THE INTERACTION OF TARIFF BARRIERS AND IMPORT DUTIES AS A MEASURE OF TARIFF PROTECTION IN GROWTH EMPIRICS

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Abstract
The ratio of import duties to total imports is a widely used measure of tariff policy in growth empirics; as a matter of fact, however, no clear and robust relationship emerges from the statistical analysis linking such an index to growth. This failure may be explained by precise theoretical reasons. Total import duties are generated by different fiscal instruments, such as “ad valorem” and specific tariffs, which (according to the insights of R&D based endogenous growth models) exert completely different growth effects. As a consequence, the theoretical form of the relationship between import duties and growth critically changes according to which kind of tariff barrier is mainly raised and no clear empirical link may be expected to emerge in a cross-section of economies characterized by sufficiently heterogeneous tariff policies.

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1. Introduction

The ratio of import duties to imports is often used as an index of trade restrictiveness in empirical papers dealing with the growth impact of trade policy; such a ratio is generally considered as a measure of the “average tariff” implicit in the overall tariff regime of a given country.¹ Yet, the evidence emerging from these papers is quite controversial and contradictory. To mention just some of them, Harrison and Hanson (1999) find a negative (but not robust) relationship between imports duties and economic growth, whereas in Yanikkaya (2003) the estimated link is positive. Interestingly, according to the findings of Clemens and Williamson (2004), who analyze a very long period (1869-1999), the sign of the empirical relationship has changed over time: higher tariffs (that is, import duties) were generally associated to higher growth rates in the sub-period which ends with World War II, but to lower growth afterwards.

This paper discusses some theoretical reasons, which suggest that import duties may be an inappropriate index of tariff policy (at least in the analysis focusing on the link between trade policy and growth) and consequently may help explain the contradictory results provided by the empirical research². The basic idea developed in the paper is that total import duties are generated by different tariff instruments, ad valorem and specific tariffs, which, according to the insights of R&D endogenous growth models, exert qualitatively different effects upon economic growth; as a consequence the empirical relationship between import duties and growth may completely change according to which kind of tariff instrument is mainly used.

The paper is organized as follows. The next section briefly recalls the model presented by Baldwin and Forslid (1999) to study the links between different kinds of import tariffs and growth.³ Then, this formalization is exploited to analyze the link between import duties and growth; it will be shown that such a link is ambiguous, in the sense that its shape completely changes according to which kind of tariff barrier is privileged by policymakers. This result is then confirmed by numerical simulations of the theoretical model. Finally, the paper discusses some implications for further theoretical and empirical research.

¹ “The average tariff rate is measured here as the share of customs revenues (import duties only) in total import values” (Clemens and Williamson, 2004)
² For a more general critique of the empirical analyses of the growth implications of trade policy see Harrison and Hanson (1999) and Rodriguez and Rodrik (2000).
³ Baldwin and Forslid (1999), draw on and extend previous results obtained by Rivera-Batiz and Romer, (1991). Rivera-Batiz and Romer (1991) study an open-economy version of the model in Romer (1990), where they analyze the growth effects of “ad valorem” tariffs. I have followed here the Baldwin and Forslid (1999) formalization as their assumptions make it a bit simpler the extension of the model.
2. The theoretical relationship between tariffs and growth in a R&D based endogenous growth model

In the two-country model by Baldwin and Forslid (1999) a single consumption good \( Z \) is produced in each economy according to a Cobb-Douglas technology: 
\[
Z = a_i Q_z \alpha L_Z^{1-\alpha},
\]
where \( 0 < \alpha < 1 \), \( a_i \) is a parameter, \( L_Z \) represents the labour force engaged in the production of \( Z \) and \( Q_z \) is a CES function (with elasticity \( \sigma \)) of a set of \( K+K^* \) differentiated intermediate goods (asterisks are referred to foreign variables and thus \( K^* \) is the number of imported varieties). The consumption good \( Z \) is sold in a perfectly competitive market at a price \( p_z \) and is not subject to trade restrictions. The intermediate goods are produced using only labour (with a unitary input-output requirement) and supplied in a Dixit-Stiglitz monopolistic competition setting; their imports may be subject to an "ad valorem tariff rate \( t \) as well as to a specific tariff \( T \). The total labour supply \( L \) in each country is exogenous and constant over time. The wage rate \( w \) is assumed to be the numeraire (\( w=1 \)).

Consumers maximize a logarithmic utility function; utility deriving from future consumption is discounted at a rate \( \rho \). The model assumes perfect symmetry, so that the parameters describing technology, preferences and trade policy take on the same values in the two economies; \textit{inter alia} this implies: 
\[
t = t^*; T = T^*; K = K^*.
\]
A part of the total labour supply is engaged in a R&D sector, which has the task to discover new varieties of intermediate goods; the availability of new varieties makes output per worker to growth in the \( Z \) sector and represents thus the growth mechanism of the economy. The productivity of the R&D sector is such that 
\[
1/\delta(K+K^*) \text{ labour units are necessary to introduce a new variety, where} \delta \text{ is a positive parameter.}
\]
It follows from the preceding assumptions that the prices of domestically produced intermediates is 
\[
p = \sigma/(\sigma -1), \text{ while imported varieties bear a price} \quad p^* = p(1+T)\tau \quad (\text{where:} \quad \tau \equiv 1+t).
\]
For each monopolist in the intermediate goods sector the share \( S^* \) of total sales coming from the market abroad is equal to 
\[
S^* = \phi/(1+\phi), \text{ where} \quad \phi \equiv (p^*/p)^{1-\sigma} \text{ may be considered as a measure of trade openness (it is equal to 1 when no tariffs are raised, but goes to 0 when tariffs are prohibitive). In each economy} S^* \text{ represents also the share of expenditures in imported intermediate goods on total expenditures intermediates (this is equal to} \alpha E, \text{ with} \quad E \equiv p_z Z \text{ denoting total national expenditures in the consumption good). The profit margin related to the sales of each variety of intermediates is}
\]
\[\text{Actually this parameter does not appear in the formalization by Baldwin and Forslid (1999) (or, in other words, it is implicitly set equal to 1 in their paper); I introduce it, as this is useful in order to generate realistic values of the growth rate in the numerical solution of the model. The notation of this parameter is the same as in Rivera-Batiz and Romer (1991), who also present a numerical solution of their model, while Baldwin and Forslid (1999) do not.}\]
given by $M = \sigma^{-1}[1 - S^* + (S^*/\tau)]$ and operating profits are $\pi = \alpha ME/K$. $M$ is a U-shaped function of the “ad valorem” tariff rate; this happens because a marginal (and symmetric) increase in the “ad valorem” tariff rate exerts contrasting effects on domestic and foreign sales (the former increase, whereas the latter decrease), so that the net impact on profits is a priori ambiguous and depends on the initial tariff level.\(^5\)

Total imports are $I_M = \alpha ES^*$, while import duties are equal to: $R = \alpha \eta E$, where:

$$\eta = S^*(\tau - 1) + \left[\frac{T/p(1 + T)}{\tau}\right]$$

The term $\eta$ and consequently import duties $R$ are non-monotonic bell-shaped functions of both “ad valorem” and specific tariffs (the reason of this nonlinearity is the usual one: a marginal increase in tariffs increases also import duties at low protection levels, as price effects overcome quantity effects; however, at high protection levels the reduction in imported quantities is so strong that changes in import duties are negatively associated to changes in tariff protection).

Finally, it may be shown that in the long run equilibrium the number of intermediate goods grows at a rate $g$:

$$g = \frac{2\alpha \delta ML - \rho[1 - \alpha(\eta + M)]}{(1 - \alpha \eta')}$$

while per-capita income grows at a rate proportional to $g$, that is at a rate $g\alpha/(\sigma - 1)$.

How is $g$ influenced by trade policy? The growth rate depends on tariffs through the non-monotonic terms $M$ and $\eta$ (note that $g$ is an increasing function of both). It may be easily shown that, when imports are subject only to “ad valorem” tariffs, the relationship between $g$ and the tariff rate is U-shaped, exactly as it is the link between $M$ and $\tau$; this happens because the effects of changes in $\tau$ on the profit margin function $M$ are quantitatively more relevant than those (of opposite sign) on the function $\eta$. On the contrary, when only specific tariff are raised, $M$ is a constant (equal to $\sigma^{-1}$) and $g$ is a inverted-U function of the tariff rate, as a consequence of the functional link between $T$ and $\eta$.\(^6\)

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\(^5\) Baldwin and Forslid (1999) explain this result as follows. A marginal (and symmetric) increase in $\tau$ increases the market share in the domestic market and decreases the market share abroad; it is easy to show that \textit{coeteris paribus} the net outcome of this “sales effect” is always an increase in the overall profit margin. However, for a given distribution of total sales between the two markets, an increase in $\tau$ implies also a decrease in the profit margin on exports (evaluated at consumer prices); this a “pro-competitive” effect. The sales effect prevails when the initial level of $\tau$ is already high, so that sales on foreign markets are quantitatively limited: in such a case a further marginal increase in the “ad valorem” tariff rate exerts a limited downward influence on the profit margin. However, when the initial tariff rate is sufficiently low (and foreign markets are quantitatively important), an increase in $\tau$ provokes a wider reduction of the profit margin on foreign sales and the pro-competitive effects may be larger than the sales effect.

\(^6\) The economic intuition is that import duties are supposed to be redistributed to economic agents, who in turn use them to finance not only consumption expenditures but also R&D investments.
Thus the functional form between the tariff rate and growth is generally nonlinear but changes completely according to which kind of tariff instruments is raised. It seems also worth noting that these nonlinear non-monotonic effects, which are drawn in Fig.1 for a given set of parameters \((\alpha = 0.33; \sigma = 8; \delta L = 10; \rho = 0.05)\), are not the result of particular ad hoc assumptions, but emerge in the open-economy version of standard models of endogenous technological change like those developed by Romer (1990) and Grossman and Helpman (1991).7

Fig.2 provides a three-dimensional plot of the tariff-growth rate link, when both tariffs are raised, under the same parameters. Actually, when both tariffs are raised, the functional link between the tariff rates \(t\) and \(T\) on the one hand and the functions \(M\) and \(\eta\) on the other hand becomes a bit more complex, and as a consequence the interaction of tariffs affects the tariff-growth link as well. In particular it may be shown (this is discussed in Appendix 1) that, when \(T\) is positive, \(M\) is always a U-shaped function of the “ad valorem” tariff rate, but \(\eta\) may be a bell-shaped as well as a monotonically decreasing function of \(t\), depending on the value of the specific tariff rate (intuitively the reason is that, when the specific tariff rate is sufficiently high, a marginal increase in \(t\) may induce a stronger effect on quantities than on prices even when the initial “ad valorem tariff rate is relatively low). Also, when \(t\) is positive, the function \(M\) is increasing in \(T\) (because an increase in the specific tariff rate increases in this case the share of domestic sales on total sales, which in turns increases the profit margin), while \(\eta\) may be a bell-shaped as well as a monotonically decreasing function of the specific tariff (for the same reasons as above). Finally, when either \(t\) or \(T\) tend to \(\infty\) (autarky), \(M\) and \(\eta\) tend respectively to \(1/\sigma\) and 0 independently on the value of the other tariff rate; in such a case \(g\) assumes a constant value.

3. What does the model imply about the link between import duties and growth?

The model presented in the preceding section has at least two important empirical implications. The first one, outlined by Baldwin and Forslid (1999) themselves, is that the regressions of many empirical papers dealing with the growth effects of trade policy do not take into account the possibility of nonlinear effects and thus probably suffer from a serious misspecification bias. The

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7 It is worth recalling that nonlinear (but qualitatively different) links between tariffs and growth emerge also in other growth models (see for ex. Rodriguez and Rodrik, 2000). The assumptions on parameters \(\alpha\) and \(\rho\) made here reflect those in Rivera-Batiz and Romer (1991); the hypothesis about \(\sigma\) (this parameter does not appear in Rivera-Batiz and Romer, 1991, because they work with a simpler production function) is compatible with the available (and actually quite heterogeneous) estimates of the elasticity of demand in monopolistic competition models (see Erkel-Rousse and Mirza, 2002). Finally, \(\delta L\) has been calibrated in such a way to generate a realistic value of the income growth rate, as done in Rivera-Batiz and Romer (1991).
focus here, however, is on a second and different issue not explicitly discussed by Baldwin and Forslid (1999) but implied by their model: given that the growth effects of different trade policy instruments such as “ad valorem” and specific tariffs are qualitatively different, aggregate measures of trade policy based on some average of the different import taxes may present relevant drawbacks in growth empirics and lead to misleading conclusions, if these indexes mask the heterogeneity (in terms of growth impact) of the single trade barriers upon which they are built.

To make it clear this point, let us analyze the relationship between growth and a widely used index of trade policy such as the ratio of import duties to total imports (note that actually data on aggregate import tax revenue are generally more easily available to researchers than the detailed data on applied tariff rates distinguished by kind of tariff instrument). The model analyzed above implies that the import duties ratio (denoted by $W$) is equal to:

$$W = \frac{R}{I_m} = \frac{(\tau - 1)}{\tau} + \frac{T}{p(1+T)\tau}$$

It is easy to check that $W$, differently from $R$, is a monotonically increasing function of both the tariff rates $\tau$ and $T$. To understand why this (desirable) property is not enough to make $W$ a satisfactory aggregate measure of the tariff barriers, let us consider how its link with growth changes under different assumptions about the structure of the import tariff regime.

Let us begin with the situations in which only a single tariff barrier is raised on import flows. If imports were subject to only “ad valorem” or alternatively specific tariffs, $W$ would be equal respectively to $(\tau - 1)/\tau$ or $T/p(1+T)$; in these two extreme cases the functional link between $g$ and $W$ would have the same form as that between $g$ and $t$ or $T$ (according to which kind of tariff is raised) and measuring the level tariff barriers through $W$ (rather than $t$ or $T$) would produce a negligible loss of information. Thus the simple comparison of these two polar cases shows that the relationship between growth and import duties is ambiguous and cannot be predicted without more detailed information about the structure of the applied tariff rates.

The picture becomes more complex, when imports may be subject to both kinds of tariff barriers

In this intermediate scenario the actual form of the link between $W$ and $g$ intuitively depends on the relative weight of the two kinds of tariffs. As these produce heterogeneous growth effects, a clear relationship between import duties and growth may be expected to emerge only when a kind of tariff has a much larger weight than the other one (in the sense that the average applied tariff rates

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8 Results similar to those presented below emerge also when the tariff policy index is represented not by the import duties ratio, but by a simple average of the “ad valorem” tariff rate and the “ad valorem” equivalent (AVE) of the specific tariff rate.
of the former is much larger than that of the latter), while no clear empirical link between $W$ and $g$ should be discernible if the magnitude of the applied rates is sufficiently similar.

In order to shed light on this point, I present a numerical exercise with the aim to reproduce a sample of data and to analyze how the relationship between $W$ and $g$ changes under different assumptions about the structure tariff policy, allowing for both kinds of tariff instruments to be applied. Fig.3a-3c report the link between import duties and growth obtained after randomly generating a set of pairs of tariff rates $(t, T)$. These “observations” have been generated by independent uniform distributions (with more than 1,000 draws) in such a way that the tariff rates lie in a range where the minimum value is always 0 but the maximum may vary according to the kind of tariff. In particular the scatter diagram in Fig.3a reports the relationship between the import duties ratio and growth derived from a set of pairs $(t, T)$ in which the “ad valorem” tariff rates $t$ lie in the interval 0 - 0.4 (with an average value of $t$ equal to 0.2) and the range of the specific tariffs is 0 - 0.05 (with an average value of $T$ equal to 0.025), while Fig.3b reports exactly the opposite case. Obviously, the assumptions of different intervals for each kind of tariff is only a simple way to artificially reproduce cases in which the two tax instruments have a largely different weight in terms of average tariff rate and tax revenue. In other words, Fig.3a and Fig.3b have to be understood as examples of cases in which policymakers rely mostly on a single kind of tariff barrier and it is thus not surprising that the observations tend to be aligned along the similar nonlinear (U-shaped or alternatively bell-shaped) curves, which describe the direct link between growth and the tariff rates $(t$ or $T$).

If the randomly generated data reported in Fig.3a and Fig.3b represented real cross-country observations, $W$ would probably be a satisfactory index of tariff policy in the sense that the import duties ratio could be explain a large part of the variance in growth rates, provided nonlinearities are taken into account in the regression specification. Fig.3a and Fig.3b report the results of a regression in which the nonlinear effects are modelled simply through the introduction of a quadratic term (the nonlinear fit is represented by the continuous line). The values of $R^2$ are relatively high (between 0.45 and 0.76); moreover, the coefficients are statistically significant at conventional levels and have the expected sign, in the sense that they are coherent with a U-shaped relationship when import duties are mainly generated by “ad valorem” tariffs (Fig.3a), or alternatively with an inverted-U link if tariff protection relies mainly on specific tariffs.\(^9\)

In order to analyze what happens when there is not a privileged tariff instrument, Fig.3c reports the same scatter diagram derived by a set of pairs $(t, T)$ obtained by draws in which the values of the two tariff rates lie in the same range. In this case, which may be considered as representative of a

\(^9\) The standard errors have not been reported (in order to make the picture clearer) but are obviously available upon request.
scenario of a set countries with heterogeneous tariff policies, no clear link emerges between the import duties ratio and growth and the explanatory power of the polynomial regression model estimated above is drastically reduced and practically equal to zero ($R^2$ is less than 0.04), even though differences in tariff protection are the only source of variance in growth rates, while the fitted growth rate seems to take on a constant value.\textsuperscript{10} This is due to the fact that “ad valorem” and specific tariffs exert different and offsetting effects upon growth.

4. Conclusions and directions for future research

The theoretical and numerical results presented above may play a role in the solution of the empirical puzzle recalled in the introductory section. They suggest for example that the contradictory findings of Clemens and Williamson (2004) (defined a “tariff-growth paradox” by the authors themselves) might be due to the progressive move in the last century from specific to “ad valorem” tariffs; indeed, according to the R&D base endogenous growth model of Section 2, such a change would be enough to generate a reversal of the sign of the correlation between the import duties ratio and economic growth.\textsuperscript{11}

More generally the model implies that the correlation between growth and the import duties ratio will turn out to be contingent on the average tariff rate (as a consequence of nonlinear effects) and the kind of tariff barrier (as a consequence of the different functional relationship). In other terms it follows from the model that the marginal impact of a change in the import duties ratio upon growth cannot be predicted without detailed information on the structure of tariff policy. But even when detailed data are available, no systematic link should be expected to emerge between $W$ and growth in a sample of economies characterized by heterogeneous tariff policies. To sum up, the import duties ratio presents relevant drawbacks if used as an aggregate index of tariff policy; empirical results based on this index should be interpreted with great caution and it should note be used as an aggregate measure of tariff policy, when more detailed data are available. A greater effort should be made to collect detailed data on applied tariff rates by kind of tariff instrument and to make them available to researchers. Theoretical developments appear necessary as well; for example we know

\textsuperscript{10} I have checked that higher degree polynomials would not substantially improve the quality of the fit. Note that the coefficients of Fig.3c are statistically significant (again, standard errors are available upon request), but their magnitude is such that changes in $W$ produce practically no change in $g$.

\textsuperscript{11} Clemens and Williamson note that at the international level “ad valorem” tariffs have progressively replaced unit taxes as the privileged trade policy instrument. They mention the estimates reported in Irwin (1998) according to which for ex. in the USA the share of imports subject to specific or mixed tariffs was about 2/3 in the period between the Civil War and the Great Depression, but only about ½ in the 1960s. Clemens and Williamson (2004) note also that the relative weight of the two kinds of tariffs may significantly change in periods of high inflation or deflation even without explicit changes in the tariff regime, as (contrary to what happens with “ad valorem” tariffs) price variations are not directly reflected in variations of tax revenue, when imports are subject to specific tariffs.
very little about how the simple R&D based endogenous growth model recalled above works, when the simplifying assumptions of symmetry are removed. Also, we wonder whether an aggregate measure of tariff policy exists, such that the drawbacks highlighted here may be overcome.

REFERENCES


Fig. 1 Tariffs and growth

The figure illustrates the relationship between tariff rates and income growth. Two types of tariffs are considered:

- **Ad valorem (t>0, T=0)**: The black line represents the ad valorem tariff rate, which increases income growth initially before declining.
- **Specific (t=0, T>0)**: The gray line depicts the specific tariff rate, showing a different pattern compared to the ad valorem tariff.
Fig. 2 Ad valorem tariffs, specific tariffs and growth
Fig. 3a Import duties ratio and growth 
\((t_{\text{max}}=0.4, T_{\text{max}}=0.05)\)

\[ y = 0.028x^2 - 0.0107x + 0.0369 \]
\[ R^2 = 0.7649 \]

Fig. 3b Import duties ratio and growth 
\((t_{\text{max}}=0.05, T_{\text{max}}=0.4)\)

\[ y = -0.0141x^2 + 0.0055x + 0.0363 \]
\[ R^2 = 0.4537 \]

Fig. 3c Import duties ratio and growth 
\((t_{\text{max}}=0.4, T_{\text{max}}=0.4)\)

\[ y = 0.003x^2 - 0.0011x + 0.0365 \]
\[ R^2 = 0.0368 \]
I report here some key derivatives in order to analyze the growth effects of tariff barriers when both kinds of tariffs are raised on imports.

a) The first derivative of $M$ respect to $\tau$ is:

$$\frac{\partial M}{\partial \tau} = \sigma^{-1} \left( \frac{S^*}{\tau^2} \right) \left[ (\sigma - 1)(\tau - 1)(1 - S^*) - 1 \right]$$

The derivative $(\partial M/\partial \tau)$ is zero at some critical finite value $\tau_c$, which is the solution of the nonlinear function: $F[\sigma; \tau(\sigma)] = [(\sigma - 1)(\tau - 1)(1 - S) - 1] = 0$. From the implicit function theorem we can see that this critical value $\tau_c$ is decreasing in $\sigma$. The derivative is surely positive for values higher than $\tau_c$, thus $M$ is U-shaped in the “ad valorem” tariff rate independently on $T$.

b) The first derivative of $\eta$ respect to $\tau$:

$$\frac{\partial \eta}{\partial \tau} = \left( \tau \mu^{-1} + \tau \right)^{-2} \left\{ (1 + \sigma \mu^{-1}) \left[ 1 - \frac{T}{p(1+T)} \right] - (\sigma - 1)\mu^{-1} \right\}$$

This derivative can be negative for every value of $\tau$ under a sufficiently high positive value of $T$ (when specific tariffs are already sufficiently high, a marginal increase in the “ad valorem” tariff rate may reduce import duties, even if the initial tariff rate is zero).

c) The first derivative of $M$ respect to $T$ is:

$$\frac{\partial M}{\partial T} = \frac{\sigma - 1}{\sigma} \left( \tau - 1 \right) S^* (1 - S^*) [(1 + T)\tau]^{-1}$$

which is positive as long as $\tau > 1$.

d) The first derivative of $\eta$ respect to $T$ is:

$$\frac{\partial \eta}{\partial T} = \left[ \tau (1 + \mu^{-1}) \right]^{-2} \left[ \frac{\tau}{p(1+T)} \right] \left[ \frac{1 - (\sigma - 1)T}{(1+T) \mu} - \sigma (\tau - 1) \right] + \frac{1}{(1+T)}$$

By inspection $(\partial \eta/\partial T)$ could be negative when evaluated at any value of $T$, for a sufficiently high value “ad valorem” tariff rate $\tau$. 

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