liberalization in the intermediate markets leads to a rise in productivity. Unlike other studies (Halpern, Koren and Szeidl 2006, Kasahara and Rodrigue 2008), I provide the formulas that link trade tariffs with productivity, which are useful in deriving the optimal policy.

I also show that wages might increase or decrease with trade liberalization. Amiti and Davis (2008) argue that the impact of trade liberalization on wages depend on the nature of the markets and the mode of globalization of the firms. In particular, the firms that are more globalized (i.e. exporting/importing firms) experience a rise in wages after trade liberalization while those that are less globalized (do not import nor export) see a decline in wages. My paper explores a new channel through which tariffs affect wages: Wages respond to trade reforms depending on the nature of the markets and the degree of differentiation of intermediate inputs. When intermediate inputs are highly differentiated, trade liberalization in the final market increases wages, while trade liberalization in the intermediate market makes wages decline. As with productivity, the conclusions about changes in wage reverse when intermediate inputs are less differentiated.

I apply a methodology that is similar to the one used by Pavcnik (2002), Fernandes (2003) and Topalova (2004) to study the correlation between the total factor productivity and tariffs. Data in Mexico in the 1980s seems to support our predictions. The effects of output and input tariffs are higher for the firms that are in sectors importing relatively more intermediate inputs.
I also provide estimates for the elasticity of substitution among intermediate inputs across sectors. These estimates determine how input and output tariffs affect productivity and wages as I discussed above. Also as the gains in productivity increase when intermediate inputs are more differentiated, these estimates help to compute the gains from trade liberalization.

VII Appendix

VII.1 Estimating TFP

In this section, I am looking for the evidence that trade liberalization in the intermediate market and trade protection in the final market actually improves within-firm productivity. We then need a measure of TFP, chosen as the Solow residual: TFP is the residual when I subtract all the possible factors from total output. That suggests the following estimation:

\[ y_{it} = \beta_l l_{it} + \beta_m m_{it} + \beta_k k_{it} + \omega_{it} \]

The dependent variable is total output, the independent variables are labor, material and capital, all are taken in log terms. The problem in this estimation is, however, that the productivity shock \( \omega_{it} \) is presumably correlated with capital: anticipating a higher productivity shock, the firm will invest more capital. This leads to a biased estimate of the capital coefficient. Olley-Pakes(1996) recognizes this problem and suggests a way to fix it that consists three steps:

- The first step is to regress output on labor, material and a fourth-order polynomial of investment and capital.

\[ y_{it} = \alpha l_{it} + \gamma m_{it} + g(I_{it}, k_{it}) + u_{it} \]

- This step will give us a consistent estimate of the labor and material share. I also get the residual \( \varphi = y - \alpha l - \gamma m_{it} \). The second step is to approximate the survival probability by a polynomial of lagged investment and lagged capital, using a probit model. In particular, for each firm there will be a binary
variable indicating whether that firm still exists in the market the next period. I approximate that binary variable as follows:

\[ P = Pr(\chi_{t+1} = 1 | \omega_{t+1}) = \phi(k_t, I_t) \]

- \( \phi \) is a fourth-order polynomial of \( k_t \) and \( I_t \). The third step is to regress \( \varphi \) from the first step on capital and a polynomial of lagged \( P \) and lagged \( h = \varphi - \beta * k \):

\[ \varphi_{it} = \beta * k_{it} + f(P_{it-1}, h_{it-1}) + u_{it} \]

The regression is non linear as \( \beta \) in the polynomial \( f \) is also the capital coefficient. The log of total factor productivity is given by:

\[ \log(TFP_{it}) = y_{it} - \alpha * l_{it} - \gamma * m_{it} - \beta * k_{it} \]

In the above regressions, \( y_{it}, l_{it}, m_{it}, k_{it}, I_{it} \) are respectively the log value of Output deflated by producer price index, the log total remuneration deflated by producer price index, the log materials cost deflated by raw price material price index, the log replacement cost of capital deflated by machinery price index and the log acquisitions cost of capital deflated by machinery price index at the firm level in a particular year \( t \).

Table 10 shows the coefficients of labor, material and capital when we estimate TFP using Olley-Pakes (1996).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
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</tr>
<tr>
<td>Materials</td>
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<td>(.0046)</td>
</tr>
<tr>
<td>Capital</td>
<td>.067***</td>
<td>(.0029)</td>
</tr>
</tbody>
</table>

The numbers in parentheses are the standard errors.

Table 11 shows the coefficient of the polynomial approximating the firms’ survival probability.
Table 11: The survival probability approximation

<table>
<thead>
<tr>
<th>Capital</th>
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</tr>
</thead>
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<td>Capital2</td>
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<tr>
<td></td>
<td>(.010)</td>
</tr>
<tr>
<td>Capital3</td>
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<td>(.0034)</td>
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<td>(.048)</td>
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<tr>
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<td>(.00039)</td>
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<td>(.00014)</td>
</tr>
<tr>
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<tr>
<td>Cap3 * Inv</td>
<td>.00035</td>
</tr>
<tr>
<td></td>
<td>(.00096)</td>
</tr>
</tbody>
</table>

The numbers in parentheses are the standard errors

VII.2 Proof of Proposition 3

Here I only consider the case when the effects of input tariffs in the long run have the same signs as in the short run, i.e. \( \sigma - 1 > \frac{1-\alpha}{\alpha} \) or \( \sigma - 1 < \frac{2-1-\frac{1-\alpha}{\gamma}}{\gamma} \). To show that the effects in productivity on the long run are bigger than in the short run, one needs to prove that:

\[
\frac{-\gamma \epsilon}{\alpha \epsilon - \gamma(\alpha + \epsilon - 1)} > \frac{\epsilon}{\alpha + \epsilon - 1}
\]

\( \iff -\gamma \epsilon (\alpha + \epsilon - 1) < \gamma \epsilon^2 - \gamma \epsilon (\alpha + \epsilon - 1) (since (\alpha + \epsilon - 1)(\alpha \epsilon - \gamma(\alpha + \epsilon - 1)) < 0) \)

\( \iff 0 < \gamma \epsilon^2 \)

To show that the effects on wages in the long run are bigger than in the short run, one needs to prove that:
\[
\frac{\epsilon(\gamma - 1)}{\gamma(\alpha + \epsilon - 1) - \alpha \epsilon} < \frac{1 - \alpha}{\alpha + \epsilon - 1}
\]

\[\Leftrightarrow\]

\[(1 - \alpha)\gamma(\alpha + \epsilon - 1) - (1 - \alpha)\alpha \epsilon < \epsilon(\gamma - 1)(\alpha + \epsilon - 1)\]

\[\Leftrightarrow\]

\[(\alpha + \epsilon - 1)(\gamma - \alpha \gamma - \epsilon \gamma + \epsilon) < (1 - \alpha)\alpha \epsilon\]

\[\Leftrightarrow\]

\[\alpha^2 \gamma - 2\alpha \epsilon \gamma - \epsilon^2 \gamma + \epsilon^2 - \gamma - \epsilon + \alpha^2 \epsilon < 0\]

\[\Leftrightarrow\]

\[\epsilon(\epsilon - 1) + \alpha^2(\epsilon - \gamma) - 2\alpha \epsilon \gamma - \epsilon^2 \gamma - \gamma < 0\]

which is true as \(\epsilon < 1 < \gamma\), and :

\[
\frac{(1 - \alpha)\epsilon}{\alpha + \epsilon - 1} < \frac{(1 - \alpha)(\gamma - 1)\epsilon}{\gamma(\alpha + \epsilon - 1) - \alpha \epsilon}
\]

\[\Leftrightarrow\]

\[
\frac{1}{\alpha + \epsilon - 1} < \frac{\gamma - 1}{\gamma(\alpha + \epsilon - 1) - \alpha \epsilon}
\]

\[\Leftrightarrow\]

\[\gamma(\alpha + \epsilon - 1) - \alpha \epsilon < (\gamma - 1)(\alpha + \epsilon - 1)\]

\[\Leftrightarrow\]

\[\alpha + \epsilon - 1 - \alpha \epsilon < 0\]

\[\Leftrightarrow\]

\[(1 - \alpha)(1 - \epsilon) > 0.\]

References


