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Baybars Karacaovali
Fordham University, Department of Economics

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Department of Economics
Fordham University
441 E Fordham Rd, Dealy Hall
Bronx, NY 10458
(718) 817-4048

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Baybars Karacaovali*
Fordham University

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Abstract

In the growth literature that investigates the effect of trade liberalization on productivity, nearly all studies assume that trade policy is determined independently of productivity, hence it is exogenous. I show, both theoretically and empirically, that this assumption is not valid in general. I find that in Colombia more productive sectors receive more protection and the sectors with higher productivity gains are liberalized less even in the presence of a large unilateral liberalization shock that affects all sectors. Researchers may be underestimating the positive effect of liberalization on productivity when they do not account for the endogeneity bias.

JEL Classification: D24, F13, F14.

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*Assistant Professor, Department of Economics, Fordham University, Bronx, NY 10458. E-mail: karacaovali@fordham.edu. This paper was part of my dissertation at the University of Maryland and I greatly acknowledge Nuno Limão for his support throughout this project. I am grateful to the co-editor, Charles Horioka, and four anonymous referees for many helpful comments. I thank John Haltiwanger, Luis Quintero, and especially Marcela Eslava for generously sharing part of their data. I have also benefited from the comments of Marco Arena, Thorsten Beck, Roger Betancourt, Quy-Toan Do, Allan Drazen, Jonah Gelbach, Guliz Kalender, Harry Kelejian, Varun Kshirsagar, Ramon López, John McLaren, Peter Murrell, John Shea, an anonymous referee for the World Bank Policy Research Working Paper series and the seminar participants at the World Bank Development Economics Research Group (January 2006), Midwest International Economics and Economic Theory Meeting (Purdue, October 2006), Eastern Economic Association Annual Meeting (New York, February 2007), International Trade and Finance Association Conference (Miami, May 2007), and Econometric Society European Meeting (Budapest, August 2007). Any remaining errors are my own.

1 Introduction

In general, the effect of government policies on economic outcomes is a crucial issue for both economists and policymakers. In particular, it is important to know how government trade policies affect productivity in the economy, hence eventually growth and development. While trade policy and economic performance linkages have been explored since the 1950s (e.g. Johnson 1955)[1], recently an ever-growing number of empirical studies test the effect of trade liberalization on productivity (e.g. Tybout and Westbrook 1995, Pavcnik 2002, Schor 2004). Many developing countries (for example, Brazil, Colombia, Chile, India, Mexico, and Turkey) have aggressively pursued trade liberalization in the late 1980s and the early 1990s, in part, to boost productivity. So, does trade liberalization really increase productivity? Recent micro-level empirical findings indicate that the answer is "Yes." However, nearly all of these studies fail to recognize that trade policy might be endogenous with respect to productivity. And, even if they acknowledge the existence of this endogeneity, most do not control for it. In this paper, I show, both theoretically and empirically, that productivity directly affects trade policy. Thus, the concern for an endogeneity bias is well-founded. Moreover, when we account for the bi-directional causality between trade policy and productivity, the positive effect of trade reform on productivity may become stronger.

In Section 2, I provide a theoretical model of tariff policy determination for a small open economy. I show that under my political economy model of protection, sectoral tariffs depend on industry production (size) and hence, on sectoral productivity if these sectors are organized and lobby for protection. Tariffs increase in productivity if supply is not highly elastic because larger and more productive sectors have got more to gain from lobbying and can potentially generate more protection. This is a modified result (as I explain later in the text) from the, now standard, political economy models such as Grossman and Helpman (1994). However, if supply is highly elastic, tariffs will decrease in productivity because the cost of production distortion dominates the benefit of protection in the government's objective.

It is often argued that trade reform may be considered as an exogenous change in policy and that this helps identify the effect of trade policy on productivity with little concern about its endogeneity. In order to account for this argument, I model an additional channel for protection which is a perceived benefit to the government and its elimination leads to a unilateral trade liberalization shock that is common across sectors. I find that under such a common exogenously timed shock, the reduction in tariffs is also affected by productivity in the presence of political economy. Initially, I keep the additional channel simple, making sure that it is clearly the political economy consideration that is driving the results. Next, I give more structure to the extra channel of protection and to the way the liberalization shock manifests

[1] A detailed historical review of the papers concerned with the effects of trade on industrial performance appears in Pack (1988). He suggests that the early evidence is rather mixed.

itself by allowing for an infant industry argument which, for example, is mentioned as an important motive for protection in Grossman and Horn (1988). This argument led to the widespread use of import substitution policies in most developing countries until the mid-1980s and its dismissal was the source of much unilateral trade liberalization since then.

In my two period model, the government initially believes that there exists a learning-by-doing (LBD) process and decides about current tariffs by considering both the political economy effects and the effect of these tariffs on future welfare through LBD. In the second period, the government realizes that the infant industries do not mature and its belief reaches a terminal point, and thus initiates a trade reform. Given that political economy forces still determine tariffs, the extent of liberalization differs across sectors despite this common shock. The crucial implication from the models I present is that, assuming cross-sectional differences in trade policy to be independent of cross-sectional differences in productivity is incorrect.

I employ Colombian data for the empirical tests of my theory. Colombia has been used in various studies (for example, Roberts 1996; Melendez, Seim and Medina 2003; Fernandes 2007) given that it provides a great natural experiment environment. Colombia experienced a drastic trade reform in the early 1990s and had a stable economy in this period without major crises. In Section 3, I discuss the trade policy in Colombia during the sample period of 1983 through 1998, and describe how we can rule out a uniform change in tariffs across sectors.

In Section 4, I briefly review the empirical literature and then in Section 5, I econometrically test the theoretical predictions obtained in Section 2 using Colombian data. My productivity estimates come from Eslava, Haltiwanger, Kugler and Kugler (2004) and the dataset has the great advantage of containing input and output prices at the plant level which enables good productivity estimates with smaller bias as compared to the majority of other studies that need to employ non-parametric estimates and sector level price deflators instead. I estimate the effect of productivity on trade protection by closely following my theoretical analysis. I find that sectoral tariffs are inversely related to the import penetration ratio and import demand elasticity, whereas they are positively related to total factor productivity.

In the estimations, I account for the elimination of the government belief in learning-by-doing which leads to a large common decline in tariffs. For this purpose, I allow for a shift in the common terms across sectors over time. The results indicate that the sectors with more productivity gain (or less productivity decline) are liberalized less. I tackle the potential endogeneity of the right-hand-side variables, namely the inverse import penetration to import demand elasticity ratio and productivity, by using instrumental variables which I confirm to be valid based on a test of overidentifying restrictions, and I further explain intuitively in Section 5.

By showing how trade policy depends on productivity both theoretically and empirically, I provide solid evidence for the endogeneity of trade policy with respect to productivity. Finally, in Section 6, I estimate a system of equations for TFP, tariffs, and the elasticity adjusted inverse import penetration ratio. In the system, I correct for the endogeneity of tariffs and show that the positive effect of trade liberalization on productivity may be slightly underestimated when the endogeneity bias is not accounted for.

2 Theory

2.1 Basic Model

In this section, I introduce a political economy model of trade policy to link import tariffs to productivity which can be easily interpreted as a reduced form of a model where lobbying is given micro-foundations such as in Grossman and Helpman (1994).

I have the following assumptions. The output and factor markets are perfectly competitive. The numeraire good, $i = 0$, is produced with labor only, using a constant returns to scale process, whereas the non-numeraire goods, $i = 1, ...n$, are produced using labor and one sector-specific factor. The production function for the non-numeraire goods is $X_i(p_i) = A_i Q_i(p_i)$, where A_i stands for the Hicks-neutral total factor productivity (TFP). The international prices for all goods $i = 0, ..., N$, denoted by p_i^w, are normalized to one. Furthermore, assuming a large enough aggregate supply of labor, the wage rate (marginal revenue product of labor) is also tied at one. The numeraire good is traded freely, hence its domestic price is equal to the world price of one. The owners of each specific factor organize into lobbies, and ask for government protection only in their own sector since they are assumed to constitute a negligible share of the total population. The consumers cannot overcome the free-rider problem and are not organized as discussed in Olson (1965). For simplicity, export subsidies are not allowed and only tariffs are available for trade protection.[2] Maintaining the small country assumption and the world prices normalized to 1, the domestic price of the remaining goods is given by $p_i = 1 + \tau_i$, where τ_i denotes both the specific and advalorem tariff rate.

The government sets its trade policy by maximizing the following political support function

$$G \equiv L + \textstyle\sum_{i=1}^{N} \left(\int_{1+\tau_i}^{\infty} D_i(\tau_i) d\tau_i + \omega \int_{0}^{1+\tau_i} A_i Q_i(\tau_i) d\tau_i + \tau_i M_i(\tau_i) \right) \quad (1)$$

where L is the aggregate labor supply and income, $D_i(\tau_i)$ is the aggregate demand, $X_i(\tau_i) = A_i Q_i(\tau_i)$

[2] Trade with the rest of the world is balanced through movements of the numeraire good.

is the aggregate supply, and $M_i(\tau_i) = D_i(\tau_i) - A_iQ_i(\tau_i)$ is the aggregate import demand for good i. Thus, G is a weighted sum of the aggregate consumer and producer surplus, as well as tariff revenue and labor income. The tariff revenue, $\sum_{i=1}^{N} \tau_i M_i(.)$, is fully rebated back to the public (both consumers and producers) in a lump-sum manner. The weight, $\omega \geq 1$, represents the relative importance given to the producer surplus with respect to the rest of the social welfare and if $\omega = 1$, the objective reduces to a standard social welfare function with no lobbying.

Given the additive separability of the government objective, we can obtain the optimal tariff rate for sector i by maximizing equation (1) with respect to $\boldsymbol{\tau}_i$. Consequently, the equilibrium specific and advalorem tariff rates for sector i are implicitly defined as

$$\tau_i = (\omega - 1)\frac{A_iQ_i(\tau_i)/M_i(\tau_i)}{\varepsilon_i(\tau_i)} \tag{2}$$

where $\varepsilon_i(.)$ stands for the elasticity of import demand.[3] This expression is a standard one obtained in various political economy models (Helpman 1997). Accordingly, the tariff rate for sector i is an increasing function of the extra political economy weight provided to producers, $(\omega - 1)$, whereas it is a decreasing function of the import demand elasticity, ε_i, and the import penetration ratio, M_i/A_iQ_i. A tariff is a tax on imports so the deadweight loss created is lower the more inelastic the import demand is. Thus, a smaller value of ε_i allows for higher tariffs to be applied. In addition, a relatively larger market for imports (i.e. a lower X_i/M_i) creates a greater price distortion potential which should be avoided by the government. Finally, the marginal benefit of a tariff is higher when it applies to more units and more productive processes.

Partially and implicitly differentiating equation (2) with respect to A_i, we obtain the following relationships between tariff protection and productivity

$$\frac{\partial \tau_i}{\partial A_i} = -(\omega - 1)\frac{Q_i(\tau_i)}{M_i'(\tau_i)} > 0 \tag{3a}$$

$$\frac{d\tau_i}{dA_i} = -\frac{(\omega - 1)Q_i(\tau_i)}{M_i'(\tau_i) + (\omega - 1)A_iQ_i'(\tau_i)} \left.\begin{matrix} > 0 \text{ if } \eta_i < (1 + 1/\tau_i) \\ < 0 \text{ if } \eta_i > (1 + 1/\tau_i) \end{matrix}\right. \tag{3b}$$

I assume that $Q_i(\tau_i)$, $D_i(\tau_i)$ and hence, $M_i(\tau_i)$ are linear for ease of exposition (i.e. $Q_i''(\tau_i) = D_i''(\tau_i) = 0$). I have the same assumption throughout the text. This is not a necessary condition for the inequalities in equation (3b) to hold or the other results to follow. The price elasticity of supply, $\eta_i = X_i'p_i/X_i$, determines the sign of the inequality in equation (3b). Intuitively, the more elastic the supply curve is,

[3] See the appendix (Section A.1) for the derivation of equation (2). The import demand elasticity is defined as $\varepsilon_i \equiv -M_i'p_i^w/M_i$, so it differs from the standard definition which is evaluated at the domestic price. I account for this in the empirical estimations as explained in the appendix (Section A.2).

the higher the production distortion loss will be. Thus, for a highly elastic supply, the government will be setting tariffs lower for more productive and larger sectors to avoid bigger deadweight losses. Otherwise tariffs increase in productivity due to their higher benefit to the larger and more productive producers at the margin.

The empirical estimates of price elasticity of supply tend to be close to 0 (cf. Gagnon 2003, Marquez 1990), which in our case implies higher tariffs would be set for more productive sectors. The condition that calls for a positive sign in equation (3b), $\eta_i < (1 + 1/\tau_i)$, is also equivalent to a political economy weight value such that $\omega < 2 - \frac{D_i'(.)}{A_i Q_i'(.)}$, as shown in the appendix. This is actually an upper bound that is significantly over the estimates in the recent empirical political economy literature. For example, Goldberg and Maggi (1999) estimate ω to be equal to 1.014 for the United States, whereas Karacaovali and Limão (2008) estimate it to be between 1.0025 and 1.0042 for the European Union. In this paper, as I will discuss in Section 5.3, the main estimates of ω for Colombia are more realistic and range between 1.112 and 1.215, which are still below the upper bound.

Based on these estimates, I predict the sign of the inequality in equation (3b) to be positive. However, I do not impose any theoretical restrictions on the parameter values because the effect of productivity on tariffs is ultimately an empirical question which I test in Section 5. The main result here is that, based on a standard political economy model, we expect the productivity of an organized sector to affect the amount of tariff protection it receives. Thus, this is a slight modification of the size effect identified by the influential work of Grossman and Helpman (1994) which has been tested and confirmed in various papers (like Gawande and Bandyopadhyay 2000, Goldberg and Maggi 1999, and Mitra, et al. 2002). More importantly, this basic result naturally raises doubts about the assumption of exogeneity of trade policy with respect to productivity in the earlier empirical literature.

2.2 Trade Reform

Nearly all papers examining the trade reform-productivity linkage involve a period of unilateral liberalization which is usually assumed to be an exogenous shock independent of productivity and common across sectors. To examine whether such a common shock does indeed produce a proportional, non-selective decline in tariffs, I simply augment the baseline government objective function, G, with an additional term, $\Sigma(\boldsymbol{\tau}) = \alpha \sum_{i=1}^{N} \sigma_i(\boldsymbol{\tau}_i)$. This extra term does not create a different economic structure, that is we still have consumers with quasilinear utility functions, a constant returns to scale production with no spillovers and so on. The government objective function can now be expressed as

$$\Gamma \equiv G + \alpha \sum_{i=1}^{N} \sigma_i(\boldsymbol{\tau}_i) \tag{4}$$

where G is the same as in equation (1), $\sigma_i(.)$ is increasing in $\boldsymbol{\tau}_i$ (and concave), and $\alpha > 0$ is a constant. $\Sigma(\boldsymbol{\tau})$ is meant to capture the government perceived benefit of using protective trade policy and would call for protection even in the absence of lobbying. One can think of the government perceived benefit of protection emanating from a belief in import substitution or a belief in an unquestioned historical legacy of trade protectionism. Initially, I use this approach to be able to clearly show that the tariff changes and levels depend on the productivity changes and levels even under the simplest setup of trade reform. However, in the next sub-section, I put more structure on the way liberalization manifests itself by modeling an infant industry argument, which is known to be a crucial protection motive for developing countries.

The equilibrium tariff rate obtained by maximizing equation (4) is given by

$$\tau_i = (\omega - 1)\frac{A_i Q_i(\tau_i)/M_i(\tau_i)}{\varepsilon_i(\tau_i)} + \frac{\alpha\sigma_i'(\tau_i)}{M_i(\tau_i)\varepsilon_i(\tau_i)} \tag{5}$$

The derivation follows that of equation (2). The first expression in equation (5) is essentially the same as equation (2). However, the additional σ_i' term captures the marginal perceived benefit of tariffs, weighted by imports, import demand elasticity, and coefficient of perceived benefit, α. I assume that the σ_i' terms are identical across sectors in order to get a uniform effect, that is $\sigma_i' = \sigma_j'$ for $i \neq j$.

Many developing countries, including Colombia, have gone through significant unilateral trade liberalization in the late 1980s through the early 1990s. I am going to model such a unilateral liberalization shock as a dramatic decline in the parameter α, say, all the way down to zero. On purpose, this shock is modeled to be common across sectors and it does not depend on any industry characteristics. The shift in policy may occur due to a contingent loan from the IMF or a policy recommendation from the World Bank which require certain stabilization and liberalization policies from our "small" country. Alternatively, it might be due to a change in the paradigm based on observing the success of other comparable liberalizing countries and a new international consensus degrading import substitution type of policies. For example, Edwards (1997) analyzes the role of the World Bank in its effect on trade liberalization reforms and acknowledges its contribution through research and policy dialogue.

With the reduction in α to zero, we obtain

$$\Delta\tau_{it+1} \equiv \tau_{it+1}|_{\alpha=0} - \tau_{it}|_{\alpha>0} = -\frac{(\omega-1)A_{it+1}Q_{it+1}(\tau_{it+1})}{M'_{it+1}(\tau_{it+1})} + \frac{(\omega-1)A_{it}Q_{it}(\tau_{it})}{M'_{it}(\tau_{it})} + \frac{\alpha\sigma_i'(\tau_{it})}{M'_{it}(\tau_{it})} \tag{6}$$

Then, using the linearity of M_i,[4] equation (6) can be re-expressed as

$$\Delta\tau_{it+1} = -(\omega-1)\frac{(\Delta A_{it+1})Q_{it}(\tau_{it}) + A_{it+1}(\Delta Q_{it+1})}{M_i'} + \frac{\alpha\sigma_i'(\tau_{it})}{M_i'} \tag{7}$$

We obtain the following relationships between tariffs and productivity in levels and changes

$$\frac{d\tau_{it}}{dA_{it}}|_{\alpha\geq 0} = -\frac{(\omega-1)Q_{it}(\tau_{it})}{M_{it}'(\tau_{it}) + (\omega-1)A_{it}Q_{it}'(\tau_{it}) + \alpha\sigma_i''(\tau_{it})} \gtrless 0 \tag{8a}$$

$$\frac{d\Delta\tau_{it+1}}{d\Delta A_{it+1}}|_{\tau_{it},A_{it}} = -\frac{(\omega-1)Q_{it+1}(\tau_{it+1})}{M_i'(.) + (\omega-1)A_{it+1}Q_{it+1}'(\tau_{it+1})} \gtrless 0 \tag{8b}$$

Equation (8a) is obtained by implicitly differentiating equation (5) with respect to A_{it} whereas, equation (8b) is obtained by implicitly differentiating $\Delta\tau_{it+1}$ as expressed in equation (7) with respect to ΔA_{it+1} for given initial levels of τ_{it} and A_{it}. We naturally have $\partial\tau_{it}/\partial A_{it} > 0$ and $\partial\Delta\tau_{it+1}/\partial\Delta A_{it+1} > 0$. The total differentials are also positive if the price elasticity of supply is not very high. Equivalently, a positive sign requires a less restrictive upper bound for the political economy weight, $\omega < 2 - \left(\frac{D_i'(.)+\sigma_i''}{A_iQ_i'(.)}\right)$, as compared to the previous section (note that $\sigma_i'' < 0$).

We see that the productivity of a sector still affects the level of its tariff protection and the extent of liberalization in a sector depends on the change in its productivity despite an exogenous shock common across sectors. The sectors that continue to receive higher protection are the same ones due to the political economy channel. Thus, we have reasons to worry about endogeneity of tariffs with respect to total factor productivity. Accordingly, in the empirical studies where sector level productivity is regressed on sector level tariffs that are assumed to be exogenous, there will be a direct reverse causality problem. In the case of firm level productivity being regressed on sector level tariffs, this problem will be smaller. However, to the extent that firm level productivities in a sector differ commonly from firm level productivities in other sectors or the more correlated firm level productivities are with the corresponding sector level productivities, the worse will the endogeneity problem be. In the empirical section, I use productivity estimates obtained at the firm level that are then aggregated to the sector level using production shares as weights to arrive at representative productivity values for each sector.

Finally, notice that the productivity-tariff linkage above is completely driven by the political economy channel. In the absence of lobbies, that is, when the extra political economy weight is null ($\omega - 1 = 0$), productivity has no effect on tariffs. Nevertheless, again because of political economy, the reduction in tariffs varies across sectors based on productivity differences regardless of the common shock.

[4] I assume that the parameters do not change over time, and combining with the earlier linearity assumption we get $M_{it+1}'(.) = M_{it}'(.) = M_i'(.)$.

2.3 Government Perceived Learning-by-Doing

In developing countries, learning-by-doing and infant industry arguments have been a major motivation for protection which should be accounted for. Grossman and Helpman (1995) provide a comprehensive survey of the literature on technology and trade and indicate that "some countries might wish to use trade or industrial policies to alter their patterns of specialization... The short-run income loss for such a country would be small, while the policy would generate a permanent boost to its productivity growth..." (p. 1297). However, it should be noted that import substitution policies and infant industry protection have been largely abandoned especially after the 1980s and some critics have indicated that the infants actually never seem to grow (see, e.g., Krueger and Tuncer 1982). In this spirit, trade liberalization episodes in developing countries can be seen as a result of the disillusion about the infant industry argument. That is, the governments go from strongly believing in the argument to understanding that it does not work and that infants do not mature. I examine the effect of such a shift in government beliefs on the structure of liberalization by modelling a learning-by-doing (LBD) process which is merely a perception by the government.[5] Although there is no LBD, the government believes that there is some and thus sets its tariffs accordingly until it realizes that this is a false perception and then embarks upon a trade reform. Edwards (2001) notes that César Gaviria (President of Colombia from 1990 to 1994) "developed from early on a critical view regarding CEPAL's [Economic Commission for Latin America] import substitution development strategies, then in vogue in most of Latin America."

More specifically, the government believes that more production today has a positive impact on tomorrow's productivity and it takes this relationship into account while determining its current trade policy. However, firms decide about their production by simply reacting to the prices determined by the government trade policy and their decisions do not depend on any LBD process. For simplicity, I assume that the government has a two-period policy setting horizon. One can think that the government sets trade policy quite infrequently such that tariffs are first determined when the government believes that there exists a strong learning-by-doing process at play and later when this perception is discarded because learning-by-doing is not observed or the process reaches its terminal point. Alternatively, this might be a short lived government that expects to be in power for two periods only. This assumption is not only computationally convenient but also helps us partially capture the real experience in Colombia. This is a feature shared by many other developing countries such as Turkey, Brazil, and India that experienced significant liberalization around the 1983-1985, 1991-1996, and 1990-1993 periods, respectively.

In this setup, I aim to provide a plausible explanation for the way unilateral liberalization is introduced. The liberalization shock is common across sectors as in the basic model but now the government

[5] I gratefully acknowledge Nuno Limão for his suggestions here.

perceived benefit of protection has a specific reasoning based on a LBD process. Equation (1) still defines the government objective, but this time the government has the following belief about the form of the supply function

$$X_{it}(\tau_{it}) = A_{it}(\phi_{it}, \lambda_{it})Q_{it}(\tau_{it}) \tag{9}$$

$A_{it}(.) = \phi_{it}\lambda_{it}$, like before, denotes total factor productivity, $\lambda_{it} = \lambda(X_{it-1})$ represents the learning-by-doing process, and ϕ_{it} stands for determinants of TFP that are independent of LBD. The government believes that $\lambda(.)$ is an increasing function of past production within the same sector, that is $\lambda'(.) > 0$. Note that the true supply function is actually $X_{it}(\tau_{it}) = \phi_{it}Q_{it}(\tau_{it})$. Each period, the government sets tariffs considering their current effects on the weighted social welfare as discussed in the previous section but now it additionally considers the perceived future effects of current tariffs via learning-by-doing. In a similar spirit, Dasgupta and Stiglitz (1988) and more recently Melitz (2005) model infant industry protection based on learning-by-doing which is an idea dating back to 19^{th} century (e.g. List 1856, Mill 1848) and increased production due to protection is thought to decrease future costs.

The equilibrium tariffs for period t can be obtained as

$$\hat{\boldsymbol{\tau}}_t \equiv \arg\max_{\boldsymbol{\tau}_t}[G_t + \delta E_t(G_{t+1}|\iota_t)] \tag{10}$$

where the G_j terms are defined as in equation (1) but with time subscripts and $X_{it}(.)$ takes the form in equation (9). ι_t denotes the information set of the government in period t, and $\delta < 1$ is the time discount factor. At period t, the government knows that TFP has some baseline value $A_{it}(.) = \phi_{it}$ and believes that the future expected TFP is given by $E_t(A_{it+1}(.)) = E_t(\phi_{it+1}\lambda_{it+1}) = \overline{\phi}_{it+1}\lambda(\phi_{it}Q_{it})$.[6]

Solving backwards, we obtain the tariffs for period $t+1$. The realized values of these tariffs are set after the government observes A_{it+1} and finds out that LBD is passé. Therefore, the actual period $t+1$ tariff rate is equal in its form and value to equation (2). However, in order to set the tariffs in period t, the government needs to compute the future expected welfare which depends on the expected period $t+1$ tariffs. Given that there are two periods, the expected tariffs for period $t+1$ have the standard form similar to equation (2); yet, due to the LBD process, each of its components, hence itself is expected to depend on period t tariffs

$$E_t(\tau_{it+1}) = \tau^e_{it+1}(\tau_{it}) = (\omega - 1)\frac{\overline{\phi}_{it+1}\lambda(X_{it}(\tau_{it}))Q_{it+1}(X_{it}(\tau_{it}))/M_{it+1}(X_{it}(\tau_{it}))}{\varepsilon_{it+1}(X_{it}(\tau_{it}))} \tag{11}$$

[6] Note that the government is not taking expected values over alternative values of ϕ_{it+1}. Instead it expects ϕ_{it+1} to be equal to $\overline{\phi}_{it+1}$ with probability 1.

As I show in Section A.1 in the appendix, the equilibrium tariff rate for period t is obtained from equation (10) such that the tariffs now include the perceived learning-by-doing motive in addition to the political economy channel.

$$\tau_{it} = (\omega - 1)\frac{\phi_{it}Q_{it}(\tau_{it})/M_{it}(\tau_{it})}{\varepsilon_{it}(\tau_{it})} + \delta\omega\frac{\Lambda_i/M_{it}(\tau_{it})}{\varepsilon_{it}(\tau_{it})} \tag{12}$$

The variable Λ_i stands for the LBD effect and it is defined as

$$\Lambda_i \equiv \left(\frac{\lambda'(\phi_{it}Q_i(\tau_{it}))}{\lambda(\phi_{it}Q_i(\tau_{it}))}\phi_{it}Q'_{it}\right)\int_0^{1+\tau^e_{it+1}} \overline{\phi}_{it+1}\lambda(\phi_{it}Q_{it})Q_{it+1}d\tau_{it+1} > 0 \tag{13}$$

Thus, Λ_i measures the government perceived growth in productivity due to the LBD process multiplied by the responsiveness of the current supply to tariffs and weighted by the future producer surplus. The tariff rate is increasing in the additional LBD term since the government considers the positive effect of increased production through today's protection on tomorrow's welfare.

Let us consider the following functional form for the LBD process

$$\lambda_{it+1} = \lambda(X_i(\tau_{it})) = [\phi_{it}Q_i(\tau_{it})]^n,\ n < 1 \tag{14}$$

I assume $\lambda(.)$ is concave to avoid the unrealistic possibility that tariffs could be raised unboundedly. Next, in order to see the effect of productivity on tariffs, we employ this functional form in equation (13) which is an element of equation (12) and, as I show in the appendix (Section A.1), derive the following relationships

$$\text{(a)}\quad \frac{\partial\tau_{it}}{d\phi_{it}} > 0 \qquad \text{(b)}\quad \frac{d\tau_{it}}{d\phi_{it}} \gtrless 0 \qquad \text{(c)}\quad \frac{d\tau_{it}}{d\overline{\phi}_{it+1}} \gtrless 0 \tag{15}$$

Thus, assuming that ϕ_{it}, the part of the government perceived productivity that is independent of the LBD process, and $\overline{\phi}_{it+1}$, its future expected value, are positively correlated with the actual underlying determinants of TFP, the tariff rate is affected by the current and expected future productivity. This might be one of the reasons why we need to suspect the validity of using lagged tariff rates as a way to get around the endogeneity problem while regressing productivity on tariffs. More importantly, the effect of productivity on tariffs reaffirms the main result in my basic model in this richer setup.

Next, I also confirm that the change in tariffs is related to the change in productivity, which is derived in the appendix

$$\frac{d\Delta\tau_{it+1}}{d\Delta\phi_{it+1}}|_{\tau_{it},\phi_{it}} \gtrless 0 \tag{16}$$

Equation (16) will be positive if supply is not highly elastic, i.e. $\eta_i < (1 + 1/\tau_i)$, like in equation (3b). We see that, introducing a government perceived LBD process adds a new channel of protection and some structure to the onset of unilateral trade liberalization. The effect of productivity on tariffs, as established in the basic political economy model prevail but unlike the basic model, tariffs depend on productivity even in the absence of lobbying (i.e. $\omega = 1$).

As discussed in Section 2.1, I expect tariffs to depend positively on productivity in Colombia, although theoretically, the association could go either way depending on parameter and elasticity values.[7] Thus, the specifics of how productivity affects tariffs need to be tested and documented empirically as I do in Section 5.

3 Trade Policy in Colombia

Colombia is a perfect example of a developing country that went through phases of heavy trade protection prior to the mid-1980s and finally a dramatic unilateral trade liberalization in the early 1990s, as can be seen in Figure 1. The barriers were first lowered during the 1977-1981 period in response to an increase in coffee prices, increased foreign borrowing, and drug trafficking (Fernandes 2007). However, the Latin American debt crisis and the worsening terms of trade led to an increase in protection in the first half of the 1980s (Edwards 2001). President Virgilio Barco Vargas started the initial movement towards a real trade reform after he took office in 1986. He was succeeded by President Cesar Gaviria who completed the trade reform swiftly in two years (1991 and 1992).

I focus on protection through tariffs in my empirical estimations which directly follows from Section 2 and is consistent with the productivity studies in the literature. Note that import licenses were also commonly used in conjunction with the tariffs prior to the trade reform. Nevertheless, the trade reform not only rolled back the tariff rates but also almost eliminated the import licenses (Edwards 2001). Thus, a reduction in one form of protection was not replaced with another. Moreover, tariff rates tend to be better measured and they are positively correlated with import licenses. However, I also have access to effective rate of protection (ERP) data which I use to augment my results with tariffs. The effective rates take into account the tariffs on inputs, and they are based on value added. They are considerably higher

[7] In an alternative model suggested by an anonymous referee of this journal, we could allow for learning-by-doing to actually occur in some industries. Then, the government might have an incentive to reduce protection more for those industries which already achieve the increase in productivity and we could eventually obtain $d\Delta\tau_{it+1}/d\Delta\phi_{it+1} < 0$.

than nominal tariff rates but their pattern over time is similar (see Figure 1). Amiti and Konings (2007) find that in Indonesia, the reduction in input tariffs has a stronger positive effect on productivity gains so it is important to address how this measure of protection also depends on productivity.

As I mentioned above, most studies in the trade reform and productivity literature do not address the endogeneity of trade policy. Although some authors (e.g., Pavcnik 2002 for Chile; Ferreira and Rossi 2003 for Brazil) acknowledge the potential for endogeneity, they argue that it may not be such an issue in their studies given that the tariffs were reduced uniformly or proportionally across sectors. This is not true for Colombia; the liberalization was not uniform. Edwards (2001) notes that the trade liberalization reform of Colombia ("*La Apertura*") was "announced during the presidential campaign [of Cesar Gaviria] as a 'gradual' and 'selective' process." As can be observed in Figure 2, there is quite some variation in tariff reductions across sectors. Note that the reductions are computed as percentages to account for the variation in the initial tariffs. Moreover, the Spearman's rank correlations of tariffs vary over time (see Table 1), implying a selective as opposed to a uniform liberalization process. Otherwise, the ranking of sectors in terms of their protection rate would not change.

The average advalorem tariff rates in my sample of 4-digit ISIC industries declined from 43% in 1983 to about 14% in 1992 and stayed around that rate in the following years (Table 2). The dispersion of tariffs across sectors also declined (Table 2). Considering only the standard deviations, the decline appears to be markedly higher. However, we need to take into account the differences in the magnitude of tariffs across periods so the coefficient of variation is a better measure. The decline in dispersion is notably lower based on the coefficient of variation. However, this outcome does not indicate that political economy is no longer a factor in determining tariffs after reform. The decrease in dispersion is predicted by my models given the fact that liberalization occurs through the elimination of some extra channels other than political economy.

4 Empirical Literature Overview

Tybout (1991) reviews the literature on the linkages between trade and productivity, and he indicates that the net effect of liberalization is ambiguous in theory. Therefore, a majority of the studies that appear in the last decade remain empirical and do not test any particular theory.[8]

Most researchers take a two-step approach, where they first estimate productivity usually at the firm

[8] The motivation for the micro-level liberalization impact studies is based on two basic conjectures. First, trade liberalization may produce a productivity growth for the firm and the industry through economies of scale, improved access to foreign technology, and the elimination of X-inefficiencies. Second, liberalization may reallocate resources from the less efficient to the more efficient firms after the less efficient ones exit, hence leading to a rise in the average productivity in the industry. The latter channel is explicitly modeled in an influential paper by Melitz (2003) who shows how industry productivity may grow due to reallocations between firms after an exogenous trade reform shock.

level (and in some cases at the sector level), and then regress this productivity estimate on trade policy measures such as import penetration or tariffs for a single country (e.g., Schor 2004, and Tybout and Westbrook 1995). Another strand of the literature focuses on the effect of imperfect competition and analyzes the change in price-cost margins after liberalization (e.g., Harrison 1994, Krishna and Mitra 1998).

Although most studies do not address the endogeneity issue, Fernandes (2007) is one exception. She uses lagged tariff rates instead of current tariffs due to her concern about the endogeneity problem. She also considers the variables from Trefler's (1993) non-tariff barrier (NTB) equation as instruments for tariff rates as a robustness check. Using lagged tariff rates is not appropriate if the true model relates them in the current period. Then a better solution could be to use the lagged tariff rates as an instrument for current ones. Moreover, lagged tariff rates might not get around the endogeneity problem, because trade policy might differ across sectors due to persistent factors related to productivity. For instance, productivity might be autocorrelated, or tariffs may be influenced by anticipated changes in productivity as predicted by one of my theoretical results. What is more, the validity of the instruments initially used by Trefler (1993) for a different study is debatable since some of the instruments (like import penetration or regional concentration) could very well be influenced by productivity, and hence be endogenous themselves. Fernandes (2007) acknowledges that these robustness results are not reliable, as some of her instruments are clearly correlated with productivity. Muendler (2004) is another exception in trying to control for the endogeneity of trade policy. He regresses the growth rate of productivity on both tariffs and import penetration at the same time. He considers the nominal dollar exchange rate, the Brazilian consumer price index, and the average sector-specific European and US-Canadian producer price indices as instruments for the trade policy measures. However, both nominal and real exchange rates lack sectoral variation and cannot explain why tariff rates differ across sectors.[9]

Harrison (1994) uses time dummies for capturing trade liberalization but these do not account for industry level variation in policy. She also considers tariff changes and import penetration in her estimations by interacting the trade policy measures with the relevant mark-up variable. These estimations invariably suffer from the same endogeneity problems I discussed above.

Pavcnik (2002) takes yet another approach and compares the productivity changes in the tradable versus non-tradable sectors around a trade liberalization period, finding that the import-competing sectors experienced a larger increase in productivity relative to the non-tradable sectors but the results are inconclusive for export-oriented sectors. This methodology does not account for sectoral variations in trade

[9] As I have shown theoretically and will confirm empirically, tariffs and import penetration are inversely related in a systematic way so this might create a multicollinearity problem in Muendler's (2004) estimations.

policy as well. Furthermore, Tybout (1996) notes that firms usually self-select their trade-orientation and if more productive firms are more likely to become exporters, then one must use caution in asserting a casual relationship from policy to performance.

5 Estimation

5.1 Econometric Model

In this section, I would like to test how productivity affects tariffs despite a common exogenously timed trade reform shock that impacts all sectors. In the estimations, I intend to capture the common features of protection and liberalization asserted in my theoretical analysis (Section 2.)

According to the political economy channel, tariffs are inversely related to import penetration (that is Imports/Domestic Production) and import demand elasticity, and positively linked to the additional weight government places on producer welfare. Recall that the production function is denoted as $X_{it} = A_{it}Q_{it}$ where A_{it} stands for total factor productivity (TFP). The equilibrium tariff rate identified in equation (2) can then be re-expressed in logarithms as

$$\log \tau_{it} = \log(\omega - 1) + \log A_{it} + \log(Q_{it}/M_{it}\varepsilon_{it}) \tag{17}$$

The additional source of tariff protection causes a major unilateral liberalization when it vanishes. This occurs after the paradigm changes as discussed in Section 2.2, or after learning-by-doing is realized to be an obsolete perception as in Section 2.3. I model the additional channels of protection under both models with sector specific constants and the trade reform that occurs due to the disappearance of such motives as a shift in these intercept terms of the tariff determination rule. Given the parsimonious nature of the models, the sector-specific fixed effects also help to control for other determinants of tariffs that may not have been already considered.

As illustrated in Figure 1, tariffs in Colombia declined drastically starting in 1990 and the liberalization continued until 1992. Based on the theory, I first start out by assuming that liberalization is a major, once and for all shift in tariffs and relax this assumption afterwards. I capture the shift with a dummy variable, $UNILIB_t$, that takes the value one for 1990 and onwards, and zero otherwise. The basic econometric model can then be expressed as

$$\log \tau_{it} = \alpha + \beta_1 \log A_{it} + \beta_2 \log(Q_{it}/M_{it}\varepsilon_{it}) + \beta_3 UNILIB_t + \mu_i \beta_4 + u_{it} \tag{18}$$

where τ_{it} is the advalorem tariff rate for sector $i = 1, ..., N$ at period $t = 1, ..., T$. A_{it} together with

$Q_{it}/M_{it}\varepsilon_{it}$, are measures of the main political economy channel.[10] μ_i is a $1 \times (N-1)$ vector of industry dummy variables and depicts sector-specific effects. $UNILIB_t$ serves as an intercept-shifter with the interpretation described above. According to the theory, the estimate for β_1 can be either positive or negative depending on elasticity and parameter values. Nonetheless, we expect a positive estimate for β_2 and the estimate for β_3 should be naturally negative by definition (it is a unilateral liberalization). The constant, α, provides an estimate for $\log(\omega - 1)$. The error term explicitly allows for measurement error in the determinants of tariffs that are considered and that are potentially left out.

In the theory section, the liberalization shock results in a one time permanent decline in tariffs although the actual reform happens gradually. By looking at Figure 1, we can distinguish three periods with plausibly three different intercept terms: 1983-1989 (pre-reform), 1990-1992 (reform), and 1993-1998 (post-reform). What is more, there exists considerable variation within the pre-reform and reform periods.[11] Therefore, I estimate two different versions of equation (18). In the first version, I replace $\beta_3 UNILIB_t$ with $\rho_1 REF_t + \rho_2 POSTREF_t$, where REF_t is a dummy variable which equals one for 1990-1992 and zero otherwise. Similarly, $POSTREF_t$ is equal to one for 1993-1998 and zero otherwise. Both dummies control for the shift in tariffs in their respective periods relative to the sector specific constants. In the second version, I replace $\beta_3 UNILIB_t$ with $\theta_t \gamma$ where θ_t is a $1 \times (T-1)$ vector of year dummies that capture the yearly common variation in tariffs and further relaxes the assumption of a one time overall tariff reduction.

There are endogeneity problems in the estimation of equation (18). First, $Q_{it}/M_{it}\varepsilon_{it}$ is endogenous with respect to tariffs since it depends on domestic prices, hence on tariffs. Second, earlier empirical studies documented that trade policy affects productivity so this requires accounting for a potential reverse causation. I use the following list of instruments to deal with the endogeneity issues: capital to output ratio, materials prices, a measure of scale economies (value added/number of firms), and TFP of the upstream industries. The detailed variable definitions and sources are in the appendix (Section A.3). The instruments should be correlated with the endogenous regressors and yet be orthogonal to the error term. I present the formal tests of instrument validity in Section 5.4 but I would like to provide some intuition here. The capital share is expected to be negatively related to the output-imports ratio (Q_{it}/M_{it}) given that, based on comparative advantage, Colombia is more likely to produce products with smaller capital content and import products with larger capital content. Nonetheless the capital share does not depend on tariffs. The materials prices affect the domestic output prices, hence $Q_{it}/M_{it}\varepsilon_{it}$ but not the tariffs of a given sector i, conditional on Q_{it}, M_{it}, and ε_{it}. The materials prices are constructed

[10] Q_{it} is not directly observable but it is estimated by dividing X_{it} by the estimate of A_{it}.

[11] Tariffs actually increase between 1982 and 1984 and then start to decline in 1985. The sample, on the other hand, only includes 1983, 1985, and 1988-1990 for the pre-reform era. Between 1983 and 1988, the trend for tariffs is a gradual decline.

using Tornqvist indices at the plant level relative to the yearly producer price indices (Eslava, et al. 2004) and then aggregated to the 4-digit ISIC level using firms' production shares as weights. Scale economies are an inherent characteristic of a sector and are positively correlated with its productivity and size. Once we account for the size and productivity effect in the protection equation, other variables such as scale should only indirectly affect protection so they can be excluded as argued in Goldberg and Maggi (1999). The productivity of a sector is also expected to be affected by the average productivity of upstream sectors which is likely to be independent of the sector's own tariffs.

Since the model is quite parsimonious, it is also prone to an omitted variable bias. The use of fixed industry effects in equation (18) and its different versions is expected to lessen this potential problem along with the Instrumental Variables (IV) estimation.

Note that my productivity measure is a generated regressor as detailed in the next subsection. This could potentially create measurement error and affect the efficiency and consistency of the estimate for the effect of productivity on tariffs. However, Pagan (1984) notes that when generated residual levels are used in a two-step regression framework, the estimates will be consistent and efficient. Thus, this measurement error is abated in my work, given that the productivity estimates are the estimated residuals from Eslava, et al. (2004) which I use in a two-step efficient GMM estimation. Finally, my elasticity of import demand measure is also based on separate estimations (Kee, Nicita and Olarreaga 2004) so it is prone to measurement error. The IV-GMM approach should alleviate this potential problem given that the instruments are expected to be correlated with the true values of the regressors but not with the error term which includes measurement error. Nevertheless, as a robustness check in Section 5.4, I show that the results are not sensitive to an alternative elasticity measure from Nicita and Olarreaga (2007) and the corresponding errors-in-variables correction.

5.2 Data

The data for the estimations span 1982 through 1998 but given the lack of tariff and production information for certain years, the sample reduces to 1983, 1985, and 1988-1998. The tariff and effective rate of protection (ERP) figures are obtained from DNP (National Planning Department) of Colombia at the 8-digit product level,[12] which are then aggregated to the eighty 4-digit ISIC (International Standard Industrial Classification, United Nations) sectors by using simple averages.[13] The 4-digit ISIC level import data come from the COMTRADE dataset, United Nations Statistics Division and the industry

[12]The product classification code, called "Nabandina", is due to the Andean Community of Nations. I thank Marcela Eslava at Universidad de Los Andes/CEDE, Colombia for generously sharing the data.

[13]I use simple averages to be consistent with the earlier literature. An alternative way would be to use the import or production shares of each product as weights but these data do not exist for all sample years at this level of disaggregation.

production data at the same level are available through UNIDO's Industrial Statistics Database.

The productivity estimates, value added, factors of production, and materials prices data are obtained from Eslava, Haltiwanger, Kugler and Kugler (2004), where each variable (except value added[14]) is aggregated from the firm level to the 4-digit ISIC industry level with production shares used as the weights. The main data source for Eslava, et al. (2004) is the Colombian Annual Manufacturers Survey (AMS) by DANE (National Statistical Institute). They estimate total factor productivity (TFP), A_{it}, as the residual from the following production function for manufacturing firms $i = 1, ..., N$ and periods $t = 1982, ..., 1998$

$$\log X_{it} = b_1 \log K_{it} + b_2 \log L_{it} + b_3 \log E_{it} + b_4 \log I_{it} + \log A_{it} \tag{19}$$

where K_{it}, L_{it}, E_{it}, and I_{it} denote capital, labor (total employment hours), energy consumption, and materials, respectively. An important concern in such an estimation is the simultaneity bias; that is, productivity shocks may be correlated with input levels. They correct for this bias by considering a measure of downstream demand as an instrument for inputs along with regional government expenditures and input prices. A great advantage of this dataset is that it includes plant level output and input prices which have not been available to other researchers in the field requiring them to use non-parametric estimation techniques.[15] Furthermore, the output measures commonly used in the literature have been firm revenue deflated by industry-level prices. Thus, within-industry price differences (e.g. due to different markups) have been part of the output and productivity estimates of such studies, potentially biasing their results.

The import demand elasticity measure is based on the structural estimates in Kee, et al. (2004), which I combine with GDP data from the World Development Indicators, and import data from COMTRADE. The import demand elasticities are available only at the 3-digit ISIC level. See the appendix for a discussion on how the import demand elasticity is computed (Section A.2).

In order to obtain the TFP measure of the upstream industries, I employ the input-output tables provided at the 3-digit ISIC level by Nicita and Olarreaga (2001), which were compiled from version 4 of the Global Trade Analysis Project (GTAP) database. Excluding the inputs being used from the own sector, the upstream measure is based on a combination of TFPs of the remaining input sectors as weighted by their share of usage.

The variable definitions and sources are presented more in detail in the appendix (Section A.3). In

[14]Value added is used to compute a measure of scale economies where it is an unweighted total in each sector.

[15]The methodology in these studies was developed by Olley and Pakes (1996), and advanced by Levinsohn and Petrin (2003). They employ investment or intermediate inputs to control for the correlation between input levels and unobserved firm-level productivity shocks.

Table 4, I provide the summary statistics for all the variables used in the estimations.

5.3 Estimation Results

The overall correlation coefficient between $\log A_{it}$ and $\log \tau_{it}$ in the whole sample of 920 observations is -0.222 and it is significant at the 1% level. In Table 3, I present the correlation matrix for all the combinations of $\log A_{it}$ and $\log \tau_{it}$ across years. The two variables have a relatively small negative correlation which is insignificant for certain years such as 1992 through 1994. In Table 3, it is interesting to note that the two variables can be concurrently and also inter-temporally correlated. This is one reason why using lagged tariff rates may not get around the endogeneity problem of tariffs with respect to productivity. Topalova (2004) notes a similar pattern in the Indian data for the 1997-2001 period and excludes this period from her analysis due to her concern about endogeneity.

However, we cannot establish a causal relationship between tariff protection and productivity based on these crude observations alone. We need to control for the other important variables required by the theory and tackle the endogeneity issues. As noted in Section 5.1, the two right-hand-side variables–total factor productivity, and the inverse import penetration to import demand elasticity ratio–in the tariff regressions are potentially endogenous. I confirm the endogeneity of $\log A_{it}$ and $\log(Q_{it}/M_{it}\varepsilon_{it})$ econometrically through a Durbin-Wu-Hausman endogeneity test. Thus, I employ the two-step efficient generalized method of moments (henceforth IV-GMM) estimator with fixed effects for my unbalanced panel. This methodology is more efficient than regular instrumental variables in the presence of heteroskedasticity of unknown form due to its use of an optimal weighting matrix (Cragg 1983). A Pagan-Hall (1983) test confirms the presence of heteroskedasticity in the data and further justifies the use of the IV-GMM methodology.

Although the theoretical section involves protection through tariffs, I repeat all the tariff specifications using instead effective rates of protection (ERP) in order to see whether the results hold with a different measure of protection. ERP data are provided by the National Planning Department of Colombia (DNP) and I am limited by their computations since I do not have the detailed data to calculate them myself. Effective rates are higher than regular tariff rates but otherwise display a similar trend (see Figure 1 and Table 4)[16].

In Table 5, I present the main estimation results with tariffs and ERP. The biased ordinary least squares (OLS) results are in columns 1 and 5 for comparison with the main IV-GMM results. The main estimates for equation (18) are in column 2. Tariff rates depend positively on total factor productivity

[16] I exclude the three sectors that exhibit negative ERP (in levels not logs), because it is hard to argue that these sectors are indeed protected. The excluded sectors are: a) ISIC 3122, manufacture of prepared animal feeds; b) ISIC 3512, manufacture of fertilizers and pesticides; c) ISIC 3822, manufacture of agricultural machinery and equipment.

(A_{it}) and positively on the inverse import penetration to import demand elasticity ratio ($Q_{it}/M_{it}\varepsilon_{it}$). The coefficients on the two main variables, β_1 and β_2, are positive and statistically significant at the 1% level. The unilateral liberalization variable, $UNILIB_t$, takes out the common reduction in tariffs after 1990, and it is significant and negative as expected. In column 3, I provide the estimates for a first variant of equation (18) where we divide the sample into three periods as opposed to imposing a one time major decline in tariffs. The two intercept-shifters, REF_t (period dummy for 1990-1992) and $POSTREF_t$ (period dummy for 1993-1998), control for the common decline in tariffs across sectors relative to the 1983-1989 period and come out negative and significant. In column 4, I present the estimates for a second variant of equation (18) that allows for further variation across time through year fixed effects and captures the gradual decline in tariffs. Both β_1 and β_2 are still positive and statistically significant at the 1% level in columns 3 and 4. The year dummies in column 4 are jointly significant just like the industry fixed effects are in all three IV-GMM equations. The constant term provides an estimate for $\log(\omega - 1)$ so I estimate the additional political economy weight on producer surplus, ω, to range between 1.112 and 1.215.

In columns 5 through 8, I repeat the tariff specifications using ERP and the results are robust. The only difference is that the significance levels for the main variables are lower, and the constant term becomes insignificant in columns 7 and 8. Note that the OLS coefficients in columns 1 and 5 have the same signs as the IV-GMM estimates but they are smaller.

A positive coefficient on $Q_{it}/M_{it}\varepsilon_{it}$, indicating that tariffs are inversely related to import penetration and import demand elasticity is a result consistent with the previous findings in the empirical political economy literature (such as Gawande and Bandyopadhyay 2000 for the U.S., Mitra, et al. 2002 for Turkey, and Karacaovali and Limão 2008 for the EU). Although my estimates of ω may arguably be small (c.f. Gawande and Krishna 2003, Imai, et al. 2008), they significantly exceed the earlier estimates for the US, Turkey, and the EU.[17] A positive coefficient on A_{it}, indicating that more productive sectors receive higher tariff protection, complements this result which is important because none of the earlier researchers separate the size effect into the effect of A_{it} and the effect of Q_{it}. Moreover, I account for the exogenous unilateral liberalization shock common across sectors in all specifications so there is no doubt that political economy does matter for the sectoral variation in tariffs. Therefore, the endogeneity

[17] For the United States the estimates of ω are 1.014 (Goldberg and Maggi 1999) and 1.0003 (Gawande and Bandyopadhyay 2000); for Turkey they range between 1.010 and 1.013 (Mitra, et al. 2002); and for the EU they range between 1.0025 and 1.0042 (Karacaovali and Limão 2008). In a follow-up paper, Mitra et al. (2006) argue that "...it is clearly the treatment of all sectors as organized, along with having estimating equation more tightly tied to theory, that can provide more realistic parameter estimates." (p. 208) In their replication of the US estimations (with NTBs), Mitra et al. (2006) find that estimates of ω range between 1.02 and 1.03 when they assume 10% of the population is organized; they range between 1.03 and 1.06 when they assume 50% of the population is organized; and they range between 1.21 and 1.42 when they assume 90% of the population is organized (Table 2, p. 201).

of tariffs with respect to productivity is a prevailing problem when researchers plainly regress tariffs on productivity.

In Table 6, I examine the effect of past productivity (one period lag) on current tariffs to check whether policy implementation occurs with a one period lag. It is sensible to think that policymakers would respond to the recently observed productivity rather than the current one which may not be readily available at the time of policymaking. I employ one period lags of scale and upstream TFP as instruments for the lag of productivity, and hence repeat the IV-GMM specifications in Table 5 with $\log A_{it-1}$ instead of $\log A_{it}$. The results indicate that more productivity yesterday calls for more protection today in all three versions of the modified equation (18) for both tariffs and effective rates of protection.

5.4 Robustness Analysis

Hansen-Sargan tests of overidentifying restrictions indicate that our instruments are valid, that is they are uncorrelated with the error term and are correctly excluded from the estimated equations. The Hansen-Sargan test probability values are presented in the last row of each relevant table. The probability values for the null hypothesis that the instruments are valid, range from 0.144 to 0.933 for the main tariff specifications presented in Table 5 (columns 2 through 4). These tests fail for the ERP specifications in Table 5 as well as for the specification in column 6 of Table 6 but to ensure consistency with the tariff specifications the same set of instruments is used. Yet one can be concerned about the weakness of the instruments. As an anonymous referee pointed out, we may expect the tariffs to affect the scale of operations or factor prices, hence the capital to output ratio. Therefore I ran the regressions by excluding scale and capital share instruments one at a time and the results are robust to these exclusions.

In Table 7, I report the first stage regressions for the main tariff and ERP specifications of Table 5 (i.e. columns 2 and 6). All the instruments are jointly significant and these regressions have high explanatory power. The partial R-square values based on Shea (1997) indicate that the instruments for $\log A_{it}$ explain a substantial fraction of its variation. The same is not true for $\log(Q_{it}/M_{it}\varepsilon_{it})$.

In Table 8, I present the results from several different specifications based on equation (18) as a robustness check. Tariff specifications appear in the first six columns which are repeated in the next six columns for effective rates of protection.

In the original estimations, I assume that all sectors at the 4-digit level are organized but it is plausible to expect a differential effect for the organized versus the unorganized sectors. In columns 1 and 7 of Table 8, I test whether the results are robust to including an indicator variable that captures organization. I employ a dummy variable, D_i^{org} that takes the value one if a 3-digit ISIC sector shows an indication of organization based on labor union activity or membership in economic associations/groups identified by Quintero (2006). In column 1, the coefficient on D_i^{org} is negative and insignificant while in column 7 it is positive and significant at the 5% level. These sectors seem to receive more protection but the coefficients on the main variables are neither affected in magnitude nor in significance when we compare them with their counterparts in columns 2 and 6 of Table 5. This may be explained by the fact that industry effects are included in all estimations and they already account for sectoral differences in protection. The constants which capture the average political economy weight naturally differ after we allow for a differential effect in organized sectors.

Alternatively, we can allow the political economy weight to differ across sectors based on certain sectoral characteristics. For example, a sector with a higher share of employment is likely to have a higher weight given that it generates more political votes (Caves 1976). Typically, labor intensive sectors are less productive so this could potentially affect the results. In columns 2 and 8, I control for the labor share of each sector and the coefficient on this variable comes out insignificant in both cases, whereas the main results remain intact. This might be due to the fact that the fixed effects already account for the different sectoral characteristics as determinants of protection.

Although the IV-GMM approach should alleviate the measurement error problem in the elasticity of import demand which is a generated regressor, I test the sensitivity of the results to an alternative time-invariant elasticity estimate from Nicita and Olarreaga (2007). With the alternative measure, the estimates for the main coefficients change neither in significance nor in magnitude. Nicita and Olarreaga (2007) also report standard errors for this measure so I am able to apply an errors-in-variables (EIV) correction based on the methodology detailed in Gawande and Bandyopadhyay (2000). As reported in columns 3 and 9, the main estimates remain the same but we lose about 25% of the observations due to lack of data and the EIV correction.

Given the fact that tariffs are censored from below, in columns 4 and 10 I test the sensitivity of the main estimates to using Newey's two-step tobit estimator. The results are robust to this estimation technique and the coefficients are slightly smaller but still significant at the 1% level.

In columns 5 and 11, I use a first-differenced model based on equation (18) where the fixed effects are essentially eliminated and the error term is corrected for autocorrelation. The results confirm that due to political economy, the extent of liberalization is smaller for sectors with a larger increase in productivity (or a smaller reduction in productivity). Given the definition of $UNILIB_t$, $\Delta UNILIB_t$ becomes just a year dummy for 1990 which may not be adequate to capture the actual changes in policy and may partially explain the reduction in significance of the main coefficient estimates. Thus, in columns 6 and 12, I replace $\Delta UNILIB_t$ with a dummy variable for the period 1990-1992, REF_t, in order to control for the gradual trade liberalization between 1990 and 1992. All the coefficients are again significant at the

1% level.

According to part (c) of equation (15), current tariffs depend positively on expected future productivity. I tested this prediction with the assumption that actual future productivity is correlated with its expected value and can be used as a proxy. I found that under the main specification of equation (18) (i.e. with $UNILIB_t$), we can confirm the positive dependence of current tariffs on future productivity at the 1% significance level. However, this result is not robust to the other two versions of equation (18).

When we run the main regressions separately for pre-reform and post-reform periods the link between protection, productivity and elasticity adjusted inverse import penetration remains intact but the coefficients become larger after the reform.

Figure 1 indicates that in Colombia, the major trade liberalization era started in 1990 and continued until 1992 when new persistently lower levels of tariffs were reached. Given the restrictiveness of $UNILIB_t$ by construction, I allowed it to use 1991 instead of 1990 as the cutoff point as well and the results remained robust to this different cutoff value.

6 Endogeneity Bias and the Effect of Tariffs on Productivity

The theoretical and empirical results I presented in the earlier sections indicate that we should be worried about the endogeneity of trade policy with respect to productivity. If researchers do not account for the endogeneity, their estimates of the trade policy effects on productivity will be biased. However, it is hard to tell the direction magnitude of the endogeneity bias once other regressors are part of the system.[18] Therefore, I illustrate how the bias might be working with the system of equations below.

In constructing this system, I partly rely on the setup of my estimations in the previous section. Nevertheless, I do not have a structural equation showing how productivity depends on tariffs, therefore I simply try to keep it similar to the estimations in the earlier empirical literature. I model the tariff and inverse import penetration equations as before and add a third equation for productivity as follows

$$\log A_{it} = \alpha_1 + \alpha_2 \log \tau_{it} + (\log Z_{1it})\alpha_3 + \mu_{1i}\alpha_4 + Z_{2t}\alpha_5 + \upsilon_{1it} \tag{20a}$$

$$\log \tau_{it} = \beta_1 + \beta_2 \log A_{it} + \beta_3 \log(Q_{it}/M_{it}\varepsilon_{it}) + \mu_{2i}\beta_4 + \theta_t\beta_5 + \upsilon_{2it} \tag{20b}$$

$$\log(Q_{it}/M_{it}\varepsilon_{it}) = \gamma_1 + \gamma_2 \log \tau_{it} + (\log Z_{3it})\gamma_3 + \upsilon_{3it} \tag{20c}$$

[18] Suppose that we have the following two equations that relate tariffs and productivity: (1) $\log A_{it} = a_1 + a_2 \log \tau_{it} + w_{1it}$ and (2) $\log \tau_{it} = b_1 + b_2 \log A_{it} + w_{2it}$ where w_{1it} and w_{2it} are mean zero error terms with constant variances $\sigma^2_{w_1}$ and $\sigma^2_{w_2}$. Then assuming that the covariance between the two error terms is zero, i.e. $cov(w_{1it}, w_{2it}) = 0$, we obtain $cov(w_{1it}, \log \tau_{it}) = \frac{b_2}{1-b_2a_2}\sigma^2_{w_1}$. If the true values of a_2 and b_2 are such that $a_2 < 0$ and $b_2 > 0$, then we have $cov(w_{1it}, \log \tau_{it}) > 0$. If we estimate a_2 with OLS, ignoring equation (2), and get $\widehat{a}_2 < 0$ which is positively correlated with a_2, we would have an upward bias, hence underestimate a_2.

where υ_{1it}, υ_{2it}, and υ_{3it} are the error terms for sector $i = 1, ..., N$ at period $t = 1, ..., T$. μ_{1i} and μ_{2i} are $1 \times (N-1)$ vectors of industry dummies, and θ_t is a $1 \times (T-1)$ vector of year dummies. Z_{1it} and Z_{3it} are 1×2 vectors of control variables at the 4-digit ISIC sector level, whereas Z_{2t} is a 1×2 vector of economy-wide controls. Z_{1it} includes the scale measure and upstream TFP, whereas Z_{3it} includes the capital to output ratio and materials prices. Note that these industry level control variables are precisely the instruments I used in the instrumental variables estimations in Section 5 so they are expected to be exogenous. The other advantage of these controls is that I get a consistent framework with the rest of my estimations. Z_{2t} includes GDP growth and inflation to control for the macro changes in the economy that might affect productivity in all sectors.

My estimates of equation (20a) are at the 4-digit industry level. This limitation precludes any direct comparison to the recent firm-level studies. However, after I estimate the system with three-stage least squares (3SLS), I compare these results with the simple OLS estimates of equation (20a) that ignore the endogeneity and can therefore test whether accounting for endogeneity improves the results within my dataset.

In Table 9, I provide the results of estimating the whole system with 3SLS versus estimating equation (20a) alone with OLS. Similar to the earlier literature, a negative OLS estimate of the coefficient on tariffs in equation (20a), i.e. $\widehat{\alpha}_2 < 0$, is obtained indicating that productivity rises with a decline in tariffs. The 3SLS regression results confirm this finding and also show that the positive effect of lower tariffs on productivity grows a little stronger (by 1.5%) when the endogeneity of tariffs is taken into account. However, since equation (20a) is not derived structurally, this small increase in the coefficient on tariffs should be taken with a grain of salt.

The 3SLS results from equation (20b) are similar to the findings in Table 5: more productive sectors receive higher protection, and tariffs are inversely related to import penetration and import demand elasticity. In the second half of Table 9, I replicate the estimations using effective rates of protection instead of tariffs and find identical results. However, this time the positive impact of liberalization on productivity is larger by 17% when we estimate the whole system. These findings imply that trade policy effects on productivity might be somewhat underestimated when endogeneity is not accounted for.

7 Concluding Remarks

I show, both theoretically and empirically, that we should be concerned about the endogeneity of trade policy with respect to productivity. Studies that investigate the effect of trade policy on productivity often argue that the exogeneity of the trade liberalization shock helps to identify a linkage without much concern about the endogeneity of tariffs or other forms of trade policy. I account for such an argument in my theoretical and empirical models, and still find tariffs to be endogenous.

I employ a basic political economy of trade protection model and introduce two different additional channels of protection that lead to unilateral liberalization once they are removed. The extra channels are meant to capture the perceived benefit of protection to the government even in the absence of political economy concerns. I first keep the liberalization channel very simple to ensure that my results are not driven by any specific assumptions and then give it more structure by modeling a learning-by-doing argument. The main result from my theoretical models is that despite an exogenously timed unilateral trade liberalization shock that is common across sectors, protection across sectors varies with sectoral productivity.

Next, I estimate the effect of productivity on tariffs by closely following my theoretical framework. I use production, trade, and tariff data at the 4-digit ISIC industry level for Colombia between 1983 and 1998 and account for all the potential endogeneity problems by using relevant instruments and methodologies. I find that more productive sectors receive more protection and that the extent of liberalization is small for sectors that experience a higher productivity increase.

Finally, I estimate a system of equations and show that by not accounting for the endogeneity of trade policy with respect to productivity, we might underestimate the positive impact of trade reform on productivity. Thus, correcting for the endogeneity bias does not overturn the results in the earlier empirical literature but makes them somewhat stronger for Colombia. This novel finding would be interesting to test for different countries as well.

As a natural extension to this paper, it would be useful to carefully model the effect of tariffs on productivity and obtain a more structural simultaneous equations model considering all the interdependencies between tariffs, productivity, and their determinants.

A Appendix

A.1 Derivations

Equation (2)

We maximize equation (1) with respect to τ_i to obtain the following first order condition for an interior solution

$$\begin{aligned} \frac{\partial G}{\partial \tau_i} &= -D_i(\tau_i) + \omega A_i Q_i(\tau_i) + M_i(\tau_i) + \tau_i M_i'(\tau_i) \\ &= (\omega - 1) A_i Q_i(\tau_i) + \tau_i M_i'(\tau_i) \end{aligned} \tag{21}$$

Equating to zero and solving for τ_i, and then dividing both sides of this expression by $p_i^w = 1$ and using the following elasticity definition $\varepsilon_i \equiv -M_i' p_i^w / M_i$ we arrive at equation (2).

Equation (3b)

The sign of equation (3b) depends on the sign of its denominator. That is we have $d\tau_i/dA_i \gtreqless 0$ depending on $M_i'(.) + (\omega - 1) A_i Q_i'(.) \gtreqless 0$ or that $\omega \gtreqless 2 - D_i'/A_i Q_i'$. The latter parameter condition can be re-expressed as

$$(\omega - 1) \gtreqless -\frac{M_i'}{X_i'} \left(\frac{M_i}{M_i} p_i^w \right) = \frac{M_i}{X_i'} \varepsilon_i \;\; \rightarrow \;\; \tau_i \gtreqless \frac{X_i}{X_i'} \; \left(\frac{p_i}{p_i} \right) \;\; \rightarrow \;\; \eta_i \gtreqless \frac{p_i}{\tau_i} = 1 + \frac{1}{\tau_i} \tag{22}$$

where we use $p_i = (1+\tau_i) p_i^w$, $p_i^w = 1$ and the following price elasticity of supply definition: $\eta_i = X_i' p_i / X_i$.

Equation (12)

The first order condition for an interior solution to equation (10) is

$$\begin{aligned} \frac{\partial E_t(G_{it} + \delta G_{it+1})}{\partial \tau_{it}} &= (\omega - 1)\phi_{it} Q_{it}(\tau_{it}) + \tau_{it} M_{it}' - \delta \frac{\partial \tau_{it+1}^e(\tau_{it})}{\partial \tau_{it}} D_{it+1}(.) \\ &\quad + \delta\omega \frac{\partial}{\partial \tau_{it}} \int_0^{1+\tau_{it+1}^e} \overline{\phi}_{it+1} \lambda(\phi_{it} Q_{it}(\tau_{it})) Q_{it+1}(\tau_{it+1}) d\tau_{it+1} \\ &\quad + \delta \frac{\partial \tau_{it+1}^e(\tau_{it})}{\partial \tau_{it}} M_{it+1}(.) + \delta \frac{\partial \tau_{it+1}^e(\tau_{it})}{\partial \tau_{it}} \tau_{it+1}^e(\tau_{it}) M_{it+1}' \end{aligned} \tag{23}$$

which after a few steps of manipulation becomes

$$\begin{aligned} \frac{\partial E_t(G_{it} + \delta G_{it+1})}{\partial \tau_{it}} &= (\omega - 1)\phi_{it} Q_{it}(\tau_{it}) + \tau_{it} M_{it}' \\ &\quad + \delta\omega \left[\frac{\lambda'(\phi_{it} Q_{it}(\tau_{it}))}{\lambda(\phi_{it} Q_{it}(\tau_{it}))} \phi_{it} Q_{it}' \int_0^{1+\tau_{it+1}^e} \overline{\phi}_{it+1} \lambda(.) Q_{it+1}(\tau_{it+1}) d\tau_{it+1} \right] \\ &\quad + \delta \frac{\partial \tau_{it+1}^e(\tau_{it})}{\partial \tau_{it}} \left[(\omega - 1)\overline{\phi}_{it+1} \lambda(.) Q_{it+1}(\tau_{it+1}^e(\tau_{it})) + \tau_{it+1}^e(\tau_{it}) M_{it+1}' \right] \end{aligned} \tag{24}$$

Using equation (11) to substitute in for $\tau^e_{it+1}(\tau_{it})$ and employing the definition in equation (13), the first order condition simplifies to

$$\frac{\partial E_t(G_{it}+\delta G_{it+1})}{\partial \tau_{it}} = (\omega-1)\phi_{it}Q_{it}(\tau_{it}) + \tau_{it}M'_{it} + \delta\omega\Lambda_i = 0 \tag{25}$$

Dividing both sides of equation (25) by $p^w_i = 1$ and using the same elasticity term ε_i as described above we arrive at equation (12).

Equations (15) (a), (b), and (c)

Employing the functional form given in equation (14), the LBD term can now be expressed as

$$\Lambda_i = n\phi^n_{it}Q'_{it}(Q_{it}(\tau_{it}))^{n-1}\int_0^{1+\tau^e_{it+1}} \overline{\phi}_{it+1}Q_{it+1}(\tau_{it+1})d\tau_{it+1} \tag{26}$$

The relationships in parts (a), (b), and (c) of equation (15) are then obtained by plugging equation (26) in equation (25) and differentiating τ_{it} in equation (25) with respect to ϕ_{it} (partially), ϕ_{it} (implicitly), and $\overline{\phi}_{it+1}$ (implicitly). For ϕ_{it} we get the following two

$$\frac{\partial \tau_{it}}{\partial \phi_{it}}|_{n<1} = -\frac{\delta\omega n^2\phi^{n-1}_{it}Q'_{it}(Q_{it})^{n-1}\int_0^{1+\tau^e_{it+1}}\overline{\phi}_{it+1}Q_{it+1}d\tau_{it+1} + (\omega-1)Q_{it}}{M'_{it}} > 0 \tag{27}$$

$$\frac{d\tau_{it}}{d\phi_{it}}|_{n<1} = -\frac{\delta\omega n^2\phi^{n-1}_{it}Q'_{it}(Q_{it})^{n-1}\int_0^{1+\tau^e_{it+1}}\overline{\phi}_{it+1}Q_{it+1}d\tau_{it+1} + (\omega-1)Q_{it}}{M'_{it} + \delta\omega n(n-1)\phi^n_{it}(Q'_{it})^2(Q_{it})^{n-2}\int_0^{1+\tau^e_{it+1}}\overline{\phi}_{it+1}Q_{it+1}d\tau_{it+1} + (\omega-1)\phi_{it}Q'_{it}} \gtrless 0 \tag{28}$$

For $\overline{\phi}_{it+1}$ we get

$$\frac{d\tau_{it}}{d\overline{\phi}_{it+1}}|_{n<1} = -\frac{\delta\omega n\phi^n_{it}Q'_{it}(Q_{it}(\tau_{it}))^{n-1}\int_0^{1+\tau^e_{it+1}}Q_{it+1}d\tau_{it+1}}{M'_{it} + \delta\omega n(n-1)\phi^n_{it}(Q'_{it})^2(Q_{it})^{n-2}\int_0^{1+\tau^e_{it+1}}\overline{\phi}_{it+1}Q_{it+1}d\tau_{it+1} + (\omega-1)\phi_{it}Q'_{it}} \gtrless 0 \tag{29}$$

Equations (28) and (29) are positive if $\omega < 2 - \frac{D'_i(.)}{\phi_{it}Q'_i(.)} - \delta\omega n(n-1)\phi^{n-1}_{it}Q'_{it}(Q_{it})^{n-2}\int_0^{1+\tau^e_{it+1}}\overline{\phi}_{it+1}Q_{it+1}d\tau_{it+1}$, and negative otherwise. Note that $n<1$ so the third term on the right-hand-side of the parameter condition for ω is also positive making it less restrictive than the earlier two cases.

Equation (16)

The actual tariff in period $t+1$ is similar to the one in equation (11) but now its terms are not dependent on X_{it}, because in the second period the LBD process is realized to be an obsolete perception:

$$\tau_{it+1} = (\omega-1)\frac{\phi_{it+1}Q_{it+1}(\tau_{it+1})/M_{it+1}(\tau_{it+1})}{\varepsilon_{it+1}(\tau_{it+1})} \tag{30}$$

Now, by using equation (12) and equation (30), we can express the difference in the tariff rates between the two periods as

$$\begin{aligned}\Delta\tau_{it+1} &= \tau_{it+1}|_{n=0} - \tau_{it}|_{n>0} = -\frac{1}{M_i'}(\omega-1)(\phi_{it+1}Q_{it+1} - \phi_{it}Q_{it}) \\ &+\frac{1}{M_i'}\delta\omega n\phi_{it}^{n}Q_{it}'(Q_{it})^{n-1}\int_0^{1+\tau_{it+1}^{e}}\overline{\phi}_{it+1}Q_{it+1}d\tau_{it+1}\end{aligned} \tag{31}$$

Equation (16) is then obtained by implicitly differentiating equation (31) with respect to $\Delta\phi_{it+1}$.

$$\frac{d\Delta\tau_{it+1}}{d\Delta\phi_{it+1}}|_{\tau_{it},\phi_{it}} = -\frac{(\omega-1)Q_{it+1}(\tau_{it+1})}{M_i'(.)+(\omega-1)\phi_{it+1}Q_{it+1}'(\tau_{it+1})}\left.\begin{matrix} >0 \text{ if } \eta_i < (1+1/\tau_i) \\ <0 \text{ if } \eta_i > (1+1/\tau_i)\end{matrix}\right\} \tag{32}$$

A.2 Import Demand Elasticity

In the theory section, I define the import demand elasticity, ε_i, as $-M_i'p_i^w/M_i$ but traditionally and in the empirical data it is evaluated at domestic prices, not world prices. I take this into account in obtaining the elasticity adjusted inverse import penetration ratio, given the fact that output value is evaluated at domestic prices, whereas imports are evaluated at world prices. Therefore,

$$\frac{X_i/M_i}{\varepsilon_i} = -\frac{X_i/M_i}{M_i'p_i^w/M_i} = -\frac{p_iX_i/p_i^wM_i}{M_i'p_i/M_i} \tag{33}$$

Based on Kee, Nicita and Olarreaga (2004), I obtain the import demand elasticity for sector i as

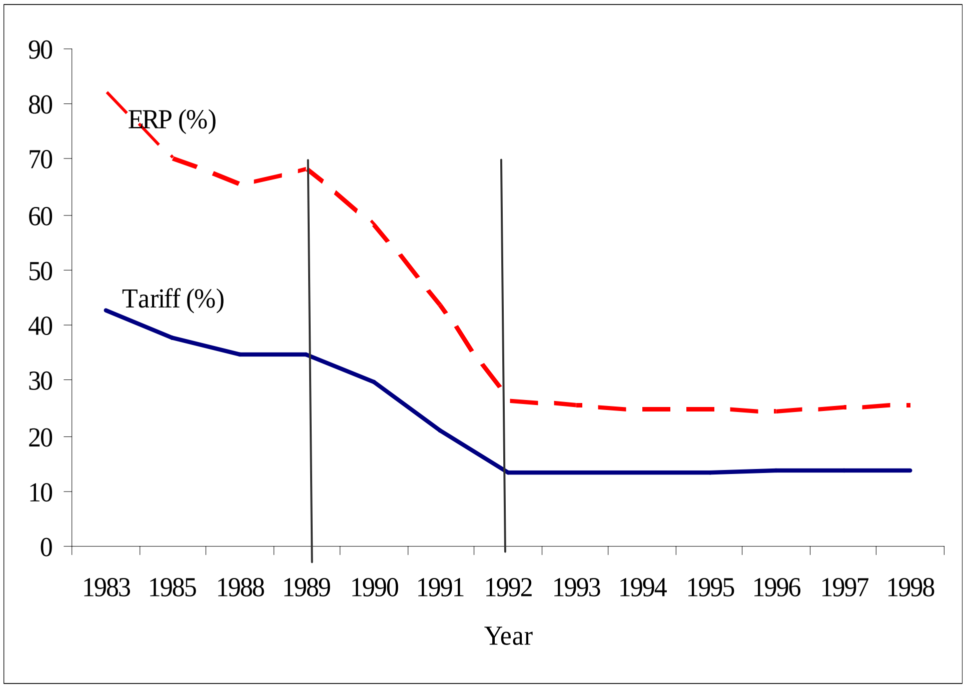
$$\varepsilon_{it} = \frac{a_i}{s_{it}} + s_{it} - 1 \tag{34}$$

where s_{it} is the negative of the imports to GDP ratio and a_i is an estimated structural price parameter from a GDP function in Kee, et al. (2004).

A.3 Variable Definitions and Sources

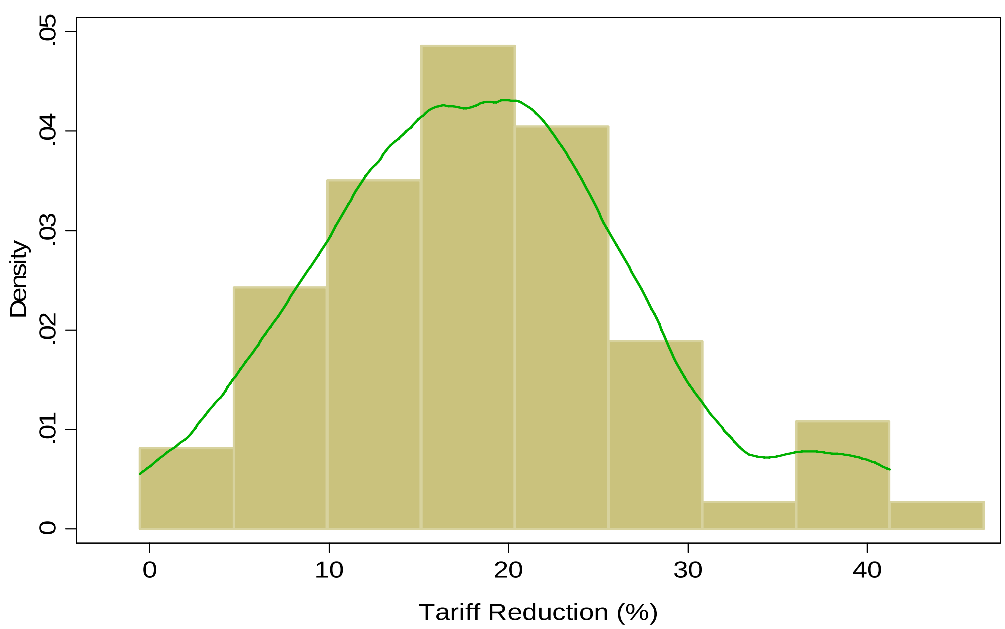
Name	Definition	Source
τ_{it}	Advalorem tariff rate (%): Obtained at the 8-digit product level ("Nabandina" code) and aggregated to the 4-digit ISIC level by simple averaging	National Planning Department (DNP), Colombia
τ_{it}^{eff}	Effective rate of protection (%): Obtained at the 8-digit product level ("Nabandina" code) and aggregated to the 4-digit ISIC level by simple averaging	National Planning Department (DNP), Colombia
X_{it}	Output values in 1000 USD at the 4-digit ISIC level	UNIDO, Industrial Statistics Database
M_{it}	Import values in 1000 USD at the 4-digit ISIC level	COMTRADE, United Nations Statistics Division
ε_{it}	Import demand elasticity at the 3-digit ISIC level: obtained by combining import and GDP data with estimated structural price parameters.	Structural estimates (Kee et al. 2004), GDP (World Development Indicators, World Bank), imports (COMTRADE).
A_{it}	Total factor productivity (TFP): Obtained at the firm level by estimating production function residuals with a 2SLS model. Aggregated from the firm to the 4-digit ISIC level by using production shares as weights.	Eslava, Haltiwanger, Kugler and Kugler (2004)
$Capital\ Share_{it}$	Capital stock series obtained at the firm level using fixed assets, gross investment, "observed" depreciation rates, and a gross capital formation deflator. The ratio of capital stock to output is then aggregated to the 4-digit ISIC level by using firms' production shares as weights.	Eslava, Haltiwanger, Kugler and Kugler (2004)
$Materials\ Prices_{it}$	Obtained at the firm level using Tornqvist indices which are aggregated to the 4-digit ISIC level by using firms' production shares as weights.	Eslava, Haltiwanger, Kugler and Kugler (2004)
$Scale_{it}$	The ratio of total value added to the number of firms in a given 4-digit ISIC sector.	Eslava, Haltiwanger, Kugler and Kugler (2004)
$Upstream\ TFP_{it}$	Using the input-output tables at the 3-digit ISIC level, I exclude the inputs being used from the own sector, and obtain the upstream measure based on a combination of TFPs of the remaining input sectors as weighted by their share of usage.	Input-output tables (Nicita and Olarreaga 2001, originally from Global Trade Analysis Project), TFP (Eslava, et al. 2004).
D_i^{org}	Indicator variable equal to one if a 3-digit sector shows an indication of organization based on labor union activity or membership in economic associations/groups	Quintero (2006)
$LABSH_{it}$	The ratio of labor at the 4-digit ISIC sector level to total labor in Colombia	Eslava, Haltiwanger, Kugler and Kugler (2004)
$GDP\ Growth_t$	The annual percentage change in the GDP (constant 2000 US dollars)	World Development Indicators (WDI), World Bank
$Inflation_t$	Annual percentage change in the GDP deflator	World Development Indicators (WDI), World Bank

FIGURE 1. Average Tariffs and Effective Rates of Protection in Colombia 1983-1998



Sources: DNP and author's own calculations.

FIGURE 2. Histogram of the Percentage Decline in Tariffs between Their 1983-1989 Average and 1992-1998 Average at the 4-digit ISIC Level



Note: Tariff reduction is calculated as [log(1+avg$\tau_{i1983\text{-}1988}$)-log(1+avg$\tau_{i1992\text{-}1998}$)]*100
Sources: DNP and author's own calculations.

TABLE 1. Spearman's Rank Correlation Matrix for Tariffs over Time

	τ_{1983}	τ_{1985}	τ_{1988}	τ_{1989}	τ_{1990}	τ_{1991}	τ_{1992}	τ_{1993}	τ_{1994}	τ_{1995}	τ_{1996}	τ_{1997}
τ_{1985}	0.928	1										
τ_{1988}	0.861	0.953	1									
τ_{1989}	0.862	0.954	0.997	1								
τ_{1990}	0.806	0.925	0.952	0.954	1							
τ_{1991}	0.733	0.823	0.830	0.847	0.893	1						
τ_{1992}	0.688	0.764	0.771	0.768	0.795	0.866	1					
τ_{1993}	0.700	0.761	0.773	0.770	0.779	0.861	0.993	1				
τ_{1994}	0.688	0.763	0.777	0.778	0.797	0.876	0.997	0.991	1			
τ_{1995}	0.720	0.794	0.801	0.807	0.828	0.898	0.986	0.978	0.989	1		
τ_{1996}	0.727	0.847	0.874	0.882	0.897	0.857	0.885	0.874	0.887	0.922	1	
τ_{1997}	0.732	0.852	0.882	0.882	0.907	0.859	0.887	0.876	0.889	0.925	0.999	1
τ_{1998}	0.724	0.845	0.874	0.882	0.899	0.856	0.888	0.877	0.889	0.924	0.998	0.999

Note: τ_t stands for the 4-digit ISIC level advalorem tariff rate in year *t*.

TABLE 2. Summary Statistics for Tariffs over Time

	Observations	Mean	Standard Deviation	Coefficient of Variation	Minimum	Maximum
τ_{1983}	78	0.427	0.221	0.516	0.090	1.15
τ_{1985}	78	0.377	0.148	0.393	0.059	0.70
τ_{1988}	78	0.347	0.155	0.448	0.070	0.70
τ_{1989}	75	0.344	0.155	0.451	0.070	0.70
τ_{1990}	76	0.297	0.115	0.386	0.070	0.50
τ_{1991}	74	0.211	0.093	0.442	0.016	0.35
τ_{1992}	68	0.134	0.045	0.334	0.050	0.20
τ_{1993}	65	0.135	0.046	0.343	0.050	0.20
τ_{1994}	63	0.136	0.045	0.333	0.050	0.20
τ_{1995}	65	0.136	0.046	0.334	0.043	0.20
τ_{1996}	67	0.139	0.046	0.333	0.048	0.20
τ_{1997}	66	0.140	0.046	0.332	0.048	0.20
τ_{1998}	67	0.140	0.045	0.323	0.048	0.20

Note: τ_t stands for the 4-digit ISIC level advalorem tariff rate in year *t*.

TABLE 3. Correlation Matrix for Tariffs and Productivity over Time

	$\log\tau_{1983}$	$\log\tau_{1985}$	$\log\tau_{1988}$	$\log\tau_{1989}$	$\log\tau_{1990}$	$\log\tau_{1991}$	$\log\tau_{1992}$	$\log\tau_{1993}$	$\log\tau_{1994}$	$\log\tau_{1995}$	$\log\tau_{1996}$	$\log\tau_{1997}$	$\log\tau_{1998}$
$\log A_{1983}$	**-0.187**	-0.153	-0.064	-0.071	-0.049	0.003	-0.100	-0.117	-0.073	-0.088	-0.007	-0.014	0.007
$\log A_{1985}$	-0.233**	**-0.179**	-0.108	-0.116	-0.104	-0.076	-0.085	-0.097	-0.076	-0.108	0.012	0.008	0.028
$\log A_{1988}$	-0.220*	-0.237**	**-0.269****	-0.211*	-0.249**	-0.198*	-0.144	-0.151	-0.158	-0.226*	-0.241**	-0.244**	-0.239*
$\log A_{1989}$	-0.208*	-0.217*	-0.197*	**-0.199***	-0.233**	-0.206*	-0.141	-0.125	-0.129	-0.196	-0.219*	-0.223*	-0.220*
$\log A_{1990}$	-0.223*	-0.241**	-0.235**	-0.229**	**-0.260****	-0.253**	-0.138	-0.135	-0.146	-0.198	-0.233*	-0.231*	-0.233*
$\log A_{1991}$	-0.177	-0.195*	-0.238**	-0.224*	-0.234**	**-0.268****	-0.127	-0.124	-0.132	-0.203	-0.205	-0.204	-0.208*
$\log A_{1992}$	-0.145	-0.156	-0.158	-0.162	-0.163	-0.251**	**-0.039**	-0.054	-0.074	-0.199	-0.113	-0.112	-0.115
$\log A_{1993}$	-0.170	-0.193	-0.200	-0.204	-0.229*	-0.265**	-0.161	**-0.148**	-0.163	-0.201	-0.257**	-0.258**	-0.260**
$\log A_{1994}$	-0.195	-0.251**	-0.263**	-0.262**	-0.308**	-0.362***	-0.185	-0.161	**-0.175**	-0.218*	-0.275**	-0.271**	-0.277**
$\log A_{1995}$	-0.179	-0.225*	-0.239*	-0.238*	-0.269**	-0.346***	-0.154	-0.132	-0.147	**-0.227***	-0.225*	-0.225*	-0.227*
$\log A_{1996}$	-0.180	-0.217*	-0.245**	-0.245**	-0.257**	-0.297**	-0.141	-0.125	-0.144	-0.213*	**-0.241****	-0.244**	-0.247**
$\log A_{1997}$	-0.167	-0.194	-0.226*	-0.231*	-0.241*	-0.294**	-0.146	-0.126	-0.143	-0.220*	-0.225*	**-0.232***	-0.234*
$\log A_{1998}$	-0.206*	-0.229*	-0.272**	-0.271**	-0.294**	-0.337***	-0.223*	-0.205	-0.219*	-0.265**	-0.302**	-0.307**	**-0.311****

Notes: $\log\tau_t$ stands for the natural logarithm of the 4-digit ISIC level advalorem tariff rate in year *t*, and $\log A_t$ stands for the natural logarithm of the 4-digit ISIC level total factor productivity in year *t*

TABLE 4. Summary Statistics for All the Variables in the Estimations

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
$\log\tau_{it}$	920	-1.646	0.641	-4.107	0.140
$\log\tau_{it}^{eff}$	887	-1.128	0.884	-4.294	1.556
$\log A_{it}$	920	1.508	0.590	0.091	4.097
$\log(Q_{it}/M_{it}\varepsilon_{it})$	920	0.248	2.376	-6.139	11.470
$\log \textit{Capital Share}_{it}$	920	-1.765	0.777	-5.549	0.598
$\log \textit{Materials Prices}_{it}$	920	-0.067	0.267	-1.488	0.929
$\log \textit{Scale}_{it}$	920	11.726	1.489	5.595	16.264
$\log \textit{Upstream TFP}_{it}$	920	1.523	0.140	1.206	2.096
D_i^{org}	920	0.845	0.363	0.000	1.000
$\log \textit{LABSH}_{it}$	920	-4.879	1.284	-10.870	-2.083
$\textit{GDP Growth}_t$	920	3.445	1.621	0.570	6.042
$\textit{Inflation}_t$	920	24.037	7.158	14.773	45.357

Notes: The tariff data are not available for 1982, 1986, and 1987 so the starting sample includes 1310 4-digit ISIC tariff lines. After taking into account the missing output figures (in year 1984), the sample reduces to 1004 observations. Finally, considering the other missing observations for the right-hand-side variables, the sample further declines to around 920 observations for the main estimations.

TABLE 5. The Effect of Productivity on Tariffs and Effective Rates of Protection

	Dependent Variable: $log\tau_{it}$				*Dependent Variable: $log\tau_{it}^{eff}$*			
	OLS[a]	IV-GMM			OLS[a]	IV-GMM		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$logA_{it}$	0.066*	0.271***	0.386***	0.551***	0.078*	0.261***	0.190**	0.198**
	(0.034)	(0.066)	(0.097)	(0.116)	(0.044)	(0.070)	(0.091)	(0.096)
$\log(Q_{it}/M_{it}\varepsilon_{it})$	0.120***	0.390***	0.606***	0.864***	0.140***	0.333***	0.270*	0.303**
($\beta_2 > 0$)	(0.022)	(0.073)	(0.142)	(0.173)	(0.018)	(0.084)	(0.142)	(0.139)
$UNILIB_t$	-0.741***	-0.533***			-0.752***	-0.598***		
($\beta_3 < 0$)	(0.030)	(0.065)			(0.029)	(0.079)		
REF_t			-0.492***				-0.500***	
($\rho_1 < 0$)			(0.035)				(0.045)	
$POSTREF_t$			-0.306**				-0.715***	
($\rho_2 < 0$)			(0.154)				(0.165)	
Constant	-1.161***	-1.536***	-1.884***	-2.186***	0.186**	-0.415**	-0.207	-0.066
	(0.141)	(0.190)	(0.269)	(0.296)	(0.088)	(0.198)	(0.363)	(0.342)
Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	No	No	No	Yes	No	No	No	Yes
Observations	920	920	920	920	887	887	887	887
Chi^2-test p-val for all μ_i=0 [b]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chi^2-test p-val for all θ_t=0 [c]	n/a	n/a	n/a	0.000	n/a	n/a	n/a	0.000
Hansen's J p-val [d]	n/a	0.144	0.180	0.933	n/a	0.004	0.001	0.000

Notes: (1) Robust standard errors are in parentheses. (2) *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. (3) Predicted sign for the coefficient of each regressor is indicated in parentheses below the regressor. (4) IV-GMM obtained from an instrumental variable efficient generalized method of moments estimator. (5) List of the instruments (all in logs): Capital share, materials prices (deviated from the producer price index), measure of scale economies (value added/number of firms), and TFP of upstream sectors.

[a] OLS obtained from Cragg's heteroskedastic ordinary least squares estimator. The R^2 for columns (1) and (5) are 0.820 and 0.809, respectively.

[b] "Chi^2-test p-val for all μ_i=0" shows the probability value for the Chi-squared test of "H_0: All μ_i (industry fixed effects) are jointly insignificant."

[c] "Chi^2-test p-val for all θ_t =0" shows the probability value for the Chi-squared test of "H_0: All θ_t (year effects) are jointly insignificant."

[d] "Hansen's J p-val" shows the probability value for the Hansen-Sargan test of overidentifying restrictions of "H_0: Excluded instruments are uncorrelated with the error term and correctly excluded from the estimated equation."

TABLE 6. The Effect of *Past* Productivity on Tariffs and Effective Rates of Protection

	IV-GMM - *Dependent Variable:* $log\tau_{it}$				IV-GMM - *Dependent Variable:* $log\tau_{it}^{eff}$		
	(1)	(2)	(3)		(4)	(5)	(6)
$\log A_{it-1}$	0.142*	0.129*	0.193***		0.254**	0.241**	0.332***
	(0.083)	(0.078)	(0.067)		(0.100)	(0.107)	(0.102)
$\log(Q_{it}/M_{it}\varepsilon_{it})$	0.564***	0.498***	0.359***		0.599***	0.531***	0.470***
($\beta_2 > 0$)	(0.110)	(0.118)	(0.103)		(0.121)	(0.155)	(0.147)
$UNILIB_t$	-0.349***				-0.354***		
($\beta_3 < 0$)	(0.097)				(0.111)		
REF_t		-0.463***				-0.439***	
($\rho_1 < 0$)		(0.044)				(0.054)	
$POSTREF_t$		-0.374***				-0.399**	
($\rho_2 < 0$)		(0.137)				(0.183)	
Constant	-2.126***	-1.989***	-1.624***		-0.896***	-0.753*	-0.527
	(0.271)	(0.291)	(0.242)		(0.304)	(0.393)	(0.355)
Industry Effects	Yes	Yes	Yes		Yes	Yes	Yes
Year Effects	No	No	Yes		No	No	Yes
Observations	909	909	909		877	877	877
Chi^2-test p-val for all μ_i=0 [a]	0.000	0.000	0.000		0.000	0.000	0.000
Chi^2-test p-val for all θ_t=0 [b]	n/a	n/a	0.000		n/a	n/a	0.000
Hansen's J p-val [c]	0.757	0.166	0.117		0.489	0.240	0.093

Notes: (1) Robust standard errors are in parentheses. (2) *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. (3) Predicted sign for the coefficient of each regressor is indicated in parentheses below the regressor (4) IV-GMM obtained from an instrumental variable efficient generalized method of moments estimator. (5) List of the instruments (all in logs): Capital share, materials prices (deviated from the producer price index), one period lag of the measure of scale economies (value added/number of firms), and one period lag of TFP of upstream sectors.

[a] "Chi^2-test p-val for all μ_i=0" shows the probability value for the Chi-squared test of "H_0: All μ_i (industry fixed effects) are jointly insignificant."

[b] "Chi^2-test p-val for all θ_t =0" shows the probability value for the Chi-squared test of "H_0: All θ_t (year effects) are jointly insignificant."

[c] "Hansen's J p-val" shows the probability value for the Hansen-Sargan test of overidentifying restrictions of "H_0: Excluded instruments are uncorrelated with the error term and correctly excluded from the estimated equation."

TABLE 7. First Stage Regressions

	Specification: $\log\tau_{it}$		*Specification:* $\log\tau_{it}^{eff}$	
	$\log A_{it}$	$\log(Q_{it}/M_{it}\varepsilon_{it})$	$\log A_{it}$	$\log(Q_{it}/M_{it}\varepsilon_{it})$
$UNILIB_t$	0.097***	-0.686***	0.100***	-0.713***
	(0.020)	(0.067)	(0.020)	(0.0672)
log*Capital Share*$_{it}$	-0.334***	-0.109	-0.331***	-0.124*
	(0.020)	(0.069)	(0.021)	(0.071)
log*Materials Prices*$_{it}$	0.008	0.432***	0.012	0.427***
	(0.047)	(0.159)	(0.048)	(0.163)
log*Scale*$_{it}$	0.187***	-0.139***	0.186***	-0.135***
	(0.013)	(0.046)	(0.014)	(0.047)
log*Upstream TFP*$_{it}$	0.435***	-0.901***	0.430***	-0.891***
	(0.088)	(0.303)	(0.090)	(0.308)
Constant	-2.164***	4.531***	-2.140***	4.454***
	(0.205)	(0.703)	(0.208)	(0.713)
Industry Effects	Yes	Yes	Yes	Yes
Observations	920	920	887	887
R^2	0.858	0.897	0.855	0.895
Adjusted R^2	0.844	0.887	0.841	0.884
Shea's partial R^2	0.434	0.033	0.437	0.033
F statistic	59.96	86.67	59.37	85.57
Wald test p-val [a]	0.000	0.000	0.000	0.000
F statistic for excluded instruments	160.72	7.02	152.44	6.73
Wald test p-val excluded instruments [b]	0.000	0.000	0.000	0.000

Notes: (1) Robust standard errors are in parentheses. (2) *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. (3) The first stages are presented for $\log\tau_{it}$ specification in column 2 of Table 5 and $\log\tau_{it}^{eff}$ specification in column 6 of Table 5. (4) The dependent variables in the first stages are indicated in the header row of each column.

[a] "Wald test p-val" shows the probability value for the F-test of "H_0: The instruments are jointly insignificant."

[b] "Wald test p-val excluded instruments" shows the probability value for the F-test of "H_0: The excluded instruments are jointly insignificant."

TABLE 8. Robustness Analysis

	Specification: $\log\tau_{it}$						*Specification: $\log\tau_{it}^{eff}$*					
	IV-GMM	IV-GMM	IV-GMM[a]	IV-TOBIT	FD2SLS	FD2SLS	IV-GMM	IV-GMM	IV-GMM[a]	IV-TOBIT	FD2SLS	FD2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\log A_{it}$	0.271***	0.214***	0.150**	0.145***			0.261***	0.292***	0.158**	0.215***		
	(0.066)	(0.064)	(0.064)	(0.054)			(0.070)	(0.069)	(0.077)	(0.065)		
$\log(Q_{it}/M_{it}\varepsilon_{it})$	0.390***	0.269***	0.244***	0.325***			0.333***	0.258***	0.214***	0.322***		
	(0.073)	(0.061)	(0.047)	(0.075)			(0.084)	(0.068)	(0.059)	(0.090)		
$\Delta\log A_{it}$					0.645**	0.705***					0.842*	0.734***
					(0.288)	(0.209)					(0.448)	(0.260)
$\Delta\log(Q_{it}/M_{it}\varepsilon_{it})$					0.645**	0.701***					0.902**	0.779***
					(0.272)	(0.216)					(0.438)	(0.286)
$UNILIB_t$	-0.533***	-0.621***	-0.619***	-0.557***			-0.598***	-0.634***	-0.675***	-0.595***		
	(0.065)	(0.059)	(0.056)	(0.068)			(0.079)	(0.065)	(0.071)	(0.084)		
$\Delta UNILIB_t$					-0.095**						-0.114	
					(0.045)						(0.076)	
REF_t						-0.205***						-0.190***
						(0.048)						(0.072)
D_i^{org}	-0.393						0.939**					
	(0.345)						(0.422)					
$\log LABSH_{it}$		-0.120						0.021				
		(0.114)						(0.062)				
Constant	-1.143***	-2.109***	-1.223***	-1.696***	-0.007	0.054***	-1.354***	-0.255	-0.021	-0.338	0.024	0.055***
	(0.222)	(0.423)	(0.141)	(0.191)	(0.036)	(0.016)	(0.312)	(0.367)	(0.139)	(0.226)	(0.061)	(0.020)
Ind. Effects	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No
Observations	920	920	690	920	674	674	887	887	677	887	650	650
Exogeneity p [b]	0.144	0.000	0.605	0.174	0.017	0.173	0.003	0.002	0.026	0.187	0.179	0.380

Notes: (1) Robust standard errors are in parentheses. (2) *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. (3) IV-GMM obtained from an instrumental variable efficient generalized method of moments estimator. (4) IV-TOBIT obtained from an instrumental variable Newey's two-step tobit estimator with left censoring. (5) FD2SLS obtained from an instrumental variable efficient generalized method of moments estimator in first-differences clustered at the 4-digit ISIC level. In columns 5 and 6, the dependent variable is $\Delta\log\tau_{it}$ and in columns 11 and 12, it is $\Delta\log\tau_{it}^{eff}$.
(6) List of the instruments (all in logs): Capital share, materials prices (deviated from the producer price index), measure of scale economies (value added/number of firms), and TFP of upstream sectors.

[a] In columns 3 and 9, an alternative time-invariant elasticity of import demand estimate is used (obtained from Nicita and Olarreaga 2007) which I corrected for errors-in-variables following Gawande and Bandyopadhyay (2000).

[b] "Exogeneity p" shows the p-values for the Hansen Sargan test except in columns 4 and 10 where it shows the p-values for the Wald test of exogeneity.

TABLE 9. Tariffs / Effective Rates of Protection and Productivity

	Specification: $\log\tau_{it}$				*Specification: $\log\tau_{it}^{eff}$*			
	OLS	3SLS			OLS	3SLS		
	$\log A_{it}$	$\log A_{it}$	$\log\tau_{it}$	$\log(Q_{it}/M_{it}\varepsilon_{it})$	$\log A_{it}$	$\log A_{it}$	$\log\tau_{it}^{eff}$	$\log(Q_{it}/M_{it}\varepsilon_{it})$
$\log\tau_{it}$ ($\log\tau_{it}^{eff}$)	-0.066***	-0.067***		1.869***	-0.059***	-0.069***		1.513***
	(0.022)	(0.021)		(0.107)	(0.022)	(0.020)		(0.080)
$\log A_{it}$			0.198***				0.320***	
			(0.057)				(0.074)	
$\log(Q_{it}/M_{it}\varepsilon_{it})$			0.362***				0.468***	
			(0.096)				(0.127)	
log*Capital Share*				1.038***				1.074***
				(0.082)				(0.082)
log*Materials Prices*				1.041***				0.966***
				(0.241)				(0.239)
log*Scale*	0.246***	0.245***			0.247***	0.247***		
	(0.029)	(0.014)			(0.029)	(0.014)		
log*Upstream TFP*	0.260***	0.257***			0.265***	0.247**		
	(0.092)	(0.096)			(0.092)	(0.098)		
Constant	-1.842***	-1.828***	-1.612***	5.227***	-1.767***	-1.729***	-0.545*	3.906***
	(0.321)	(0.219)	(0.229)	(0.239)	(0.332)	(0.229)	(0.302)	(0.183)
Industry Effects	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Year Effects	No	No	Yes	No	No	No	Yes	No
Observations	920	920	920	920	887	887	887	887
R^2	0.812	0.812	0.770	0.338	0.809	0.809	0.756	0.363
Wald test p-val [a]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: (1) Robust standard errors are in parentheses. (2) *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. (3) The dependent variables are indicated in the header row of each column. (4) The $\log A_{it}$ equations include GDP growth and inflation as controls which are not reported here.

[a] "Wald test p-val" shows the probability value for the Chi-squared-test of "H_0: The regressors are jointly insignificant."

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