E. J. OURSO COLLEGE OF BUSINESS
Department of Economics

DEPARTMENT OF ECONOMICS WORKING PAPER SERIES

When is Trade Protection Good for Growth?

Jenny Minier
University of Kentucky

Bulent Unel
Louisiana State University

Working Paper 2009-09
http://www.bus.lsu.edu/economics/papers/pap09_09.pdf

Department of Economics
Louisiana State University
Baton Rouge, LA 70803-6306
http://www.bus.lsu.edu/economics/

When is Trade Protection Good for Growth?*

Jenny Minier
University of Kentucky

Bulent Unel
Louisiana State University

This Version: October 19, 2009

Abstract

The empirical relationship between trade protection and economic growth is surprisingly fragile, as shown in a number of other papers. After demonstrating this empirical sensitivity, we address one possible explanation for these findings: that the relationship is nonlinear. Following the endogenous growth literature, we test for the possibility that the relationship between trade barriers and growth is contingent on measures of comparative advantage. The findings suggest that these nonlinearities do in fact exist — in particular, the correlation between tariffs and growth is strongest and positive for capital-abundant countries — and are robust to the choice of control variables.

JEL Codes: F13, F43, O19, and O24

Keywords: Comparative advantage, economic growth, tariffs, total factor productivity.

---

*J. Minier (corresponding author), University of Kentucky, 335 Gatton Building, Lexington KY 40506-0034; e-mail: jminier@uky.edu. B. Unel: Department of Economics, Louisiana State University; Baton Rouge, LA 70803-6302; e-mail: bunel@lsu.edu. We would like to thank Chris Bollinger, Josh Ederington, Rob Reed, Andreas Savvides, Athanasios Vamvakidis, and participants at the 2008 Southern Growth Conference at the SEA meetings for helpful comments and discussion. Any errors are ours alone.

1 Introduction

There is a widespread belief, among economists, policy makers, and the general public, that more open economies grow faster than closed economies. Many international organizations emphasize this correlation; for example, the World Trade Organization proclaims on its website that it has "helped to create a strong and prosperous trading system contributing to unprecedented growth."[1] Among economists, Anne Krueger is representative in stating that, "trade liberalization offers the only known way to escape from the ever-slowing growth rates of developing countries."[2]

However, the empirical evidence is mixed. Supporting the positive correlation between openness and growth, Sachs and Warner (1995) demonstrate a strong, positive relationship between growth and a variable they construct to indicate an "open" economy. Using an instrumental variables approach based on geographical factors, Frankel and Romer (1999) find a large, positive (although not strongly statistically significant) correlation between trade openness and growth. Lee, Ricci, and Rigobon (2004) use "identification through heteroskedasticity" and find that openness has a positive, but small, effect on growth, controlling for the positive effect of growth on openness. Edwards (1998) shows a consistently positive relationship between growth and nine measures of openness. Harrison (1996) finds a positive relationship between a number of measures of openness and growth in a panel study of developing countries. In a sample of 81 industrialized and developing countries, Lee (1993) finds that trade distortions (tariffs and black market premia) lower both the growth rate and the investment rate.

Anecdotal evidence, such as the frequently cited comparison between the outward-oriented, fast-growing East Asian economies and the stagnating Latin American economies focused on import substitution strategies, also supports the belief that trade protection and growth are negatively related. However, a number of papers have cast doubts on the strength

[1] "The WTO in Brief," http://www.wto.org

[2] Krueger (1998).

of this relationship. In their classic sensitivity analysis of growth regressions, Levine and Renelt (1992) fail to find a robust relationship between growth and any trade or international price-distortion variable (although a positive correlation between the trade-output ratio and the investment ratio is one of their few robust findings). Vamvakidis (2002) finds no evidence of a positive relationship between trade openness and growth prior to the 1970s. In a study of ten countries over the period 1860-1913, O'Rourke (2000) finds that tariffs and growth were positively correlated. Similarly, Clemens and Williamson (2002) demonstrate that the high tariff barriers of pre-1914 Latin America were accompanied by rapid subsequent growth, while low tariffs and low growth prevailed in Asia during this period. Greenaway, Morgan, and Wright (1997) find a negative relationship between trade liberalization and economic growth in a panel study of 76 developing countries in the post-1985 period.[3]

Papers such as Harrison and Hanson (1999), Clemens and Williamson (2004), and Rodríguez and Rodrik (2000) demonstrate directly a lack of robustness in the relationship between trade policy and growth. Harrison and Hanson (1999) demonstrate the fragility of previous empirical results that rely on the Sachs and Warner (1995) index of openness, concluding that the difficulty in establishing a link between trade reform and growth is due largely to the lack of good objective data on trade policies across countries. Clemens and Williamson (2004) demonstrate a positive relationship between tariffs and growth prior to World War II; the relationship reverses during the post-War period. Rodríguez and Rodrik (2000) conduct an extensive critical review of some of the more widely cited papers—primarily Sachs and Warner (1995), Dollar (1992), Ben-David (1993), and Edwards (1998)—that have shown an empirical link between less trade protection and faster growth. They conclude that this link has not been convincingly demonstrated, and they remain "skeptical that there is a strong negative relationship in the data between trade barriers and economic

[3]With a similar panel data set, Greenaway, Morgan, and Wright (1998) find evidence of a positive relationship between liberalization/openness and growth, although the relationship is fairly modest and occurs with a lag; this further illustrates the point that the relationship is not robust.

growth, at least for levels of trade restrictions observed in practice" (p. 316).

In general, the empirical growth literature has downplayed trade variables in its work. For example, the variable most closely related to trade in Barro (1991) is the purchasing-power-adjusted investment deflator. Levine and Renelt (1992) cite trade policy as an example of a variable frequently omitted entirely from growth studies. Many empirical growth studies have included measures of terms-of-trade shocks to proxy for changing international conditions, following Barro and Lee (1994), although these shocks are not intended as proxies for openness.

Perhaps it is not surprising that empirical work has failed to identify a strong negative correlation between trade protection and growth, because theory does not generally provide an unambiguously negative relationship. For example, in the neoclassical Solow model, trade policy has no effect on steady-state growth. In addition, in endogenous growth models in open-economy frameworks, the relationship between trade policy and growth is frequently a contingent one; in Grossman and Helpman (1990) and Matsuyama (1992), among others, the effect of trade barriers on growth depends on the pattern of comparative advantage across countries.

Despite this, empirical examinations of the relationship between trade and growth have until recently allowed only for linear relationships. A notable exception is DeJong and Ripoll (2006), who investigate the relationship between tariffs and growth and its contingency on income levels. In a panel of 60 countries, they find that the negative correlation between tariffs and growth holds only among higher-income countries. A second exception is Papageorgiou (2002), in which trade openness is a threshold variable separating countries into distinct growth regimes; however, openness is not directly included in his growth specification, but operates indirectly, as a separating variable.

The focus of this paper is somewhat different. First, much of the theoretical motivation for considering nonlinearities is based on the idea that trade protection may direct factors of production into more or less productive sectors, depending on the pattern of comparative advantage. We investigate the effect on total factor productivity (TFP) growth as well as the effect on growth in income per worker.

Unlike DeJong and Ripoll (2006), who focus primarily on income as the source of the contingent relationship, we follow the endogenous growth literature and also allow for the possibility that the relationship between trade barriers and growth is contingent on the pattern of comparative advantage.[4] Relying on the pattern of comparative advantage, rather than income, as the source of differences in the correlation between growth and tariffs is closer to the predictions of endogenous growth models, although we do include income levels in some specifications as an additional control variable. We also examine a longer time period (a 20-year cross-section, instead of 5-year dynamic panels). Since the pattern of comparative advantage is unlikely to change much over short periods of time (but the timing of business cycle fluctuations across countries may be affected by the pattern of comparative advantage), we think that examining the correlation over a longer period of time is more likely to uncover how the relationship between trade protection and growth varies according to comparative advantage. Unlike Papageorgiou (2002), we focus on the potential nonlinearity of the *direct* relationship between trade barriers and growth. We find evidence that such nonlinearities do, in fact, exist, in that the relationship between tariffs and growth is contingent on the pattern of comparative advantage, and this effect is stronger than the contingency based directly on income. Our results provide some support for the predictions of Grossman and Helpman (1990), in that tariffs are positively correlated with growth in countries with a comparative advantage in manufactured goods.

Our paper is also related to Nunn and Trefler (2009), who examine the relationship between the skill bias of a country's tariff structure (the degree to which tariffs favor the country's skill-intensive industries) and economic growth. We focus on how the correlation between overall tariffs and growth varies across countries with different patterns of comparative advantage.

[4]As a robustness check, DeJong and Ripoll (2006) do include the ratio of the tariff on primary goods to the tariff on manufactured goods, although they do not include measures of the composition of trade itself.

In what follows, section 2 demonstrates the sensitivity of conventional regressions of tariff protection on growth. In section 3, we discuss theoretical reasons to suspect a nonlinear relationship between trade protection and growth. Section 4 presents the empirical analysis allowing for nonlinearities in the relationship between tariff protection and growth, and we conclude in section 5.

2 Trade Barriers and Growth: Conventional Empirics

The question addressed in this paper is whether countries with lower barriers to international trade have higher growth rates, controlling for other country characteristics. Despite the conventional wisdom that such a correlation exists, it does not generally appear in the data. To illustrate this, Table 1 presents conventional growth regressions over the period 1980-2000 that include a measure of average tariffs (import duties as a percentage of import value) as an explanatory variable. In Regression 1, the coefficient on tariffs (averaged over the period 1975-90) is positive but not statistically significant; in Regression 2, a tariff squared term is included. Although the magnitude of the standard errors suggests that one should not put too much weight on the point estimates themselves, the estimates indicate that the correlation between tariffs and growth is negative until tariffs (as a percentage of import value) reach a level of approximately 12% (this includes 49 observations, or 54% of the sample); at higher values of tariffs, the correlation is positive. However, as in Regression 1, both the linear and the squared term are statistically insignificant. These results are not atypical, as simple measures of tariff barriers rarely enter significantly into standard growth regressions.

Because of such statistically insignificant results, many researchers have concluded that average tariffs, despite being an obvious and direct measure of trade restrictions, are an inappropriate measure of trade policy. For example, it is well known that simple calculations of (import-weighted) average tariffs tend to underestimate the "protectiveness" of trade policy, since import volume tends to be lower in industries with high tariffs. In response,

Table 1: Standard Growth Regressions

	(1)	(2)
τ	0.074 (0.032)**	0.084 (0.078)
τ^2		-0.030 (0.203)
$\ln y_0$	-0.006 (0.003)*	-0.005 (0.003)*
$\ln h_0$	0.000 (0.010)	0.000 (0.010)
Inv/GDP	0.124 (0.037)***	0.124 (0.037)***
Pop growth	-1.056 (0.256)***	-1.066 (0.270)***
Openness	0.004 (0.004)	0.004 (0.004)
constant	0.048 (0.033)	0.048 (0.035)
Adj. R^2	0.296	0.288

Notes: There are 94 observations and the dependent variable is the average annual growth rate of GDP per worker between 1980 and 2000. τ is the average tariff rate over 1975-90, $\ln y_0$ is log GDP per worker in 1980, and $\ln h_0$ is the log average human capital in 1980. Inv/GDP, pop growth, and openness cover the period 1975-90. Heteroskedasticity-consistent standard errors appear in parentheses. *** indicates statistical significance at 99%; ** at 95%; and * at 90%. See Appendix A for data definitions and sources.

many researchers have constructed other measures of trade policy. Perhaps the most influential has been the "openness" measure used in Sachs and Warner (1995), which classifies a country as "open" if it meets all five of the following criteria: (a) average tariffs below 40%; (b) average non-tariff barriers on capital and intermediate goods below 40%; (c) average black market premium below 20%; (d) no export marketing board; and (e) not a socialist economy. However, in their critique of this literature, Rodríguez and Rodrik (2000) find no reason to discard average tariffs as a useful measure of trade policy, pointing out that no paper documents a serious bias in tariffs as a measure of trade policy, or establishes that an alternative measure performs better. In addition, less direct measures of openness have the disadvantage of conflating measures of trade restrictions with additional variables (such as the extent of free markets or financial liberalization) that are not necessarily related to trade policy but are correlated with growth. We find the Rodríguez and Rodrik (2000) argument that average tariffs are a reasonable measure of trade restrictiveness persuasive, and so use average tariffs as the measure of trade barriers in this paper.

3 Theoretical Background

A large body of work links openness to growth. Two centuries ago, Adam Smith observed that the specialization allowed by trade leads to increased productivity. Indeed, there is a standard presumption on the part of economists that lower trade restrictions will lead to increased incomes and higher growth. This is based primarily on the well-known result that in static models of trade, free trade is the first-best policy. Thus, most trade economists expect an unambiguous, negative relationship between trade barriers and long-run growth.

However, this presumption is incomplete. For example, if one assumes a standard Solow growth model with diminishing marginal returns and exogenous technological progress, then trade barriers have no effect on the steady-state rate of growth. It is true that episodes of trade liberalization, which increase a country's level of real GDP, can increase growth in the short run as the economy transitions to a new higher steady-state level of output (also see the empirical evidence presented in the introduction to this paper). However, even these positive short-run effects come with caveats as, in the presence of market failures or externalities, trade liberalization could also potentially reduce output, negatively affecting growth in the short-run. Thus, neither standard static welfare models nor conventional economic growth models provide an unambiguous prediction of a negative correlation between trade barriers and long-run growth.

This raises the question of whether such an unambiguous relationship can be found in the endogenous growth literature. Again, the answer is no. Specifically, in models of endogenous growth, where growth is generated through factor accumulation or endogenous technological change, the effect of trade barriers on growth is contingent on country characteristics. This contingent relationship can be illustrated by considering two standard citations: Grossman and Helpman (1990) and Matsuyama (1992). Both papers model the effects of trade on endogenous growth in a small country with no cross-border knowledge spillovers.[5]

[5] For empirical evidence on this, see Keller (2002), who finds that the benefits from technology spillovers decline with distance, and concludes that technology is substantially local. An implication, of course, is that technology depends more on domestic R&D than on global R&D.

Matsuyama (1992) presents an endogenous growth model in which a single factor of production, labor, is used to produce two goods: a primary good and a manufactured final good. Knowledge accumulation occurs in the manufacturing sector through learning-by-doing that is external to individual firms but internal to the manufacturing sector as a whole, so that innovation in the economy is a function of the size of the manufacturing industry. A direct implication of this framework is that trade, which reduces the size of the manufacturing sector in countries with a comparative advantage in primary goods production, could potentially reduce the rate of knowledge accumulation (and hence growth). In contrast, in countries with a comparative disadvantage in primary goods production, trade results in an expansion of the manufacturing sector as resources flow to the exporting side of the economy. Thus, countries that specialize in manufacturing will see a corresponding increase in the rate of knowledge accumulation, and therefore an increase in growth, due to trade.

Alternatively, Grossman and Helpman (1990) assume that technological innovation occurs not through learning-by-doing in a manufactured final good sector, but rather through research and development in a non-traded intermediate input sector. Specifically, Grossman and Helpman (1990) assume two factors of production, skilled and unskilled labor, which are used in three sectors: a primary goods sector, a manufacturing sector and a (non-traded) intermediate input sector. Human capital in this framework can be used to produce either in the manufacturing sector or to perform R&D in the intermediate input sector. As in Matsuyama (1992), trade causes resources to flow into the manufacturing sector in those countries which have a comparative disadvantage in primary goods production (i.e., the skilled-labor abundant countries). However, in contrast to Matsuyama (1992), this resource reallocation will reduce the rate of technological innovation as it pulls resources (i.e., skilled labor) out of the R&D sector. Likewise, trade increases the rate of R&D in countries that specialize in primary goods production as skilled labor is freed up to move to the intermediate input sector.

There are several lessons that can be drawn from the endogenous growth literature. First, as Grossman and Helpman (1990) and Matsuyama (1992) illustrate, small changes in the underlying assumptions of the model can result in drastically different conclusions. Thus, rather than attempting a precise structural estimation of any particular model, we follow the conventional growth literature by running reduced-form growth regressions to investigate possible correlations between tariff barriers and GDP growth.

Second, as can be seen in these two examples, the effects of trade barriers on growth depend crucially on how trade reallocates resources in the economy. However, the effect of trade on resource allocation also depends fundamentally on a country's particular pattern of comparative advantage. The direct implication of this is that one should look for a contingent relationship between trade barriers and growth when analyzing cross-country data. Thus, in Section 4, we examine whether the correlation between growth and tariffs varies depending on the levels of variables that proxy for a country's pattern of comparative advantage.

4 Empirical Setting and Results

Following Hall and Jones (1999), among others, we assume that output in country i is produced according to:

$$Y_i(t) = K_i(t)^{\alpha} \left[A_i(t)H_i(t)\right]^{1-\alpha}, \tag{1}$$

where K_i and H_i represent stocks of physical and human capital, and A_i is the level of total factor productivity (TFP). The stock of human capital is given by $H_i = h_i L_i$ where h_i is the average human capital per worker and L_i is the number of workers used in production.

The data on output (GDP) and the labor force are taken from Penn World Tables mark 6.1. Physical capital stocks are constructed by using the standard perpetual inventory method with a six percent depreciation rate. The average human capital per worker is given by $h_i = e^{\phi(E_i)}$, where E_i denotes years of schooling and $\phi(E)$ represents the efficiency of a unit of labor with E years of education. The data on average years of schooling for the population aged 25 and above are taken from Barro and Lee (2002); and following Klenow and Rodríguez-Clare (2005), we assume that $\phi(E_i) = 0.085E_i$ and $\alpha = 1/3$.[6] The appendix provides a more complete description of the data.

An obvious problem with investigating potential nonlinearities in the relationship between tariff barriers and growth is that the number of potential model specifications is nearly infinite while the available data are much more limited. Thus, in this paper, we concentrate on incorporating interaction terms into conventional growth regressions to allow the marginal effect of tariff barriers on growth to differ across countries. Based on the endogenous growth literature, this marginal effect should be different in countries with different patterns of comparative advantage. We extend the conventional growth regression literature by estimating the following specification:

$$g_i = \beta_\tau \tau_i + \beta_{\tau z} \tau_i \cdot \mathbf{Z}_i + \beta_x \mathbf{X}_i + \varepsilon_i, \tag{2}$$

where g_i denotes the average annual growth in GDP per worker over the period 1980–2000, τ_i is the average tariff rate over 1975–90, $\mathbf{Z}_i$ includes variables that proxy for country i's initial pattern of comparative advantage, and $\mathbf{X}_i$ is a set of country characteristics that we will introduce as we use them. Most control variables cover the period 1975–90;[7] initial values are measured in 1980.

We consider three variables that may affect the marginal correlation between tariffs and growth. First, the pattern of comparative advantage in a country is fundamentally a function of the relative abundance of various resources. Thus, we consider capital per worker and skill intensity as two potential Z variables. Skill intensity is measured by the fraction of the population that completed at least secondary school.[8] The assumption is

[6] Allowing the rate of return $\phi'(E)$ to diminish with years of schooling E, as in Hall and Jones (1999), does not have any significant effect on the results.

[7] We consider the period 1975–90 to partly control for endogeneity. However, our results are quite robust to using alternative periods (e.g., 1980–2000) for those control variables.

[8] Skill intensity can also be defined as the ratio of the country's skilled workers (those that completed at least secondary school) to unskilled workers (those with at most some secondary school). Because for a few advanced countries this alternative measure of skill intensity well exceeds 1, using the above measure

Table 2: Effect of Tariffs on Growth of GDP per Worker

Variables	(1)	(2)	(3)
τ	-0.152 (0.173)	-0.278 (0.164)*	-0.399 (0.177)**
$\tau \times skill_0$	-0.044 (0.383)	-0.129 (0.385)	-0.106 (0.338)
$\tau \times \ln k_0$	0.035 (0.020)*	0.042 (0.020)**	0.053 (0.021)**
$\tau \times pexp_0$	-0.129 (0.080)	-0.066 (0.085)	-0.041 (0.075)
$skill_0$	0.005 (0.019)	-0.014 (0.019)	-0.021 (0.020)
$\ln k_0$	-0.019 (0.007)***	-0.018 (0.006)***	-0.019 (0.005)***
$pexp_0$	-0.008 (0.008)	-0.003 (0.010)	-0.005 (0.010)
$\ln y_0$	0.008 (0.006)	0.002 (0.007)	-0.001 (0.006)
Inv/GDP	0.169 (0.037)***	0.113 (0.033)***	0.092 (0.037)***
$\ln h_0$	0.013 (0.019)	0.030 (0.022)	0.017 (0.021)
Pop growth	-1.057 (0.265)***	-0.875 (0.355)**	-0.495 (0.326)
Openness	0.005 (0.004)	0.008 (0.004)**	0.006 (0.005)
Geography	no	yes	yes
Governance	no	no	yes
Adjusted $\bar{R}^2$	0.465	0.557	0.593
$\beta_\tau + \sum \beta_{\tau z}$	0.091 (0.038)**	0.061 (0.041)	0.066 (0.037)*

Notes: There are 85 observations and the dependent variable is the growth in output per worker 1980–2000. Here x_0 represents 1980 value of variable x. Skill is measured as the fraction of population who completed at least secondary school. Numbers in parentheses are heteroskedasticity-consistent standard errors, and ***, **, and * represent statistical significance at the 99%, 95%, and 90% level respectively. The last row gives the marginal effect of tariffs evaluated at the means of skill (0.147), capital (9.641), and primary exports (0.668).

that countries endowed with different levels of resources will exhibit different patterns of comparative advantage, and thus have different marginal tariff effects. As a final proxy variable, we use the percentage of exports that are primary goods as a direct means of proxying for comparative advantage in primary, rather than manufactured, goods.

We present the results of this regression in Table 2. Regression 1 follows a traditional growth specification, including initial log output per worker, investment, human capital, average population growth rate, and openness (total trade/total output) as control variables.[9] The variables of interest, of course, are our measures of comparative advantage — capital, skill intensity, and primary exports — interacted with tariffs. Since interaction terms like

of skill intensity reduces the influence of these observations. However, our results are not sensitive to using the alternative measure of skill intensity.

[9]Excluding population growth rate and openness from the regressions does not significantly affect our results.

Table 3: Marginal Effects - Interaction Terms

Value	Marginal effect (s.e.)	p-value
min: lnk80=5.08	-0.174 (0.092)	0.063
Q25: lnk80=8.41	0.001 (0.039)	0.981
Q50: lnk80=9.75	0.071 (0.037)	0.059
Q75: lnk80=10.91	0.132 (0.050)	0.010
max: lnk80=11.95	0.187 (0.066)	0.006

Notes: Marginal effects are the calculated effect from Regression 3 of Table 2 of the combined linear and interaction terms, estimated at the values of capital per worker given in the first column (minimum, maximum, and quartiles), given that primary exports and skill are at their mean values (0.147 and 0.668 respectively). Standard errors appear in parentheses.

these can pick up the correlation between the dependent variable and the components of the interaction term, we also include skill, capital, and primary exports entered linearly.[10]

Regression 2 adds four geography variables from Sachs and Warner (1995), and Regression 3 includes these geography variables and six measures of the quality of governance from Kaufmann, Kraay, and Mastruzzi (2008) (see Appendix for their descriptions). In Regression 3, the most fully specified model, the coefficient on tariffs entered linearly is negative and statistically significant at the 5% level, while the marginal effect of tariffs on growth estimated at the means of skill intensity, capital per worker, and primary exports is positive and statistically significant at the 10% level. Interestingly, the coefficient estimate on the capital stock interacted with tariffs is positive and statistically significant, even with the capital stock entered linearly into the regression (the coefficient on the capital stock is also statistically significant).

Table 3 presents the marginal effects of tariffs on growth as the level of the capital stock varies, estimated from Regression 3 of Table 2. For computing the marginal effects as the capital stock varies, we assume that skill intensity and primary exports are at their mean values of 0.147 and 0.668 respectively. At higher levels of capital per worker, the correlation between average tariff rates and economic growth is positive and statistically significant. The correlation is positive and statistically significant for 46 of the 85 countries

[10]We present results including both the log of initial human capital and skill intensity. Results do not change significantly if we drop either human capital or skill intensity.

Table 4: Key Results including Income Interaction

Panel A: Coefficient estimates		
τ	-0.103 (0.286)	
$\tau \times K/Y$	0.078 (0.035)**	
$\tau \times \ln y_0$	0.006 (0.037)	
$\ln y_0$	-0.015 (0.007)**	
K/Y	-0.019 (0.004)***	
$\beta_\tau + \sum \beta_{\tau z}$	0.061 (0.037)*	
Panel B: Marginal effects		
	Marginal effect (s.e.)	p-value
min: K/Y=0.17	-0.059 (0.061)	0.342
Q25 K/Y=1.11	0.014 (0.040)	0.726
Q50 K/Y=1.54	0.047 (0.037)	0.200
Q75 K/Y=2.61	0.131 (0.052)	0.015
max K/Y=3.48	0.198 (0.077)	0.013

Notes: All other variables from Regression 3 of Table 2 are also included. Results do not differ significantly if we use $\ln(K/Y)$. Marginal effects are the calculated effect from the regression of the combined linear and interaction terms, estimated at the values of capital per worker given in the first column (minimum, maximum, and quartiles), given that primary exports, income per worker, and skill are at their mean values (0.147, 9.26, and 0.668 respectively). Standard errors appear in parentheses.

in the sample (54%). At low levels of capital per worker, the relationship becomes negative, although the estimated marginal effect is negative and statistically significant for only one country in the sample. To interpret the magnitude of these coefficient estimates, note that an increase of one standard deviation (0.081) of tariffs would translate into a predicted increase in growth of 0.00008 at the 25th percentile of capital per worker (log capital per worker equal to 8.41); at the 75th percentile (log capital per worker equal to 10.91), the prediction would be an increase of 0.011.[11]

Thus, the results of Table 2 indicate a clear relationship between a country's pattern of comparative advantage and the marginal effect of tariff barriers on growth. This relationship is consistent with the predictions of Grossman and Helpman (1990): tariff barriers are positively correlated with growth among capital-abundant countries.

Although capital intensity more closely parallels the spirit of the endogenous growth theories discussed in Section 3, we ran a supplementary regression including initial log in-

[11] In the sample, the mean (log) growth rate is 0.008, with a standard deviation of 0.019.

come per worker interacted with tariffs as a comparison to DeJong and Ripoll (2006). In panel data over five-year periods, DeJong and Ripoll (2006) found that the correlation between tariffs and growth was contingent on the level of income. Including an interaction term between income and tariffs does not change the quantitative or qualitative results of Table 2, as seen in Table 4; the coefficient estimate on the interaction term between tariffs and capital remains statistically significant and positive, while the coefficient on the income interaction term is not statistically significant. The regression in Table 4 includes the additional variables in Regression 3 of Table 2, but only the key results are presented.[12] Panel B of Table 4 includes the marginal effects when the income interaction term is included; these are analogous to the results in Table 3, and are qualitatively very similar. To summarize, the results in Table 4 suggest that the relationship between tariffs and growth depends more strongly on the level of capital than on the level of income.

It should be noted that a positive correlation between tariff barriers and growth does not necessarily imply that protection is optimal from a welfare standpoint. As Grossman and Helpman (1990) take pains to note, even though under certain circumstances trade may lead to a decline in the rate of innovation in their framework, a country can still benefit from engaging in trade. Specifically, in their model, international trade provides both the standard static efficiency gains from specialization as well as the opportunity to consume differentiated goods from abroad. Thus, the above results should not be treated as a positive statement about the desirability of trade protection, but rather as a normative statement about the observed correlation between tariff barriers and output growth.

Table 5 presents results when the dependent variable is TFP growth. The analysis based on TFP growth is important, because in the endogenous growth models discussed in Section 3, the mechanism through which tariffs affect growth is by reallocating resources to more (or less) productive sectors of the economy. According to Regression 3 in Table 5, the

[12] In Table 4, we use the capital-output ratio instead of capital per worker as our measure of capital, because the correlation between output per worker and capital per worker is over 0.95. Results in Table 2 are robust to using K/Y instead of capital per worker.

Table 5: Effect of Tariffs on TFP Growth

Variables	(1)	(2)	(3)
τ	-0.148 (0.220)	-0.281 (0.197)	-0.439 (0.216)**
$\tau \times skill_0$	-0.049 (0.458)	-0.168 (0.433)	-0.101 (0.406)
$\tau \times \ln k_0$	0.031 (0.024)	0.041 (0.023)*	0.056 (0.025)**
$\tau \times pexp_0$	-0.052 (0.096)	-0.010 (0.099)	0.010 (0.093)
$skill_0$	0.010 (0.020)	-0.013 (0.022)	-0.025 (0.025)
$\ln k_0$	-0.002 (0.006)	-0.006 (0.005)	-0.010 (0.005)*
$pexp_0$	-0.016 (0.01)*	-0.006 (0.011)	-0.005 (0.011)
$\ln tfp_0$	-0.013 (0.004)***	-0.014 (0.005)***	-0.015 (0.005)***
$\ln h_0$	0.011 (0.021)	0.028 (0.023)	0.015 (0.022)
Pop growth	-1.151 (0.310)***	-1.022 (0.396)**	-0.586 (0.398)
Openness	0.009 (0.003)***	0.011 (0.004)***	0.007 (0.005)
Geography	no	yes	yes
Governance	no	no	yes
Adjusted R^2	0.373	0.453	0.488
$\beta_\tau + \sum \beta_{\tau z}$	0.106 (0.046)**	0.080 (0.048)*	0.090 (0.044)*

Notes: There are 85 observations and the dependent variable is the TFP growth 1980–2000. Here x_0 represents 1980 value of variable x. Skill is measured as the fraction of population who completed at least secondary school. Numbers in parentheses are heteroskedasticity-consistent standard errors, and ***, **, and * represent statistical significance at the 99%, 95%, and 90% level respectively. The last row gives the marginal effect of tariffs evaluated at the means of skill (0.147), capital (9.64), and primary exports (0.668).

direct correlation between trade barriers and TFP growth is negative. However, the results in this regression also indicate that a country's pattern of comparative advantage affects the marginal effect of tariff barriers on TFP growth.

Table 6 gives marginal effects from the productivity regressions of tariffs on TFP growth, computed from Regression 3 of Table 5. Although the correlation again starts out negative at low levels of capital per worker, the negative correlation is never statistically significant. The correlation is positive and statistically significant for 57 of the 85 countries in the sample (67%).

5 Concluding Remarks

The motivation behind this paper lies in the confusing and contradictory literature concerning the impact of trade on growth. Despite years of study and numerous empirical attempts, researchers have been unable to establish an unambiguous negative correlation

Table 6: Marginal Effects - Interaction Terms

Value	Marginal effect (s.e.)	p-value
min: lnk80=5.08	-0.164 (0.117)	0.167
Q25: lnk80=8.41	0.022 (0.051)	0.672
Q50: lnk80=9.75	0.097 (0.045)	0.035
Q75: lnk80=10.91	0.161 (0.057)	0.006
max: lnk80=11.95	0.219 (0.076)	0.005

Notes: Marginal effects are the calculated effect from Regression 3 of Table 5 of the combined linear and interaction terms, estimated at the values of capital per worker given in the first column (minimum, maximum, and quartiles), given that primary exports and skill are at their mean values (0.147 and 0.668 respectively). Standard errors appear in parentheses.

between trade barriers and growth. In this paper, we argue that the reason for such disappointing results is that, theoretically, no such unambiguous relationship exists. Rather, as a quick study of the endogenous growth literature shows, the impact of trade barriers on growth depends on how trade reallocates resources through the economy. Thus, in both Grossman and Helpman (1990) and Matsuyama (1992), whether trade has a positive or negative impact depends on the pattern of comparative advantage in the country being analyzed.

By allowing the overall effect of trade barriers on growth to differ across countries based on the pattern of comparative advantage, we find that tariff barriers are most strongly and positively correlated with growth in capital-abundant countries. This contingent relationship is in line with the predictions of Grossman and Helpman (1990), and is shown to be robust to multiple alternative specifications.

Appendix: Data Description and Sources

The following set of 94 countries are used in our regressions reported in Table 1. The data on primary exports are not available for Botswana, Fiji, Gabon, Gambia, Indonesia, Israel, Lesotho, Nepal, and Zaire; consequently, we use the remaining 85 observations in estimating equation (2).

- *North Africa and Middle East:* Egypt, Iran, Israel, Jordan, Morocco, Syria, and Tunisia.
- *Sub-Saharan Africa:* Benin, Botswana, Burkina Faso, Cameroon, Comoros, Congo, Cote D'Ivoire, Ethiopia, Gabon, Gambia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali,

Table A.1: Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
y growth	0.008	0.019	-0.036	0.055
TFP growth	0.001	0.021	-0.054	0.053
tariffs (τ)	0.119	0.081	0.000	0.362
$skill_0$	0.147	0.156	0.003	0.769
$\ln k_0$	9.642	1.518	5.081	11.95
$pexp_0$	0.668	0.279	0.040	1.000
$\ln y_0$	9.259	1.039	6.849	10.74
Inv/GDP	0.164	0.078	0.020	0.450
$\ln h_0$	0.382	0.250	0.031	1.012
Pop growth	0.019	0.011	0.001	0.037
Openness	0.617	0.440	0.142	3.711

Notes: Descriptive statistics are for the sample of 85 countries in most of the empirical analysis, such as Tables 3 and 5.

Mauritius, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zaire, Zambia, and Zimbabwe.

- *America:* Barbados, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Paraguay, Trinidad and Tobago, Uruguay, USA, and Venezuela.
- *East & South Asia:* Bangladesh, India, Indonesia, Japan, and Korea, Malaysia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, and Thailand.
- *Europe:* Austria, Belgium, Cyprus, Denmark, Finland, France, Greece, Ireland, Iceland, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, and Turkey.
- *Oceania:* Australia, Fiji, New Zealand, and Papua New Guinea.

The following list defines variables used in the tables, indicates their sources, and explains how we construct them, where relevant. Table A.1 reports the descriptive statistics.

- y : GDP per worker. The data on output and labor supply are from Penn World Tables v.6.1 (PWT6.1). For Cyprus, Singapore, and Sierra Leone, output data are not available for the most recent years. Consequently, in calculating the average annual growth rates of these countries, the final is the most recent year for which the data is available.
- k : Capital per worker. Using the investment series data from PWT6.1, capital stock data are constructed with standard perpetual inventory method with 6 percent de-

preciation rate. Following Klenow and Rodríguez-Clare (1997), the initial level of the capital stock for each country is estimated as $K_{60}/Y_{60} = (I/Y)/(g + \delta + n)$, where I/Y is the average investment rate in physical capital over 1960–85, $g = 0.02$ (an estimate of the global average growth rate of Y/L), $\delta = 0.06$ is the depreciation rate, and n is the average growth rate of the country's labor supply. The results are not sensitive to using alternative initial estimates of capital stocks.

- h : Average human capital per worker, estimated as in the main text. The data on average years of schooling are taken from Barro and Lee (2002). Educational attainment data are not complete for Burkina Faso, Comoros, Cote D'Ivoire, Ethiopia, and Morocco. For these countries, we use data from countries with similar educational levels, following Nunn and Trefler (2009). For example, for Burkina Faso, we use the average of the educational attainment data from Ghana and Mali; for Morocco, we use the average of the data from Algeria and Tunisia.

- *TFP:* Given the data on output, capital, labor, and average human capital, we obtain TFP series directly from equation (1).

- τ : Import-weighted average tariff (i.e., tariffs/imports), 1975-90, from World Development Indicators.

- *skill:* Fraction of population aged 25 and above with at least a secondary degree, from Barro and Lee (2002).

- *pexp:* Primary Exports/Total Exports, from World Development Indicators.

- *Inv/GDP:* Investment/GDP, 1975–90, from PWT6.1.

- *Pop. Growth:* Average annual population growth rate, 1975–90, from PWT6.1.

- *Openness:* (Imports+Exports)/GDP, 1975–90, from PWT6.1.

- *Geography:* Four geographic variables from Sachs and Warner (1995). Three are dummy variables indicating that the country is in sub-Saharan Africa, Latin America, or is landlocked. The fourth measures the fraction of land located in a tropical climate.

- *Governance:* Six measures of the quality of governance from Kaufmann et al. (2008): voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. These six governance indicators are measured in units ranging from about -2.5 to 2.5, with higher values corresponding to better governance outcomes. Unfortunately, the data are available only for recent years (1996–2007); in our analysis, we use the average value of each indicator between 1996 and 2000.

Reference

Barro, R. J. (1991). Economic growth in a cross-section of countries. *Quarterly Journal of Economics*, *106*, 407–43.

Barro, R. J. and Lee, J.-W. (1994). Sources of economic growth. *Carnegie-Rochester Conference on Public Policy*, *40*, 1–46.

Barro, R. J. and Lee, J.-W. (2002). International data on educational attainment. Harvard University.

Ben-David, D. (1993). Equalizing exchange: trade liberalization and income convergence. *Quarterly Journal of Economics*, *108*(3).

Clemens, M. A. and Williamson, J. G. (2002). Closed jaguar, open dragon: comparing tariffs in latin america and asia before world war ii. NBER Working Paper no. 9401.

Clemens, M. A. and Williamson, J. G. (2004). Why did the tariff-growth correlation change after 1950?. *Journal of Economic Growth*, *9*(1), 5–46.

DeJong, D. N. and Ripoll, M. (2006). Tariffs and growth: an empirical exploration of contingent relationships. *Review of Economics and Statistics*, *88*(4), 625–640.

Dollar, D. (1992). Outward-oriented developing economies really do grow more rapidly: evidence from 95 ldcs, 1976-85. *Economic Development and Cultural Change*, *40*(3), 523–544.

Edwards, S. (1998). Openness, productivity and growth: what do we really know?. *Economic Journal*, *108*(447), 383–398.

Frankel, J. A. and Romer, D. (1999). Does trade cause growth?. *American Economic Review*, *89*(3), 379–399.

Greenaway, D., Morgan, W., and Wright, P. (1997). Trade liberalization and growth in developing countries: some new evidence. *World Development*, *25*(11), 1885–1892.

Greenaway, D., Morgan, W., and Wright, P. (1998). Trade reform, adjustment and growth: what does the evidence tell us?. *Economic Journal*, *108*(450), 1547–1561.

Grossman, G. M. and Helpman, E. (1990). Comparative advantage and long run growth. *American Economic Review*, *80*(4), 796–815.

Hall, R. E. and Jones, C. I. (1999). Why do some countries produce so much more output per worker than others?. *Quarterly Journal of Economics*, *114*(1), 83–116.

Harrison, A. (1996). Openness and growth: a time-series, cross-country analysis for developing countries. *Journal of Development Economics*, *48*(2), 419–447.

Harrison, A. and Hanson, G. (1999). Who gains from trade reform? some remaining puzzles. *Journal of Development Economics*, *59*, 125–154.

Kaufmann, D., Kraay, A., and Mastruzzi, M. (2008). Governance matters vii: aggregate and individual governance indicators for 1996–2007. World Bank Policy Research Working Paper no. 4654.

Keller, W. (2002). Geographic localization of international technology diffusion. *American Economic Review*, *92*(1), 120–142.

Klenow, P. J. and Rodríguez-Clare, A. (1997). The neoclassical revival in growth economics: has it gone too far?. In Bernanke, B. and Rotemberg, J. (Eds.), *NBER Macroeconomics Annual*. MIT Press.

Klenow, P. J. and Rodríguez-Clare, A. (2005). Externalities and growth. In Aghion, P. and Durlauf, S. N. (Eds.), *Handbook of Economic Growth, volume 1A*. Elsevier B.V.

Krueger, A. O. (1998). Why trade liberalization is good for growth. *Economic Journal*, *108*(450), 1513–1522.

Lee, H. Y., Ricci, L. A., and Rigobon, R. (2004). Once again, is openness good for growth?. *Journal of Development Economics*, *75*(2), 451–472.

Lee, J.-W. (1993). International trade, distortions, and long-run economic growth. *International Monetary Fund Staff Papers*, *40*(2), 299–328.

Levine, R. and Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions. *American Economic Review*, *82*(4), 942–963.

Matsuyama, K. (1992). Agricultural productivity, comparative advantage, and economic growth. *Journal of Economic Theory*, *58*(2), 317–334.

Nunn, N. and Trefler, D. (2009). The political economy of tariffs and long-term growth. manuscript.

O'Rourke, K. H. (2000). Tariffs and growth in the late 19th century. *Economic Journal*, *110*(463), 456–483.

Papageorgiou, C. (2002). Trade as a threshold variable for multiple regimes. *Economics Letters*, *77*, 85–91.

Rodríguez, F. and Rodrik, D. (2000). Trade policy and economic growth: a skeptic's guide to the cross-national evidence. In Bernanke, B. S. and Rogoff, K. (Eds.), *NBER Macroeconomics Annual*. MIT Press.

Sachs, J. and Warner, A. (1995). Economic reform and the process of global integration. *Brookings Papers on Economic Activity*, *0*(1), 1–118.

Vamvakidis, A. (2002). How robust is the growth-openness connection? historical evidence. *Journal of Economic Growth*, *7*(1), 57–80.