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Essays on International Trade and Economic Growth

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ESSAYS ON INTERNATIONAL TRADE AND ECONOMIC GROWTH

A Dissertation Presented

by

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ABSTRACT

ESSAYS ON INTERNATIONAL TRADE AND ECONOMIC GROWTH

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In this dissertation I study the relationship between trade and economic growth, with a focus on developing economies. I specifically provide a critical review of the consensus view in trade and growth, according to which a liberal trade regime is generally the best policy stance to promote growth. In the first essay of this dissertation, I provide evidence that the relationship between trade policy and growth may depend on economic structure: tariff reductions are followed by higher levels of GDP per capita for manufacturer countries, but lower levels for nonmanufacturers.

Testing for mechanisms, I find the heterogeneity seems to be linked to changes in productivity, capital accumulation, and the manufacturing share of GDP.

In the second essay, I present a model of North-South, innovation and diffusion, which provides a theoretical rationale of the evidence found in the first essay, especially regarding nonmanufacturers (the South). The model also challenges a recent consensus of the trade and innovation literature. This consensus establish that specialization according to comparative advantage is detrimental to the development of the South only if there is no international technology diffusion. Technology diffusion does exist from the North to the South in my model, but it occurs only through the modern sector. The model confirms that technology diffusion is a force of convergence but shows that trade leads to both a lower technological proximity to the frontier and a lower relative income, what I call uneven development.

In the third essay, co-authored with Emiliano Libman and Arslan Razmi (published in *Structural Change and Economic Dynamics*), we study the extent to which countries undergo structural change during and after episodes of sustained investment surges. In particular, we explore the evolution of trade flows, considering (i) exports sophistication or complexity, (ii) exports diversification, and (iii) capital goods imports. Using the episodes identified by Libman, Montecino, and Razmi (2019), we find that, while imports of capital goods increase, they are not systematically related to changes in sophistication, complexity and diversification of exports. Thus, high investment may often be a necessary but not sufficient condition for structural change.

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CHAPTER 1

INTRODUCTION

There is no debate that international trade matters for economic growth. What has been debated substantially in economics since the beginning of the establishment of the profession is if the net effects, especially dynamic ones, are positive or negative. The most common answer, and by some accounts the topic where economists agree more, is that *free* trade is the policy stance to go with[1]. Nevertheless, historical research and theory do not support that clear-cut response. On the one hand, historical and empirical research argues that protectionism was used as a tool for development in today's already developed countries, although the topic is contentious (Chang, 2003; Reinert, 2008; Lehmann & O'Rourke, 2011). On the other, although most of recent theory agrees with the common answer, classical development theory of the mid-twentieth century, following the work by economists like Raul Prebisch, Gunnar Myrdal, among others, would usually disagree. More recent literature reviews will also agree that the response in theoretical terms is not crystal clear (Grossman & Helpman, 2015; Melitz & Redding, 2021). The specific mechanisms of the impact going from international *free* trade to growth matter. And the mechanisms of this relationship are several.

The main objective of this dissertation is to contribute to this discussion, providing both empirical evidence and theoretical reasoning on how the relationship might depend on initial economic structures. In other words, I show that the sign of the impact on growth of international (free) trade, or trade opening, depends on initial economic structures, if the country is already industrialized or not.

The first essay of the dissertation provides an empirical evaluation of the impact of tariff reductions on economic growth, paying special attention to heterogeneous effects related to initial economic structure. This is, to the best of my knowledge, the first time that in econometric terms this contingency on the tariffs-growth relationship is studied. Previous empirical exercises either ignored contingencies of the relationship, or focused on the contingency coming from income (DeJong & Ripoll,

[1]For this argument, see the early summary of the literature by Krugman (1993), and the recent contributions by Furceri, Hannan, Ostry, and Rose (2020, 2022).

2006)[2]. Although I examine the contingency from initial income, and also from the level of initial schooling, I am the first to explore the contingency of the tariffs-growth relationship coming from initial economic structures. I also address this empirical question using a relatively new estimation method, at least new in this question, which is the so-called local projections difference-in-differences by Dube, Girardi, Jordà, and Taylor (2023), in a sense already applied empirically by Acemoglu, Naidu, Restrepo, and Robinson (2019).

I find that tariff reductions promotes (reduces) growth for countries with high (low) initial shares of manufacturing exports. In other words, that trade liberalization has been beneficial for manufacturer countries butt detrimental for nonmanufacturers. The estimates suggest that a one-standard-deviation reduction in tariffs (i.e., 3.65 percentage points) leads to a fall (increase) of more than 2 percent in GDP per capita fifteen years later for nonmanufacturer (manufacturer) countries. According to Estevadeordal and Taylor (2013), the median reduction in tariffs following the Washington Consensus of the 1990s was of 25 percentage points. Assuming a constant marginal effect of tariffs, a 25-percentage-point reduction in tariffs would imply a fall in GDP per capita after 20 years of about 15.8 percent for nonmanufacturer countries. To illustrate how important these magnitudes are, the Norwegian economy grew by 15.9 percent between 2000 and 2019, virtually the same magnitude than the 20-year impact from tariffs that I obtain.

The second essay of this dissertation tries to make theoretical sense of the previous finding, especially for nonnmanufacturers or the South, making use of endogenous growth theory and innovation. But it also discuss a recennt consensus of the trade and growth literature. Both according to Grossman and Helpman (2015) and Melitz and Redding (2021), the theoretical literature on trade and innovation from the last thirty years show that trade can lead the South to lower growth (and welfare) as compared to autarky if and only if there are no international knowledge spillovers. In other words, the condition is that technological progress in each country is entirely independent from that in other countries. As there is evidence of international knowledge spillovers the idea that North-South trade harms the South, from the point of view of the recent consensus, is a theoretical curiosity.

The model's outcome is that trade may still harm the South even if international technology diffusion does exist. In particular, I show that trade leads the South to experience a lower (technological) proximity to the frontier and a lower relative income, thus also matching the empirical evidence mentioned. The argument rests fundamentally on recognizing qualitative sectoral differences, as was also emphasized in the classical literature. First, technology, modeled as varieties of intermediate goods in the modern sector, does diffuse from the North to the South, but its effective imitation occurs through the manufacturing or modern sector and only later spills over

[2] For a detailed review of the empirical literature on the tariffs-growth nexus, see the paper by Irwin (2019).

to the rest of the economy. Then, trade implies for the South a lower relative price of the modern good, leading the South to specialize more in the traditional sector (i.e., less in the modern sector). Finally, with resources relocated from the modern towards the traditional sector, the steady state depicts a South that is farther from the North both in terms of technology and real income. By opening up to trade, the South ends up worse off than under autarky. Diminishing returns to labor in the traditional sector guarantee that trade does not lead the South to completely stagnate and thus absolutely diverge from the North but only to a reduction in relative income, which I call uneven development. My model thus confirms that technology diffusion promotes convergence, but that trade, separated from diffusion, can harm the South.

The third essay of the dissertation investigates empirically the connection between investment and technological upgrading. Related to the previous model, and endogenous growth theory more in general, the process of growth is essentially a process of technological upgrading, either through innovation or imitation. We thus investigate if episodes of investment surges lead to higher measures of complexity, sophistication, diversification, as measures of technological upgrading. As we make use of trade data to build the measures of complexity, sophistication and diversification, following a large literature on the topic that emerged from the seminal work by Hidalgo and Hausmann (2009), we also investigate the impact of these episodes on imports composition.

Our findings are as follows. First, we find that there is no connection between investment episodes and complexity, sophistication or diversification. In other words, accelerated investment episodes on average do not lead to technological upgrading. High investment may often be a necessary but not sufficient condition for structural change. Second, we do find that investment episodes lead to an increase in capital goods imports. This second finding can be interpreted as in line with the emphasis on balance of payments problems (constraints) coming from structuralist literature.

The rest of this dissertation goes into the details of each of these three chapters. Chapter 2 presents the results on the first empirical exercise, showing that the impact of tariffs on growth is contingent on initial economic structures. Chapter 3 presents the first sketch of the North-South trade model. Chapter 4 reveals the analysis of the impact of investment episodes on technological upgrading.

CHAPTER 2

TARIFFS AND GROWTH: HETEROGENEOUS EFFECTS BY ECONOMIC STRUCTURE

2.1 Introduction

Is free trade good for economic growth? The dominant view in economics is that countries with lower barriers to trade tend to grow faster than countries with protectionist policies. Some even argue that support for free trade is the idea on which economists disagree least (Krugman, 1993; Furceri et al., 2020, 2022). However, the theoretical literature does not provide unambiguous predictions on the nature of the trade policy-growth relationship. On the one hand, free trade may bring a scale effect in the sense that a larger market, associated with greater benefits for innovation, will boost growth for all countries involved. Trade may also enhance international technology diffusion. On the other hand, competition effects may lead backward countries to specialize in activities with lower innovation potential and therefore to experience lower growth rates (Grossman & Helpman, 2015; Melitz & Redding, 2021). The sign of the relationship is therefore an empirical question.

The empirical literature studying the trade policy-growth relationship deliver results that remain inconclusive. The seminal paper by Rodríguez and Rodrik (2001) revealed that most of the literature in the 1990s used independent variables capturing phenomena other than trade policy[1]. More importantly, the authors reanalyzed the estimates from that literature and showed, by carefully isolating trade policy from other phenomena, that the effect of trade policy on growth was not statistically significant other than zero. In other words, that free trade was neither good nor bad for growth. The authors conclude that the literature should study the heterogeneous effects of trade policy on growth, instead of focusing exclusively on a general, unambiguous relationship. For example, they suggest studying heterogeneous effects in relation to comparative advantage in manufacturing, what I call here economic

[1]For example, in the case of Dollar (1992), the variables used were exchange rate distortion and variability; in Sachs and Warner (1995), the Sachs-Warner (SW) dichotomous measure of liberalization used included trade policy information but also exchange rate distortions and state ownership of important sectors, among others; and the paper by Frankel and Romer (1999) used trade openness, which is an outcome variable but not a trade policy measure.

structure. Although there have been new contributions since then[2], the results on a general relationship remain inconclusive—as discussed below—and there are no contributions to date that study the heterogeneity in relation to the economic structure.

In this article, I demonstrate that the relationship between trade policy and growth at the country level is characterized by sharp heterogeneous effects by economic structure. I do this by investigating the dynamic medium-term effects of tariffs on GDP per capita using a panel of 161 countries from 1960 to 2019[3]. I provide evidence that tariff reductions led to lower GDP per capita for nonmanufacturer countries, but higher GDP per capita for manufacturers. The estimates suggest that a one-standard-deviation reduction in tariffs (i.e., 3.65 percentage points) leads to a fall (increase) of more than 2 percent in GDP per capita fifteen years later for nonmanufacturer (manufacturer) countries. The effects persist even after twenty years. These results may explain the apparent nonexistence of a general, unambiguous relationship. I further show that the results appear to be driven by heterogeneous effects on productivity and capital accumulation, in turn linked to changes on the manufacturing share of GDP.

To establish the baseline results, I address the selection biases stemming from pretrends, since tariff reductions are preceded by a surge in GDP. As shown in Figure 2.1, countries reducing tariffs (treatment group) are on a different trajectory ex ante as compared to countries not changing them (control group): GDP of the former is increasing in relative terms before tariff reductions (treatment). To avoid biases, I use the local projections difference-in-differences (LP-DiD) estimator, that provides a flexible semiparametric approach to control for pre-treatment values, as in conditional parallel trends (Dube et al., 2023). The underlying identification assumption of the baseline results is that, conditional on lags of growth rates, which successfully capture pretrends, changes in tariffs are as good as random.

I then demonstrate the validity of the baseline results to several robustness exercises, thus relaxing the previous identification assumption. First, I check the validity of the estimates after accounting for important confounding variables that are related to both tariff changes and growth, as well as for some common trends for different groups of countries. Second, cognizant of the problems highlighted in the recent difference-in-differences literature with estimates of average treatment effects due to effect heterogeneity and variation in treatment timing (de Chaisemartin & d'Haultfoeuille, 2020; Sun & Abraham, 2021; Callaway & Sant'Anna, 2021; Goodman-Bacon, 2021), I provide a robustness exercise aimed to address these problems. I use LP-DiD to implement the idea of comparing movers, here countries experiencing *relevant* tariff changes, and quasi-stayers, here countries

[2] Goldberg and Pavcnik (2016) and Irwin (2019) provide reviews on recent empirical contributions.
[3] Trade policy is also composed by nontariff barriers, export taxes, among others. Although I focus on the effects of tariffs, I nonetheless control for nontariff barriers changes in a robustness check.

experiencing changes in tariffs virtually equal to zero, as recently proposed by de Chaisemartin, D'Haultfœuille, Pasquier, and Vazquez-Bare (2022). Reassuringly, the effect heterogeneity is robust to these checks.

I also provide evidence of potential mechanisms underpinning this heterogeneity in the effects of tariffs on growth. I show that for nonmanufacturer countries, tariff reductions lead to lower productivity levels, also accompanied by lower capital accumulation. For manufacturer countries, on the other hand, both productivity and capital accumulation increase after tariff reductions. These results seem to be driven in turn by changes in the manufacturing share of GDP: tariff reductions lead to lower (higher) manufacturing shares of GDP for nonmanufacturer (manufacturer) countries. The evidence thus suggests manufacturing is the more dynamic sector in the economy, which might be in line with the idea by Rodrik (2013) that it is the only broad economic sector characterized by unconditional convergence. In the case of nonmanufacturer countries, the evidence can also be interpreted to support the premature deindustrialization story by Rodrik (2016), according to which developing countries deindustrialized due to globalization.

This paper provides three specific contributions to the cross-country tariffs-growth nexus empirical literature. First, this paper is the first, to the best of my knowledge, to test for heterogeneous effects of tariffs on growth related to the economic structure. Second, the effect heterogeneity documented in the paper provides a novel explanation for the apparent lack of a general, unambiguous relationship between tariffs and growth, which emerged int he early 2000s and that seems to emerge again from recent contributions. And finally, the analysis in the paper addresses the selection biases from pretrends, given that tariff reductions are preceded by a surge in GDP.

First, although previous literature has studied heterogeneous effects of tariffs on growth, this paper is the first to study the hetereogeneity that may come from economic structure. Yanikkaya (2003) first studied the relationship between growth and several different trade policies, among them tariffs, export taxes, and total taxes on international trade. His results showed that trade restrictions, particularly tariffs, encourage growth, especially in developing countries. DeJong and Ripoll (2006) then explicitly studied the heterogeneous effects of trade policy in relation to income per capita. They found that trade restrictions may encourage growth in developing countries but negatively impact growth in developed countries. Finally, Nunn and Trefler (2010) argued that what really matters is the skill bias of tariffs: higher tariffs in skill-intensive sectors are robustly associated with higher growth.

Second, the heterogeneous effects offer an explanation for the apparent lack of a general, unambiguous relationship between tariffs and growth, which was the message conveyed by Rodríguez and Rodrik (2001) and that emerges again in recent literature. The three most important recent contributions in the empirical literature on trade policy and growth, as reviewed by Irwin (2019), are those by Wacziarg and Welch

(2008), Billmeier and Nannicini (2013), and Estevadeordal and Taylor (2013). While all three articles seemed to suggest a positive and significant relationship between trade liberalization and growth, recent revisions of these papers suggest that they do not provide robust evidence of a general, unambiguous positive relationship.

The studies by Wacziarg and Welch (2008) and Billmeier and Nannicini (2013) studied the impact on growth of changes in a dichotomous measure taking value 1 for liberal countries and 0 for protectionist ones. This measure of liberalization is based on criteria including trade policy but also other phenomena related to market reforms, thus identifying more than changes in trade policy. Therefore, according to Billmeier and Nannicini (2013), the way to interpret it is as a broad measure of reforms that extend the scope of the market, and not as a measure of trade policy alone. In fact, Rodríguez (2007) showed that the results in Wacziarg and Welch (2008) are essentially driven by exchange rate policies, and not by trade policy. Moreover, the trade policy component in the dichotomous measure assumes that the trade regime is defined by certain threshold in average tariff rates. Defining that a country has a liberal trade regime if its average tariff rate is lower than 40 percent and a protectionist one otherwise seems problematic. Rodríguez (2007) actually demonstrates that the results by Wacziarg and Welch (2008) are not robust to changes in these thresholds.

The study by Estevadeordal and Taylor (2013) overcomes the problem of dubious definitions of trade policy by directly studying the effects of tariffs[4]. The authors revisited the question on the tariffs-growth nexus, focusing on the great liberalization of trade policy of the 1990s, as driven by the creation of the World Trade Organization. The analysis is carried out through a difference regression with acceleration in average growth as the dependent variable. The difference regressions only consider averages of two periods, the pre- and post-1990, thus ending with only one observation per country with available data (averaging between 31 to 47 observations). The authors show that tariff reductions in capital and intermediate goods is what really increases growth. However, I recently showed that the results of that paper are not robust and that, once again, there appears to be no general, unambiguous relationship between tariffs and growth (Hoyos, 2022).

And finally, this paper provides dynamic effects estimates that address potential selection biases from pretrends, a first in the tariffs-growth literature. The recent studies by Furceri et al. (2020, 2022) study yearly changes in average tariffs rates from 1960 to 2014 on growth and other macroeconomic variables at the country level[5]. The authors make use of a new dataset with tariff rates for 161 countries, the longest coverage to date, which is the data I use here. The authors use the local projections method (Jordà, 2005) to estimate for the first time the dynamic effects of a one-percentage-point change in tariffs. Nevertheless, those papers did not test for pretrends, which is crucial to avoid selection biases. As shown later, countries

[4]According to Irwin (2019), this is the only contribution (before his review) to use tariff rates directly.
[5]Their estimates used GDP, not GDP per capita, as the dependent variable.

that reduce their tariffs do so after experiencing higher GDP growth as compared to countries that do not change them. Additionally, the authors restricted the analysis to 5 years after tariff changes, while my analysis considers a longer analysis window, going up to twenty years after tariff reductions.

The paper has six sections in addition to this introduction. In section 2, I provide a theoretical discussion to motivate the empirical investigation of heterogeneous effects of tariffs conditional on the economic structure and explain why I use the manufacturing share of exports as the measure of economic structure. In section 3, I present the data used and some descriptive statistics. In section 4, I present the baseline results, demonstrating heterogeneous effects of tariffs on growth depending on the initial economic structure. In section 5, I present several robustness checks. In section 6, I show the analysis on potential mechanisms underpinning the heterogeneous effects. Finally, in section 7, I conclude the paper.

2.2 Theory: Economic structure matters

Traditional trade theory emphasizes the gains from trade in a static framework. As countries specialize in sectors in which they are relatively more productive due either to natural/technological or endowment differences, following their comparative advantage, production expands, and through trade, countries can secure welfare gains. This strand of the literature deals in a sense with interindustry trade. New trade theory, which emerged to explain patterns of trade between developed economies or intraindustry trade, emphasizes scale economies as the source of gains from trade. As countries specialize in some varieties, increasing production in certain lines while allowing production of other lines to disappear within their borders, welfare ends up increasing due to the greater number of varieties that consumers can access and to improvements in productivity. Thus, there are good theoretical reasons to expect positive static gains from trade (Feenstra, 2015).

Although informative on the role of trade in production, the previous theories do not deliver insights about growth. These traditional theories are static in nature, and after specialization from trade has occurred, economies do not grow in equilibrium. In a sense, the theories point to positive growth in the transition to the trade equilibrium, assumed normally to be instantaneous, whereupon, growth becomes zero. Thus, these theories abstract from long-run growth and are not informative about the engines of growth, which is a crucial question for the inquiry on medium-term dynamic effects.

Analyzing trade (policy) and its impact on growth therefore implies dealing with conceptualizations of growth and its engines. The literature on trade and growth has dealt fundamentally with two types (or causes) of growth: learning-by-doing and innovation. Learning-by-doing refers to increases in productivity due to increased production, so that as time goes on, producers become more productive simply by being involved in production. Analyses of trade and learning-by-doing go back to important contributions in the 1980s like those by Krugman (1981, 1987) and A. K. Dutt (1986), among others. Later contributions in this tradition are those from Young (1991), Skott and Larudee (1998), Redding (1999), and the more recent paper by Greenwald and Stiglitz (2006). Afterwards, with the emergence of endogenous growth theory, the analysis of trade and growth (innovation) gained new traction in the 1990s, especially due to the seminal work by Grossman and Helpman (1991b)[6]. Feenstra (1996) provides another important example in this second strand of the literature, an analysis of trade, endogenous innovation, and growth.

Although the theoretical details in the two traditions may differ, they both convey the message that the effects of trade policy vary with economic structure. The idea is that trade leads economies to specialize in economic sectors they are relatively more productive, but where those sectors may have now a differential impact on technological progress and thus on growth. Particularly, economies that end up specialized in less (more) dynamic economic activities due to trade liberalization (e.g., tariff reductions) will experience a reduction (increase) in growth rates[7]. According to Young (1991), "examining the interaction of an LDC [less developed country] and a DC [developed country], the latter distinguished by a higher initial level of knowledge, I find that under free trade the LDC (DC) experiences rates of technical progress and GDP growth less than or equal (greater than or equal) to those enjoyed under autarky" (p. 369). Because of the effect it has on comparative advantage specialization patterns, obstructing or facilitating their materialization, trade policy therefore has a significant effect on growth (Greenwald & Stiglitz, 2006).

There is a crucial assumption in this strand of the theoretical literature that drives the results, and differs to those of contributions delivering different conclusions. The models surveyed share the idea that the economy is characterized by qualitatively different economic sectors (i.e., less vs. more dynamic). Modern general equilibrium analyses of comparative advantage and growth, based mostly on the works by Melitz (2003) and Eaton and Kortum (2002), show that if sectors are qualitatively equal, trade liberalization might lead to higher economic growth for all countries engaged. However, the empirical evidence seems to back up the idea that economic sectors are different. Important work by Rodrik (2013) shows that manufacturing, unlike other sectors, experiences unconditional convergence. The author interpreted this evidence

[6] The authors provided an in-depth theoretical analysis of the interactions between growth coming from innovation and trade in several different settings. Readers are encouraged to review this important work.

[7] Highly dynamic activities, in comparison to less dynamic, refer to sectors characterized by greater learning-by-doing or innovative potential than other sectors.

as suggesting that technological diffusion might be a property of particular relevance for the manufacturing sector, in contrast to other sectors[8].

A recent article by Atkin, Costinot, and Fukui (2021) provides both theory and evidence that support the idea that qualitative sectoral differences do exist and that trade can therefore lead to dynamic welfare losses for countries specializing in traditional sectors. The authors construct a model of trade and development where sectors differ in their economic complexity, which in turn exerts positive effects on the growth of the countries producing them. The authors demonstrate theoretically that if international competition is tougher in more complex goods, then trade leads to dynamic welfare losses for most countries in the globe, only excluding a few ones that remain specialized in the production of complex goods. They then provide causal evidence that growth (and thus welfare) of a country is indeed positively affected by the average level of complexity of the goods the country is specialized in. And they show crucial evidence that suggests competition is indeed tougher in more complex goods. They conclude that "[t]hrough the lens of our model, rather than pushing countries up the development ladder, opening up to international trade tends to hold many of them back" (Atkin et al., 2021, p. 42).

In synthesis, the initial economic structure, as reflecting initial comparative advantage in more or less dynamic sectors, determines the direction of the impact tariffs have on growth. Countries with a comparative advantage in less (more) dynamic sectors that open to trade may experience GDP and welfare losses (gains).

How to account empirically for initial economic structures? For simplicity and ease of interpretation, I use the initial share of manufacturing exports as the variable to capture it. In other words, I assume that countries with high manufacturing exports have a comparative advantage in more dynamic goods and those with low exports have a comparative advantage in less dynamic sectors. This implies that manufacturing is understood to be in broad terms the relatively more dynamic sector and that the share of manufacturing exports captures comparative advantage in manufacturing. The first condition seems to be backed by the evidence provided by Rodrik (2013), as already mentioned, and the second is supported by the data used here[9].

[8]This can be interpreted as evidence supporting the model by Stiglitz (2015), where international knowledge spillovers exist, but they only materialize through the more dynamic sector, so trade leads to uneven growth.

[9]The correlation between the share of manufacturing exports and revealed comparative advantage in manufacturing is 0.98. The results obtained by using revealed comparative advantage in manufacturing, Figure A6, are virtually the same as the baseline results, presented in Figure 2.3.

2.3 Data and descriptive statistics

I put together a panel of 161 countries covering 1960 to 2019. For the outcome variable in the growth regressions, I use the data of GDP per capita in constant national prices in 2017 dollars taken from the Penn World Table (PWT) 10.0. The tariff data are taken from Furceri et al. (2022) and represent the average tariff rate applied to imports in each country on a given year, covering from 1960 to 2014. The coverage of tariff data is lower than that of the GDP data, so I end up using approximately 4,700 observations in the regressions.

To capture economic structure, I gather information on shares of manufacturing exports from COMTRADE data, cleaned by the Growth Lab at Harvard University. I calculate the share as follows. First, I exclude services exports and exports not elsewhere classified, ending up with a measure of total goods exports. And then, I get the shares by excluding exports in three broad categories of goods from the Standard International Trade Classification (SITC): (i) food and live animals chiefly for food; (ii) crude materials, inedible, except fuels; and (iii) mineral fuels, lubricants and related materials[10]. The data cover most countries in the sample and run from 1962 to 2019.

[10] Another important goods classifications is the one by Lall (2000), based on technological categories. I use this classification in a robustness check, Figure A5, and results remain basically the same.

Table 2.1: Summary statistics

Variables	**Observ.**	**Mean**	**St.Dev.**	**Observ.**	**Mean**	**St.Dev.**
		1960-1989			**1990-2019**	
GDP per capita	4,274	11,089.6	18,480.13	5,460	17,517.09	19,344.82
Tariff	1,675	17.73	20.27	3,367	8.01	7.06
Manufacturing share of exports	4,522	33.72	28.89	6,122	52.35	30.32
Trade share of GDP	2,999	62.68	46.19	5,173	86.69	56.36
Nontariff barriers	3,048	12.97	4.50	4,587	9.46	4.82
Polity score (institutional quality)	3,811	-1.58	7.41	4,504	3.25	6.57
Chinn-Ito Index (capital account openness)	2,465	0.35	0.32	4,945	0.50	0.36
Human capital index	3,644	1.76	0.60	4,350	2.40	0.69
Investment as a share of GDP	2,901	22.34	9.54	4,921	23.55	8.54
Gini index	1,553	34.31	10.47	2,826	38.29	9.18
Terms of trade (net export price index)	4,065	111.75	74.24	5,267	74.61	26.43
Real effective exchange rate	2,910	151.04	133.60	3,754	100.99	37.34
Growth forecast	0	-	-	5,353	3.25	5.96

Note: See the main text for a description of the variables. I present the descriptive statistics for two equal-sized periods of time for simplicity, one capturing years 1960-1989 and the second capturing 1990-2019.

I also gather information on important covariates to control for in the regressions. The dataset has country-year data on the trade share on GDP and investment as a share of GDP, taken from the World Development Indicators (WDI); the economic growth forecast, the net exports terms of trade, and the real effective exchange rate, taken from the IMF; the Gini index, taken from the Standardized World Income Inequality Database of Solt (2020); institutional quality, as measured by the Polity score; the Chinn-Ito index for capital account openness (Chinn & Ito, 2006); the human capital index in PWT, which improves on the traditional measure of years of schooling from R. J. Barro and Lee (2013) and has greater coverage; and a count variable that measures nontariff barriers, recently published by Estefania-Flores, Furceri, Hannan, Ostry, and Rose (2022). In a robustness check, I control for regional trends based on the World Bank classification: Africa, East Asia and the Pacific, Eastern Europe and Central Asia, Western Europe and other developed countries, Latin America and the Caribbean, the Middle East and the North of Africa, and South Asia.

Table 2.1 presents descriptive statistics of the variables that I use in the analysis. I present the summary dividing the data in two periods, 1960-1989 and 1990-2019, each capturing the same number of years and reflecting two different periods in terms of tariff levels. In the first period, tariffs are higher and more dispersed, with a mean of 18.43 percent and a standard deviation of 20.92, while in the second, the mean is 8.24 percent and the standard deviation 7.56. This grouping in two periods is made only to illustrate that the world has been moving towards a more liberal trade regime. The periods also reveal that the information on tariffs in the first period is scarcer than in the more recent one. Moreover, consistent with a more liberal regime, trade as a share of GDP has increased on average. Likewise, capital accounts have also moved towards liberalization, as captured by the Chinn-Ito index. GDP per capita, institutional quality, and human capital improved from the first to the second period. Inequality, as documented extensively elsewhere, increased. The growth forecast is available only from 1990 onward.

2.4 Baseline results

In this section, I establish the baseline results based on LP-DiD. I develop this section in three parts. First, I explain LP-DiD and its advantages and limitations. Second, I use LP-DiD to observe and then model pretrends to avoid clear violations of the parallel trends assumption. To this end, I abstract from heterogeneity and focus only on tariff changes in general. Third, I present the baseline results, according to which tariff reductions lead to lower (higher) GDP per capita for nonmanufacturer (manufacturer) countries.

2.4.1 Local projections difference-in-differences (LP-DiD)

The LP method, originally proposed by Jordà (2005), has become a well-known and widely used approach in macroeconometrics. Recent work by Dube et al. (2023) has advanced an estimator based on the seminal LP contribution but also going beyond by including a discussion of recent challenges of difference-in-differences literature, the LP-DiD estimator. LP-DiD is specifically useful for the question on the tariffs-growth nexus as it allows to estimate dynamic effects of tariffs and also capture pretrends by flexibly controlling on observables to avoid potential biases coming from violations of the parallel trends assumption. I explain these advantages in more detail below.

First, LP-DiD, although this applies for LP in general, provides a simpler form of estimating dynamic effects that arguably performs better in terms of biases as compared to VARs. LP capture the effect of a shock or a treatment on the outcome variable by estimating a regression for each horizon studied, while VARs estimate only one regression with the lags of the outcome variable as regressors, so that their coefficients capture a parametric dynamic relation. According to Ramey (2016) and Nakamura and Steinsson (2018), the advantage of LP over VARs is precisely that the former does not assume any structure for the data-generating process (semiparametric estimates), particularly regarding the dynamic relation between the treatment and the outcome. In the words of D. Li, Plagborg-Møller, and Wolf (2021), "empirically relevant DGPs are unlikely to admit finite-order VAR representations, so mis-specification of VAR estimators is a valid concern" (p. 31). These authors demonstrate that LP leads to lower biases but higher variance than VARs[11].

This ability estimate medium-term dynamic effects is advantageous with respect to previous estimates in the empirical literature. The literature has usually captured only instantaneous effects (as in Wacziarg and Welch (2008)) or captured medium-term effects by doing regression analyses on averages of GDP measures for long periods of time (i.e., between 12 to 28 years, in the case of Nunn and Trefler (2010), 15 years in the case of Estevadeordal and Taylor (2013), 10 years in the case of Yanikkaya (2003), and 5 years in DeJong and Ripoll (2006)). In the first case, capturing only instantaneous effects does not actually reflect the mechanisms derived from the reviewed theory on trade and growth, which points to a relocation of factors of production and technological changes, mechanisms that take time to emerge. The second operationalization, although arguably capturing medium-term effects, does not in fact capture dynamic effects and leads to regressions with small samples, ranging from 47 observations to a maximum of 260.

Second, LP-DiD allows to model pretrends and avoid biases coming from clear violations of the parallel trends assumption, as investigated and formalized by (Dube

[11]This feature is actually reassuring with respect to the validity of the estimates in the paper, as they are significant even under this problem of inefficiency of LP.

et al., 2023). Simple LP estimates allow to observe the trajectory of the outcome variable both after and before the treatment. In this setting, I observe GDP trends in countries that reduced tariffs in comparison to those of countries that did not. This pattern can be observed in Figure 2.1. The surge in GDP before tariff reductions constitutes a clear violation of the parallel trends assumption on which the difference-in-differences analysis is predicated. One of the main ideas behind LP-DiD is to use the flexible LP framework to model pretrends on observables, similar to what was done recently by Acemoglu et al. (2019). Particularly, the LP-DiD specification proposed by Dube et al. (2023) consists on modelling those pretrends through the inclusion of lags of first differences of the outcome variable (i.e., here, lags of growth rates). By doing this, they show that biases coming from pretrends can be effectively eliminated, so that in the case here I might be able to model the surge and eliminate the potential selection bias arising from it[12].

2.4.2 Pretrends to tariff changes

Are countries reducing tariffs on a different trajectory of GDP per capita than those not changing them? For now, I abstract from the heterogeneity in the tariffs-growth nexus linked to the economic structure and observe the trajectory of tariff changes in general. A LP equation to observe the evolution of (log) GDP per capita before and after a change in tariffs, based in Jordà (2005), is given by:

$$y_{c,t+h} - y_{c,t-1} = \beta_h \Delta TA_{c,t} + \alpha_t + \epsilon_{c,t} \tag{2.1}$$

where $y_{c,t+h}$ stands for (log) GDP per capita in country c in year $t+h$ and $\Delta TA_{c,t}$ refers to the change in the tariff level in year t with respect to year $t-1$, the variable of interest. To observe both the trajectory of GDP per capita before and after the treatment, I estimate this regression equation separately for each $h = -15, -14, ..., 0, ..., 19, 20$. In other words, this local projection equation basically regresses the cumulative change in (log) GDP per capita in year $t+h$ against the change in tariffs at time t. The cumulative change in GDP per capita in $t+h$ related to a one-percentage-point increase in tariffs is captured by β_h. Following Dube et al. (2023), I include only time fixed effects, as the equation is already in differences[13].

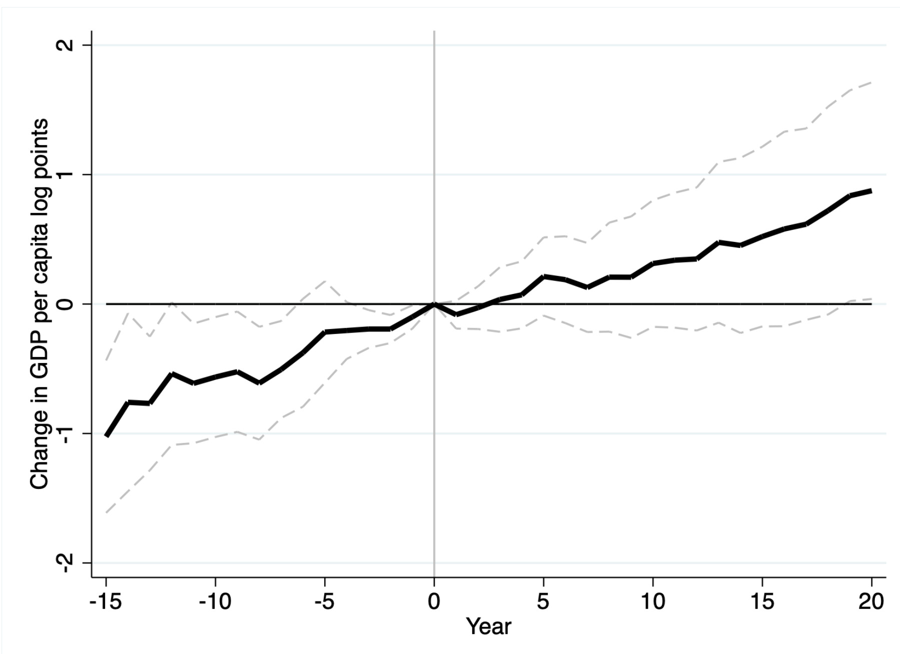
A couple of comments regarding the presentation of results are in order, as they will apply for all results presented in the paper unless otherwise specified. Instead of presenting results associated to an increase in one percentage point in tariffs, I present the results associated with a decrease in one-standard-deviation of the change

[12] Another crucial component of the LP-DiD estimator is to use clean controls to address the challenges identified by recent difference-in-differences literature. I discuss and develop this further in the next section.

[13] I include country fixed effects later as a robustness check, and the heterogeneity holds.

in tariffs, $SD(\Delta TA)$, a decrease in 3.65 percentage points. For example, in terms of equation 2.1, instead of plotting β_h I show $(-1) * SD(\Delta TA) * \beta_h$. And I also do the same for the heterogeneous results later shown. I do this for two reasons. First, most of the changes in tariffs in the data are decreases, consistent with the general trend towards liberal trade regimes in the last thirty years. Second, as shown in the Appendix in Figures A1 and A2, by separating the effects of both increases and decreases I only find significant effects for tariff reductions. This means that the average effect of tariffs presented in the paper are driven mainly by decreases in tariffs. And finally, I present the results scaled to one-standard-deviation, so they have an order of magnitude related to the changes in tariffs observed in the data. The other important aspect of the results presented across the text is that I use two-way cluster robust standard errors, in the country and year dimensions, making the inference even more robust (Thompson, 2011; Cameron, Gelbach, & Miller, 2011).

Figure 2.1: GDP per capita before and after a one-standard-deviation tariff reduction



Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

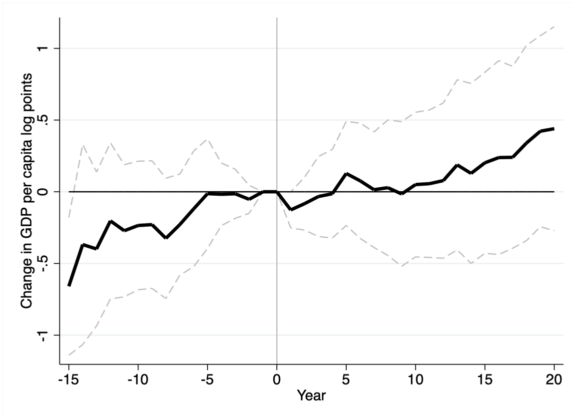
The results associated to equation 2.1 are presented in Figure 2.1. As can be observed, countries reducing their tariffs are on different pretrends from those not changing them. In particular, the former countries display a relative surge in GDP before tariff reductions as compared to the latter. In other words, tariff changes are endogenous to the evolution of GDP, such that countries that decide to decrease tariffs do so after GDP has been on a relative increase. Failure to control for this surge constitutes a clear violation of the parallel trends assumption and may lead to biases in the treatment effect estimates. How to deal with this violation of the parallel trends assumption? As mentioned before, following the approach by Dube et al. (2023) I model pretrends through lags of growth rates of GDP per capita.

Formally, the LP-DiD equation to control for pretrends is:

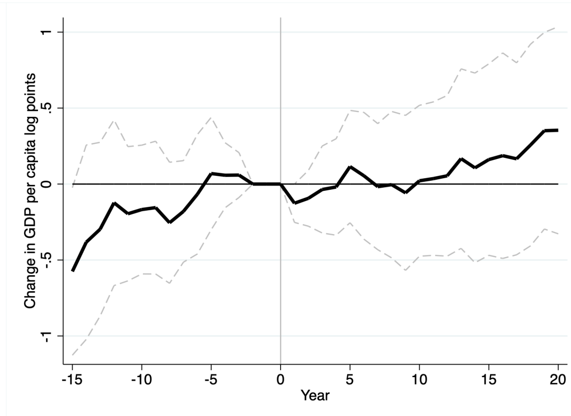
$$y_{c,t+h} - y_{c,t-1} = \beta_h \Delta TA_{c,t} + \sum_{j=1}^{1,2,4,8} \sigma_h^j g_{c,t-j} + \alpha_t + \epsilon_{c,t} \tag{2.2}$$

where, unlike in equation 2.1, I also include lags of the growth rate of GDP per capita to capture the surge in GDP preceding tariff reductions. The growth rate, $g_{c,t}$, is calculated simply as $y_{c,t} - y_{c,t-1}$, given that y already represents (log) GDP per capita. I use 1, 2, 4 or 8 lags of the growth of GDP per capita to test various alternatives to model effectively the surge in GDP.

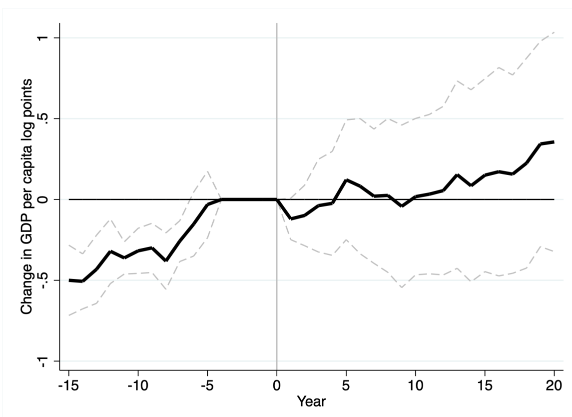
Figure 2.2: Modeling the surge in GDP per capita through lags in growth rates



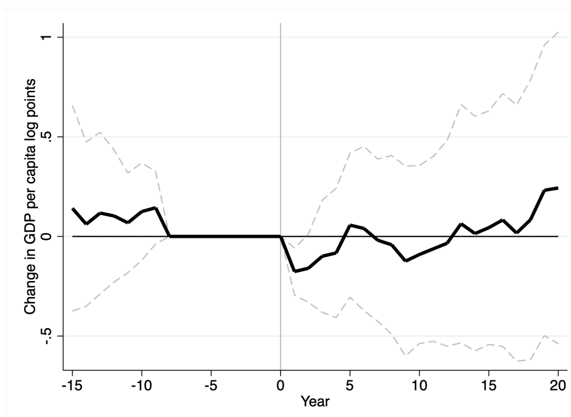
(a) 1 lag



(b) 2 lags



(c) 4 lags



(d) 8 lags

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

The results of the estimates of equation 2.2 are presented in Figure 2.2. Only in the case with 8 lags am I able to obtain equal trajectories for countries reducing tariffs and countries not changing them. More importantly, effects estimates change substantially when controlling for pretrends. While Figure 2.1 shows that GDP significantly increases twenty years after tariff reductions, Figure 2.2, with 8 lags, effectively modeling pretrends, shows that the effect estimates are less than half in magnitude and no longer significant. Therefore, from here onward, I add 8 lags of growth rates to avoid selection biases from the surge in GDP. If the researcher were to stop at this point, tariff changes and growth would appear to be uncorrelated, but that result would mask important heterogeneity, as I proceed to show below.

2.4.3 Results

I now return to the main question of interest: do tariff changes have different effects on countries in relation to their economic structure? More precisely, is there evidence that trade liberalization may differently nonmanufacturers and manufacturers?

To capture the heterogeneous effects of tariffs in relation to economic structures, I have to change the regression equation. The new LP-DiD equation is as follows:

$$y_{c,t+h} - y_{c,t-1} = \beta_h \Delta TA_{c,t} + \theta_h int_{c,t} + \phi_h m_{c,t} + \sum_{j=1}^{8} \sigma_h^j g_{c,t-j} + \alpha_t + \epsilon_{c,t} \tag{2.3}$$

where $m_{c,t}$ represents the initial share of manufacturing exports and $int_{c,t}$ represents the interaction (multiplication) between changes in tariffs $\Delta TA_{c,t}$ and the initial share of manufacturing exports $m_{c,t}$. The initial share of manufacturing exports, $m_{c,t}$, is calculated as the average of this variable in the five years before tariff reductions, to avoid contemporaneous endogeneity that may run from GDP to manufacturing exports. With this specification, the impact of tariff changes on growth varies with the initial level of the manufacturing share of exports. For example, if I want to calculate the cumulative change in GDP per capita at time $t + h$ in relation to a one-standard-deviation tariff reduction for a country with an initial manufacturing share of exports of 29 percent, I estimate it by calculating $(-1) * SD\,(\Delta TA) * (\beta_h + 29 * \theta_h)$.

To display the significance of the heterogeneous effects of tariffs on growth, I plot the estimates for the 10th and the 90th percentiles of the share of manufacturing exports. In other words, I present the estimated impact on GDP per capita of a one-standard-deviation reduction in tariffs for a country with an initial share of manufacturing exports of 3.96 percent and a country with an initial share of 88.26 percent[14]. From now on, I refer to the former estimates as those of nonmanufacturer countries and to the latter as the estimates of manufacturer countries[15].

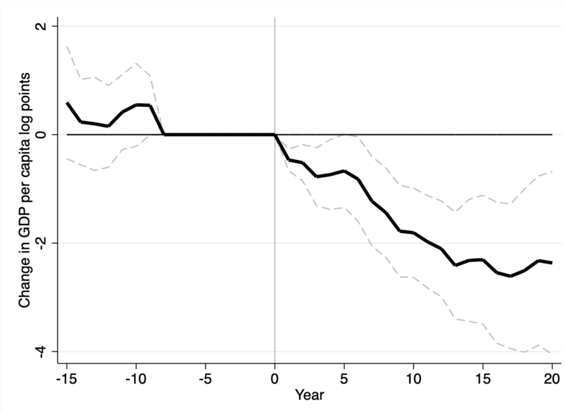
Figure 2.3 reveals the results associated to equation 2.3, capturing average effects of tariff reductions for manufacturer and nonmanufacturer countries. The crucial result is that there is a significant heterogeneous effect of tariffs on GDP per capita associated with the initial share of manufacturing exports. For nonmanufacturer countries, the effect is negative, meaning that the liberalization of trade policy has affected them negatively. For manufacturer countries, on the other hand, liberalizing

[14] The reader may recall that the Appendix shows separate effects estimates for tariff increases and tariff reductions, only the latter being significant.

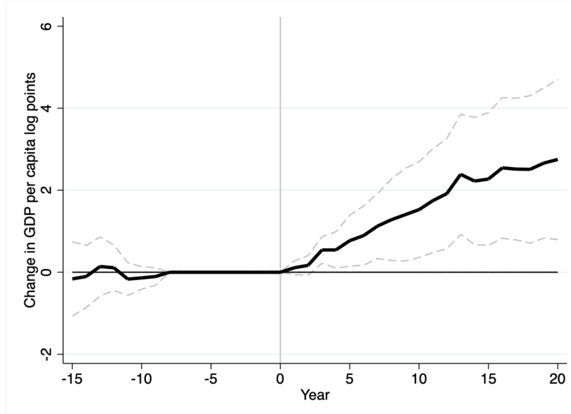
[15] In Figures A3 and A4 in the Appendix, I show that for only two deciles—the 50th and 60th—I obtain results with no significant effect. The effect is thus stronger for nonmanufacturer countries.

their trade regimes have affected them positively. Both subfigures in 2.3 also reveal that the pretrends are not different, which is reassuring on the specification with 8 lags of growth rates to avoid selection biases.

Figure 2.3: Average heterogeneous effects of tariff reductions on GDP per capita



(a) For nonmanufacturer countries



(b) For manufacturer countries

Note: The estimates presented are the predicted values for the 10th and 90th percentiles of the distribution of the share of manufacturing exports. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

The heterogeneity of the tariffs-growth nexus by economic structure is both statistically and economically meaningful. For nonmanufacturer countries, a one-standard-deviation reduction in tariffs leads to an average decrease of 2.31 percent in GDP per capita after 15 years. For manufacturer countries, on the other, a one-standard-deviation decrease in tariffs leads to an average increase in GDP after 15 years of approximately 2.32 percent. The effects seem to stabilize after ten years, but the difference in levels persists even twenty years after the tariff reductions. According to Estevadeordal and Taylor (2013), the median reduction in tariffs following the Washington Consensus of the 1990s was by 25 percentage points. Assuming a constant marginal effect of tariffs, a 25-percentage-point reduction in tariffs would imply a fall in GDP per capita after 20 years of about 15.8 percent for nonmanufacturer countries. To illustrate how important these magnitudes are, the Norwegian economy grew by 15.9 percent between 2000 and 2019, virtually the same magnitude than the 20-year impact from tariffs that I obtain.

Throughout the rest of the paper, I use the specification of heterogeneous effects of tariffs on growth from equation 2.3. However, this specification is premised on two important assumptions that need to be examined. First, the baseline specification assumes that the impact of tariffs is a linear function of the share of manufacturing exports, but this is not guaranteed a priori. To test for a nonlinear relationship, I change the regression specification by introducing dummies for six quantiles of observations according to their initial share of manufacturing exports and the interactions between these dummies and the change in tariffs. The new equation is as follows:

$$y_{c,t+h} - y_{c,t-1} = \beta_h \Delta TA_{c,t} + \sum_{k=1}^{6} \theta_h^k intd_{c,t}^k + \sum_{k=1}^{6} \phi_h^k md_{c,t}^k + \sum_{j=1}^{8} \sigma_h^j g_{c,t-j} + \alpha_t + \epsilon_{c,t} \quad (2.4)$$

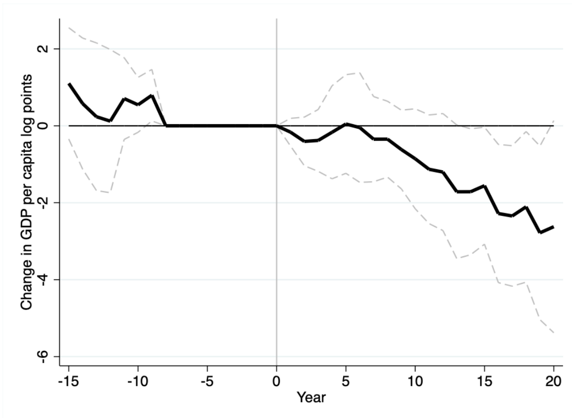
where k now refers to quantiles of manufacturing exports, so that $k = 1$ refers to observations in the bottom 16.6 percent of that variable. Also, $md_{c,t}^k$ refers to the manufacturing dummy taking value 1 if the observation belongs to the quantile k or zero otherwise. Finally, $intd_{c,t}^k$ represents the interaction between $\Delta TA_{c,t}$ and the dummy just explained, $md_{c,t}^k$. Thus, to calculate the one-standard-deviation decrease impact for each of the six quantiles of the distribution of manufacturing exports, I estimate $(-1) * SD(\Delta TA) * \left(\beta_h + \theta_h^k\right)$.

The results associated to the bottom ($k = 1, 2$) and top ($k = 5, 6$) two quantiles of estimating equation 2.4 are shown in Figure 2.4. For the first quantile of manufacturing exports, the impact on GDP per capita of reducing tariffs is negative in all the 20 years, although only statistically significant after 15 years. For the second quintile, tariff reductions lead to lower GDP per capita, with the impact being significant all 15 years after the decrease but not afterwards. For the fifth quantile, the relationship becomes positive and is significant only after 19 years of the decrease. For quantile number six, the estimates are positive and significant for all the period analyzed. Overall, the results with this specification are reassuring that there are indeed heterogeneous effects of tariffs on GDP per capita related to the initial share of manufacturing exports and that this relationship is not the outcome of the linearity assumption in the baseline results[16].

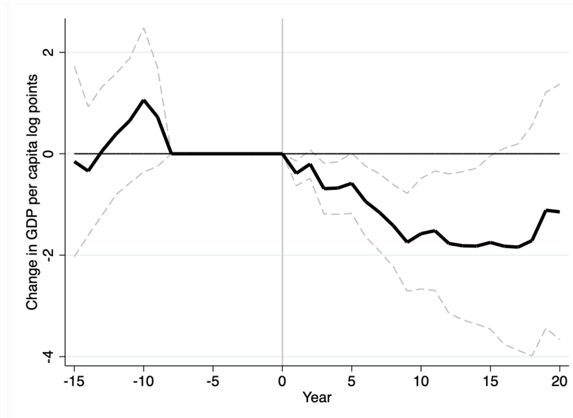
Second, in the baseline specification, I define the initial economic structure in a very specific way, namely, as the share of manufacturing exports in the five years before tariff reductions, and following the broad exports classification categories. Reassuringly, Figures A5, A6, A7 A8, A9 and A10 in the Appendix reveal that the effect heterogeneity is robust to several alternative specifications of the initial economic structure of countries, including Lall's classification of exports, revealed comparative advantage on manufacturing and a few alternatives to the lagged five-year average.

[16] I do not show the results for the third and fourth quantiles to keep the presentation simple, but they are both close to zero, consistent with the heterogeneity story.

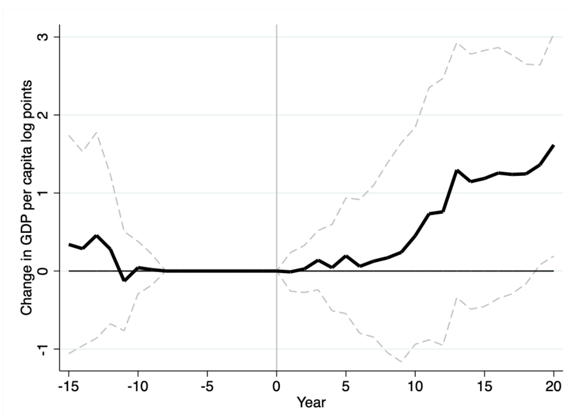
Figure 2.4: Average effects of tariff reductions on GDP per capita for quintiles of manufacturing exports



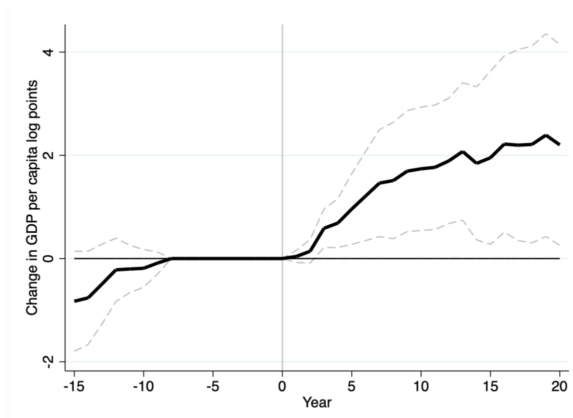
(a) First quantile



(b) Second quantile



(c) Fifth quantile



(d) Sixth quantile

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

In the Appendix, I further show that the baseline results are not driven by the specific GDP data on constant national prices from PWT that I use or by some leverage observations (or outliers). Figures A11, A12 and A13 provide robustness checks showing that the heterogeneity is also significant when using GDP per capita in constant national prices from other sources (either the World Development Indicators or the Maddison Project), and GDP per capita in constant PPP terms (from PWT). Figures A14, A15, A16, A17, A18 A19 and A20 show that the results are robust to the use of Huber (1964) weights, G. Li (1985)'s robust regression improvement on Huber weights and also hold with regressions without leverage points, following the methods proposed by Belsley, Kuh, and Welsch (1980).

2.5 Robustness

So far, I have shown that tariffs have different effects on GDP per capita for manufacturer and nonmanufacturer countries. I have also shown that the identifying assumption of parallel trends cannot be rejected, so the estimates may not be affected by biases from the surge in GDP that precedes tariff reductions. However, the validity of the baseline results still depends critically on the nonexistence of time-varying economic and/or political factors that might drive both changes in tariffs and changes in GDP (i.e., omitted variable biases) and thus potentially explain the estimates. Therefore, in this section I first investigate the validity of the results to important confounders in the tariffs-growth nexus.

Another source of potential concern is the biases that come from two-way fixed effects regressions, as highlighted by recent difference-in-differences literature. This literature has demonstrated that two-way fixed effect estimates under heterogeneous effects end up capturing terms beyond the causal effect of interest, so they might be severely biased (de Chaisemartin & d'Haultfoeuille, 2020; Sun & Abraham, 2021; Callaway & Sant'Anna, 2021; Goodman-Bacon, 2021; Callaway, Goodman-Bacon, & Sant'Anna, 2021). To address this concern, I follow the recent work by de Chaisemartin et al. (2022) precisely designed for cases where the treatment is continuously distributed in every time period, as is here.

I end this section by providing some important additional robustness checks.

2.5.1 Confounders

I perform the robustness investigation on confounders in five steps. First, I show robustness checks related to variables identified as important determinants of tariffs, coming from the endogenous trade policy literature. Second, I show robustness checks with respect to other policy changes that might be associated to changes in tariffs. Third, I show the robustness of the results to consideration of economic phenomena that have been found to be important for explaining growth. For these first three steps of the robustness exercises, I simply add four lags of changes in the covariates as done by Acemoglu et al. (2019)[17]. These specifications have to be interpreted with caution, since changes in these covariates may be endogenous to tariff changes, although using lags may relax this concern[18]. Fourth, I investigate the robustness of the effect heterogeneity to other possible heterogeneous effects from tariffs on growth. Finally, I investigate the robustness of the baseline results to different trends in GDP among groups of countries.

[17] I use a different specification only for the growth forecast variable, as explained below.

[18] I also run the regressions with contemporaneous changes in covariates instead of lags. The results, summarized in Figure B18, are qualitatively the same: heterogeneity still holds.

In short, this section confirms the validity of the baseline results after considering important covariates and thus confirms the existence of heterogeneity in the effects of tariffs on growth from initial economic structures. Instead of showing LP-DiD graphs for each robustness exercise, I summarize the results with Figure 2.5, which shows the average effect for both manufacturer and nonmanufacturer countries between 13 and 17 years after tariff reductions. Individual LP-DiD graphs for each robustness exercise can nonetheless be found in Appendix B.

Endogenous tariffs

Early in the 1980s, Findlay and Wellisz (1982) argued that trade policy in general and tariffs in particular are in practice set in response to political economy factors, particularly the active efforts or lobbying of interest groups. Important theoretical work by Mayer (1984) and Grossman and Helpman (1994) then provided formalization of this argument. These theoretical works triggered empirical work. The first factor identified to explain trade policy empirically was GDP growth. Bohara and Kaempfer (1991) presented evidence from the US that GDP growth leads to changes in tariffs—particularly, that high-growth export industries may lobby for lower tariffs to avoid future retaliatory trade policies abroad. The second factor identified was distribution itself. P. Dutt and Mitra (2002) provide evidence that higher inequality leads to higher trade protection in capital-abundant countries (arguably manufacturer countries) while lower protection in capital-scarce countries (arguably nonmanufacturer countries). And finally, Trefler (1993) shows that tariffs are particularly explained by import penetration. With data from US industries, the author provided empirical evidence that import penetration leads to lobbying and higher protection.

Given the determination of tariffs by growth, distribution itself and import penetration, the estimates might be biased if they fail to account for these potential channels of endogeneity. I explain below how I deal with these three factors.

Although the baseline framework already incorporates lags in growth rates, it might be that expectations on contemporaneous growth are what really drives tariff changes. To control for this possibility, I use growth forecast data from the World Economic Outlook of the IMF. Specifically, I calculate the change in the growth forecast for year t made in $t-1$ with respect to the growth forecast made in $t-2$. This change in the forecast captures the change in expected contemporaneous growth and thus may capture the driver of tariff changes from the GDP side, as suggested by the endogenous trade policy literature. Robustness exercise number 1 in Figure 2.5 summarizes the results of including the change in growth forecasts in the baseline specification. As can be seen, the effect heterogeneity survives this first exercise, with the average impact on GDP 13-17 years after a tariff reduction still negative for nonmanufacturer countries but positive for manufacturer countries[19].

To control for the potential endogeneity of tariff changes arising from distribution itself, I use the Gini coefficient from the Standardized World Income Inequality Database (Solt, 2020). The results are presented in robustness exercise number 2 in Figure 2.5. The average effects 13-17 years after the decrease in tariffs are still significant and of different signs for manufacturer and nonmanufacturer countries.

Finally, to control for endogeneity that may arise from import penetration, I use the share of imports in GDP from the World Bank. The results are presented in robustness exercise number 3 in Figure 2.5. The identified heterogeneity holds. A very interesting result, not shown in the figure, is that the coefficients of the changes in the share of imports in GDP are positive and significant across the whole period considered. Importing more is associated with higher growth, but tariff reductions are still associated with lower GDP for nonmanufacturer countries[20]. This might mean that the negative impact of tariff reductions for nonmanufacturer countries might derive from a mechanism other than trade volume.

Other policies

Tariff changes are usually decided in settings where countries are also changing other types of policies. The trade liberalization of the 1990s, for instance, was part of a broad set of market reforms aimed at liberalizing economies generally—an agenda known as the Washington Consensus (Williamson, 1990). Thus, the baseline estimates can potentially be driven by other policy changes, and checking the robustness to those changes becomes necessary.

First, I consider nontariff barriers, another important component of the trade policy regime. Estefania-Flores et al. (2022) recently provided the literature with a new measure of trade restrictions in government policy, which specifically accounts

[19] An important thing to note here is that the information on growth forecasts is available only from 1990. This is also reassuring of the validity of the baseline results, as the availability of data by country after 1990 becomes less biased towards developed countries. This also implies that the effect of tariff reductions that I estimate is essentially driven by the trade liberalization the 1990s.

[20] This result is actually in line with the finding by Yanikkaya (2003) where both tariffs and trade as a share of GDP are positively correlated with growth.

for nontariff barriers[21]. The results are presented in robustness exercise number 4 in Figure 2.5. The heterogeneity remains similar to that in the baseline results [22].

The second policy change that I test robustness for is capital account openness. Usually, trade liberalization occurs alongside capital account liberalization. The results are presented in robustness exercise number 5 in Figure 2.5. Reassuringly, the results again point to a significant effect heterogeneity.

Third, I test the robustness of the results to changes in institutional quality. As shown elsewhere, institutional quality is considered a fundamental to explain long-run economic outcomes (Acemoglu et al., 2019). The results are presented in robustness exercise number 6 in Figure 2.5. The effect heterogeneity holds.

Relevant variables that explain growth

Another threat to the validity of the baseline results comes from relevant covariates proven to affect GDP that might also be correlated with tariff changes. To provide reassurance on the validity of the baseline results, I control for each of them in turn.

First, I test for the possibility that the results might be affected by changes in human capital. The results are presented in robustness exercise number 7 in Figure 2.5. Changes in human capital do not drive the results, such that the heterogeneity of the effect of tariffs remains significant.

Second, I test the robustness of the results to changes in population size. The results are presented in robustness exercise number 8 in Figure 2.5. The heterogeneous effects of tariffs on GDP conditional on the initial economic structure remain similar to those found in the baseline.

Third, I test the robustness of the results to changes in trade as a share of GDP. Results are presented in robustness exercise number 9 in Figure 2.5. The heterogeneous effects of tariffs on GDP conditional on the initial economic structure once again remain significant. Additionally, changes in trade as a share of GDP are positively associated with GDP across the whole period studied, consistent with the finding regarding imports penetration.

[21] The measure is a count variable made up of dummies for subcategories of trade policy, and although it does not capture how restrictive policies are in themselves (e.g., import tariffs are captured with a dummy, ignoring the tariff level), it does provide a novel measure of how many restrictive trade policies a country has in each year. For the exercise, I use the variable that counts only nontariff barriers, excluding the dummy on tariffs, as they are already captured in the regressions.

[22] Although not shown here, changes in nontariff barriers have no significant effect on GDP in the whole period studied. This result contrasts with that presented by Estefania-Flores et al. (2022), where changes in trade restrictions in general (including the dummy on tariffs) were found to relate to a fall in GDP. I do replicate that result when controlling for the contemporaneous change in nontariff barriers instead of the four lags that I originally use. The effect heterogeneity from tariffs holds even in that case, as shown in Figure B19.

Fourth, I consider changes in capital accumulation, usually the short-run driver of growth. According to standard trade theory, countries with less abundant capital might choose to protect capital-intensive sectors such that changes in investment levels might provide reasons to change tariffs, thus biasing the estimates. The results are presented in robustness exercise number 10 in Figure 2.5. The heterogeneous effects remain significant.

Fifth, I test the results to changes in the real exchange rate. Tariff changes can be related to real exchange rates changes, that have been in turn shown to affect GDP (Rodrik, 2008), such that the baseline estimates might be biased. The results are presented in robustness exercise number 11 in Figure 2.5. The identified heterogeneity is still significant.

Finally, I test the robustness of the results to changes in the terms of trade. It can bee thought that the relation between tariffs and terms of trade runs only from the former to the latter, but I cannot discard a priori that changes in the terms of trade lead to changes in tariffs, biasing the baseline results. The results are presented in robustness exercise number 12 in Figure 2.5. The heterogeneity is still significant.

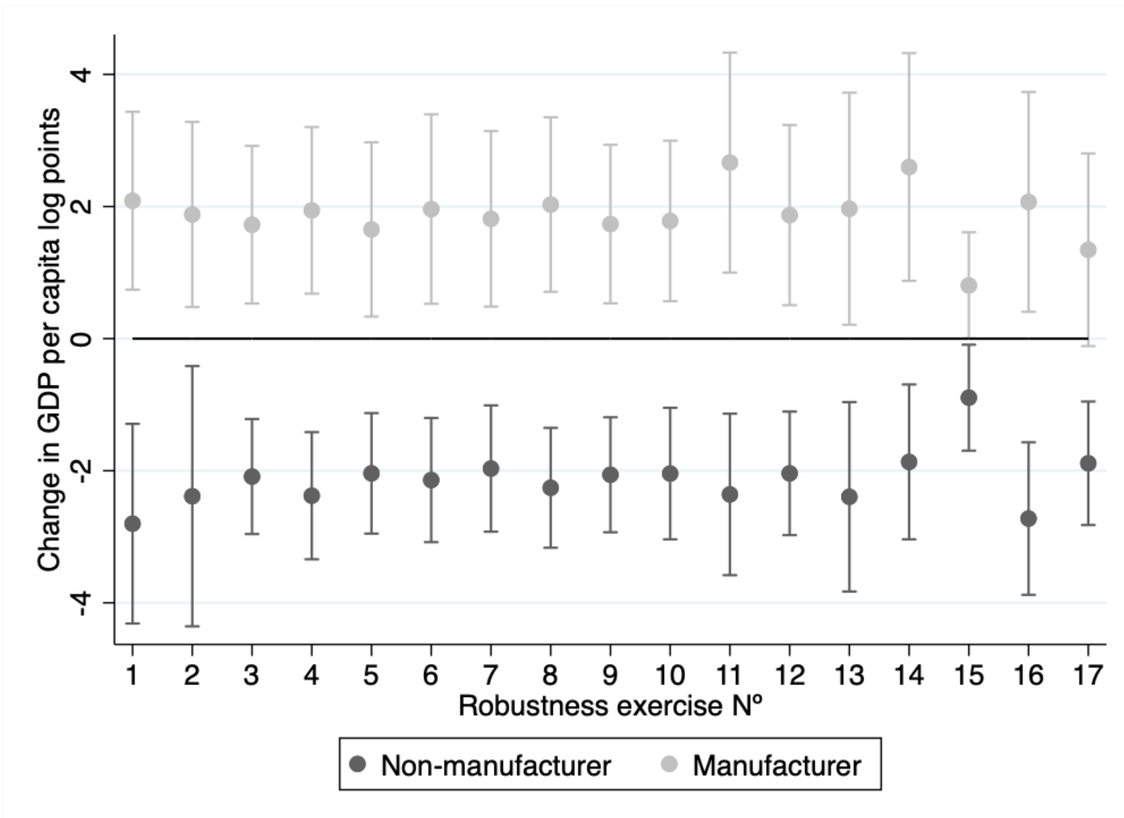
Other heterogeneous effects

The main point of this paper is that there are heterogeneous effects of tariffs on GDP in relation to the initial economic structure. Nevertheless, there might be other relevant heterogeneities at play in the effects of tariffs that might drive the results, making the estimates invalid. Two heterogeneous effects might be important. First, although I interpret the theoretical literature mainly pointing to heterogeneity from economic structures, some works talk about distance to the frontier (see Acemoglu, Aghion, and Zilibotti (2006) for an example) as the source of heterogeneity, which might be more adequately captured by initial income. Second, according to one of the models developed by Lucas (1988), uneven development might be the outcome of free trade if economic sectors differ in terms of their potential for human capital accumulation. In other words, human capital, rather than the economic structure, might be the source of heterogeneous effects of tariffs.

I first test the robustness of the results to the inclusion of an interaction between the change in tariffs and initial GDP per capita. To do so, I include in the regression the average GDP per capita for the five years before the change in tariffs and the multiplication of this term with the change in tariffs as covariates. The results are presented in robustness exercise number 13 in Figure 2.5, where I assume the median level of income to calculate the predicted values. The heterogeneity in relation to the initial economic structure still holds.

As mentioned, I also test the robustness of the results to a possible heterogeneous effect based on human capital accumulation. I introduce this possible source of heterogeneity in the same way that I did with the one coming from income. I include the average value of human capital in the five years prior to the change in tariffs and its multiplication with the change in tariffs in the regression. The results are presented in robustness exercise number 14 in Figure 2.5, where I assume the median level of human capital to calculate the predicted values. The effect heterogeneity still holds.

Figure 2.5: Robustness: average effect between 13-17 years after tariff reductions



Note: The estimates presented are the predicted values for the 10th and 90th percentiles of the distribution of initial manufacturing exports. The coefficients display the average of the average effect for each year between 13 and 17 years after tariff reductions. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level. Exercise 1 is the outcome of estimating equation 2.3 with the change in the growth forecast as a covariate. Exercise 2 is the outcome of estimating equation 2.3 with four lags of the change in the Gini coefficient. Exercise 3 is the outcome of estimating equation 2.3 with four lags of the change in import penetration. Exercise 4 is the outcome of estimating equation 2.3 with four lags of the change in nontariff barriers. Exercise 5 is the outcome of estimating equation 2.3 with four lags of the change in capital account openness. Exercise 6 is the outcome of estimating equation 2.3 with four lags of the change in Polity. Exercise 7 is the outcome of estimating equation 2.3 with four lags of the change in human capital. Exercise 8 is the outcome of estimating equation 2.3 with four lags of the change in the population size. Exercise 9 is the outcome of estimating equation 2.3 with four lags of the change in trade openness. Exercise 10 is the outcome of estimating equation 2.3 with four lags of the change in investment. Exercise 11 is the outcome of estimating equation 2.3 with four lags of the change in the real exchange rate. Exercise 12 is the outcome of estimating equation 2.3 with four lags of the change in the terms of trade. Exercise 13 is the outcome of estimating equation 2.3 with heterogeneous effects from income. Exercise 14 is the outcome of estimating equation 2.3 with heterogeneous effects from human capital. Exercise 15 is the outcome of estimating equation 2.3 with country fixed effects. Exercise

16 is the outcome of estimating equation 2.3 with different trends for country groups by income. Exercise 17 is the outcome of estimating equation 2.3 with different trends for country regions.

Interestingly, although not shown here, I also find that the interactions between human capital and changes in tariffs are negative and significant for most of the years studied. In other words, for countries with low levels of human capital, tariff reductions may lead to lower growth, while countries with high levels of human capital will gain in GDP terms from tariff reductions. Although not the focus of the paper, Lucas (1988)'s hypothesis receives support from the evidence found here.

Different trends

Up to this point, the most important threats to the validity of the finding of heterogeneous effects could come from countries (and specific groups of them) with either different time-invariant average growth rates or different trends in GDP. First, I test the robustness of the results to the inclusion of country fixed effects. Second, I add specific time trends for countries in different income groups. Third, I control for trends of different regions of countries. Reassuringly, the effect heterogeneity is robust to these checks, as shown in robustness exercises 15, 16 and 17 in Figure 2.5.

Overall, the results in Figure 2.5 are reassuring that there is significant heterogeneity in the effect of tariffs on GDP per capita depending on initial economic structures. Reducing tariffs has been bad for growth in nonmanufacturer countries but good in manufacturer countries. Although claiming causality is always difficult, I think these estimates are suggestive of a causal relationship. It is important to clearly establish the assumption that allows me to suggest a causal effect. Conditional on the inclusion of lags of growth rates and consideration of important covariates, changes in tariffs are assumed as good as random. Although there might be other phenomena that could drive both tariff changes and GDP per capita changes, the robustness exercises that further relax this assumption suggest that this is not likely the case[23].

2.5.2 Clean controls analysis

Recent contributions on difference-in-differences have shown that standard estimates based on two-way fixed effects regressions under the parallel trends assumption are not entirely reliable (de Chaisemartin & d'Haultfoeuille, 2020; Goodman-Bacon, 2021). This literature has shown that under treatment heterogeneity and differential treatment timing, estimates might be biased. The

[23]In Figure B19, I also show results of the estimates including all control variables at the same time. Although this exercise is extremely demanding, and I lose a lot of statistical power, the direction of the heterogeneous effects still holds and with statistical significance around 13 years after tariff changes. Overall, this reassures that the heterogeneity is not being driven by correlations between covariates, which were not captured when controlling for each covariate in turn.

biases arise from using units as part of the control group that, even though they may not receive any treatment in the period of interest, have been treated before. The solutions devised so far thus require the existence of "clean controls", that is, observations never treated or not treated before the time horizon at which the effect is estimated, which is the base for the new estimators that have been recently proposed (Callaway & Sant'Anna, 2021; Sun & Abraham, 2021; de Chaisemartin et al., 2022).

The baseline results can potentially be biased due to the use of "bad controls", as I used there all available country-year observations. In this setting, the treatment group comprised the observations with the largest changes in tariffs, in absolute value, while the control group was composed of countries with lower changes, in absolute value. Inference is thus made by exploiting variation in tariff changes. The problem, however, is that tariff changes at the country level occur every year, so heterogeneity in treatment timing is pervasive in this setting, and biases stemming from it could be as well. A country-year observation with a relatively low tariff change is a "bad control" because the effect can be larger for that country as compared to one with a large tariff change and also because that country might have experienced a tariff change before (de Chaisemartin & D'Haultfœuille, 2022). These two problems are actually pervasive in difference-in-differences analyses with treatments continuously distributed every time period[24].

A solution to estimating treatment effects with treatments continuously distributed every time period has been recently proposed by de Chaisemartin et al. (2022), and we therefore follow it closely. The authors propose to use movers as treatment observations and quasi-stayers as control observations. A quasi-stayer is defined as an observation where changes in treatment intensity (i.e., tariff changes) are almost negligible, so that assuming treatment doesn't change is justifiable. It is actually easy to identify quasi-stayers in the tariffs-growth setting. In most years since 1960, countries do not really change their average tariffs, but slight variation still appears in the data, even perhaps in some cases due to errors in the data collection process. More specifically, the 25th percentile of tariff changes is -0.76 percentage points, and the 75th percentile is 0.35 percentage points, so that most tariff changes are relatively small. Therefore, to differentiate between movers and quasi-stayers, I propose a definition for *relevant* tariff changes. A tariff change is *relevant* if it is one-standard-deviation separated from the mean tariff change[25]. The implication of

[24]The now widely used estimators proposed by Callaway and Sant'Anna (2021) or Sun and Abraham (2021) are not helpful for the tariffs-growth cross-country setting studied in this paper, as they are not suited to continuous treatments that might change every time period.

[25]This is in a sense similar to the LP application by Girardi, Paternesi Meloni, and Stirati (2020) analyzing dynamic effects of public spending.

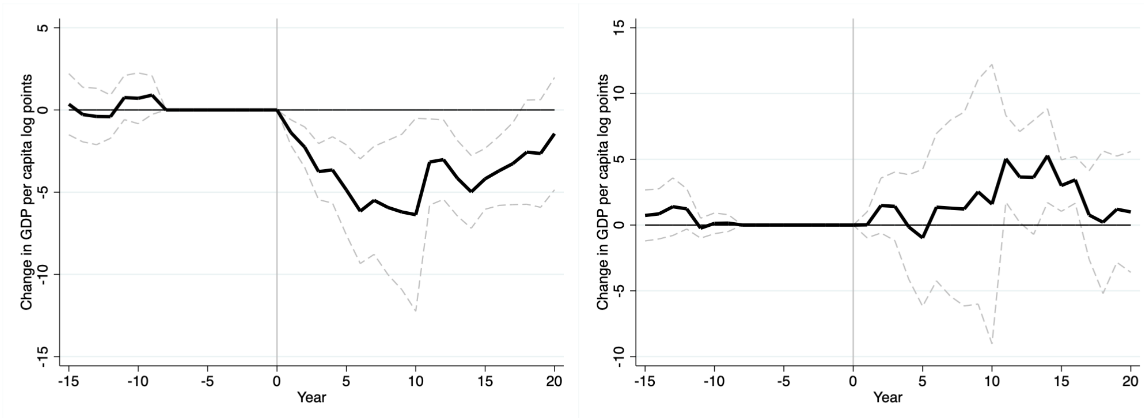
this definition is that quasi-stayers are those observations with tariff changes that are not *relevant* and the movers are those with *relevant* ones[26].

The previous definition is not enough to circumvent the problem of "bad controls". For example, an observation of a country in 1995 with no *relevant* tariff change, a quasi-stayer, is still a "bad control" if that country experienced a *relevant* tariff change in 1990. Moreover, tariffs have been in place way before 1960 and countries usually experience more than one *relevant* tariff change in the sample, so having "clean control" observations in this setting is almost impossible. Nevertheless, what matters to get a "clean control" country-year observation is not that the country never experienced a *relevant* tariff change before, but that the dynamic treatment effect of that previous treatment has stabilized at the moment of the analysis (Dube et al., 2023). In other words, what matters is that the *relevant* tariff change of 1990 led to a new GDP level as compared to control observations that has stabilized in 1995, and thus the quasi-stayer observation in 1995 is not in a differential trend as compared to the movers in that year. When have the effects of tariff changes stabilized in this setting? By observing Figure 2.3, it seems treatment effects stabilize approximately ten years after tariff reductions. Based on that, I further assume that a quasi-stayer country-year observation can only be used as a control if the country has not experienced a *relevant* tariff change in the previous ten years, what I call the ten-year rule[27].

[26] In Figures B20 and B21 in the Appendix, I verify the robustness of results to the use of different thresholds for defining *relevant* tariff changes, particularly half standard deviation and two standard deviations. The effect heterogeneity holds.

[27] In Figure B22 in the Appendix, I relax this assumption, by imposing that a quasi-stayer can only be part of the control group if the unit was not treated in the previous twenty years. Results still deliver the effect heterogeneity, but significance is only preserved for nonmanufacturer countries.

Figure 2.6: Clean controls analysis of heterogeneous effects of tariff reductions on GDP per capita



(a) For nonmanufacturer countries

(b) For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

I thus implement a clean controls analysis following de Chaisemartin et al. (2022) by relying on the definition of movers and quasi-stayers based on *relevant* tariff changes and on the ten-year rule. In practice, that means estimating the LP-DiD specification from equation 2.3 but only including both mover and quasi-stayer observations that satisfy the ten-year rule.

The results of this clean controls analysis are shown in Figure 2.6. They are much noisier than those of the baseline, as I lose not only variation in tariffs (*relevant* tariff changes happening a couple years after another one are not included) but also observations to compare them with (quasi-stayer observations are also excluded as some of them might be "bad" by the effect of a previous treatment). Nevertheless, for nonmanufacturer countries the effect of reducing tariffs is negative in the whole period and significant for almost all of it. For manufacturer countries, on the other hand, the effect is positive almost for all the horizon analyzed, and significant from 10 to 17 years after tariff reductions. In short, the baseline results are not driven by the use of "bad controls".

2.5.3 Additional robustness

The empirical analysis so far may still be subject to criticism with respect to two issues. First, it could be the case that the correlations between past and future growth depend on whether a country is a manufacturer and that global shocks (captured by year fixed effects) might be also different depending on manufacturing status. Second, when regressing the cumulative change in GDP at time $t+h$ on the tariff change observed at time t, I ignore tariff changes occurring between $t+1$ and $t+h$, which may lead to biases, as highlighted by Teulings and Zubanov (2014).

As mentioned, the relationship between past and future growth could depend on whether a country is a manufacturer. If so, then by estimating a single set of lagged growth controls for all countries, any heterogeneity in these correlations is effectively relegated to the error term. By the same token, it could be the case that the experience of global shocks, as captured by year fixed effects, might differ based on whether the country is a manufacturer. If this is the case, controlling for interactions between the initial economic structure and year fixed effects might capture potential biases from it. The results are presented in Figures B23 and B24 and confirm the baseline findings.

What if the impact of tariff changes that I estimate for the period $t+9$ is really the outcome of tariff changes happening not at t, the treatment year, but five years later? Although Teulings and Zubanov (2014) show that this effect might not be entirely ignored in the baseline specification, they show that ignoring all tariff changes can lead to biases. Thus, the robustness check is to include in the baseline framework, equation 2.3, all tariff changes occurring before $t+h$, not only that in time t, following their proposed solution. The results of this exercise are presented in Figure B25 in the Appendix. Although the estimates are less precise, as statistical power is lost, the effect heterogeneity holds.

2.6 Mechanisms

In this section, I study the mechanisms by which tariff reductions may lead to lower GDP per capita for nonmanufacturer countries but higher for manufacturers. The evidence suggests that the mechanisms in the trade theory revised have empirical support, although this investigation can not rule other things might be also at work.

I particularly explore the impact of tariff reductions on four variables: i) productivity, ii) capital accumulation, iii) manufacturing share of GDP, and iv) share of imports in GDP. I use the following specification to analyze these potential channels:

$$y_{c,t+h} - y_{c,t-1} = \beta^h \Delta TA_{c,t} + \theta^h int_{c,t} + \phi^h m_{c,t} + \sum_{j=1}^{8} \sigma_j^h g_{c,t-j} + \sum_{j=1}^{8} \gamma_j^h \Delta y_{c,t-j} + \alpha_t^h + \epsilon_{c,t}^h \tag{2.5}$$

where, unlike in the baseline specification, $y_{c,t}$ refers to one of the four variables explored, so the specification also includes eight lags of the first difference in each of them. The regression preserves the lags in GDP growth rates and time fixed effects from the baseline regression. I once again graph the impact of a one-standard-deviation reduction in tariffs for nonmanufacturer and manufacturer countries.

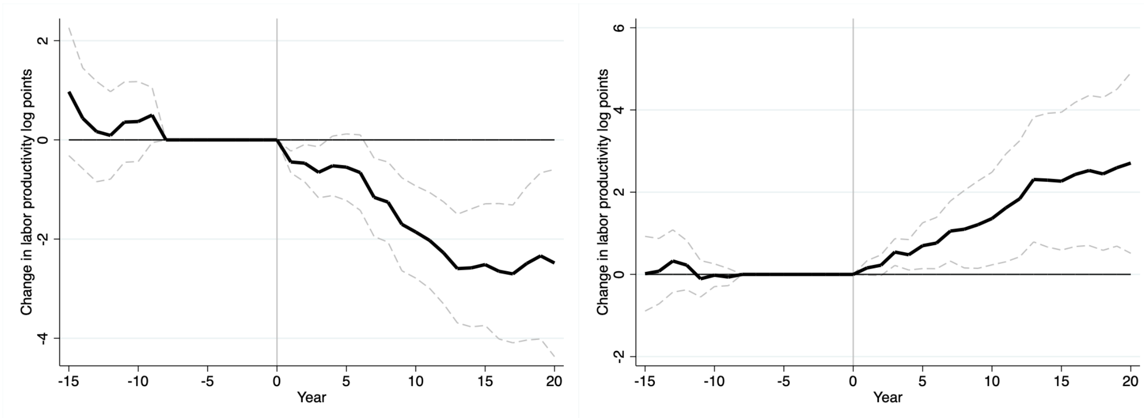
Tariff reductions lead to lower productivity in nonmanufacturer countries while higher for manufacturer ones, as shown in Figure 2.7[28]. According to the trade theory reviewed, that's precisely the effect heterogeneity expected in productivity terms. More deeply, reducing tariffs lead nonmanufacturer countries to specialize in the less dynamic sector, abandoning production in the more dynamic sector, so that productivity at the aggregate level ends up falling. In the same vein, reducing tariffs may increase productivity and growth in manufacturer countries, as it allows full specialization in the more dynamic sector and the associated productivity gains. The results in productivity are also statistically significant for all the horizon of analysis studied and economically meaningful (i.e., more than 2 percent reduction in productivity as the result of a one-standard-deviation decrease in tariffs).

As portrayed in Figure 2.8, the dynamics of capital accumulation after tariff reductions are also heterogeneous: falling stocks of capital for nonmanufacturer countries while increasing for manufacturers. Results are also statistically significant for all the horizon of analysis. In the same line as the previous results, as production in the more dynamic sector falls (increases) in nonmanufacturer (manufacturer) countries, capital accumulation might also fall (increase), given that the dynamic sector is more capital intensive than the average of the economy. One can also make sense of these results as they relate to the idea that capital accumulation moves in the same direction as productivity, as demonstrated extensively by the development accounting literature (Klenow & Rodriguez-Clare, 1997; Hsieh & Klenow, 2010)[29].

[28]In Figure C1, I also show estimates of total factor productivity (TFP) dynamics after tariff reductions. The results point to the same heterogeneity for all the horizon of analysis but effects are only significant around 15 years after tariff reductions.

[29]The effects on capital accumulation in this literature come from TFP changes, not labor productivity ones, which anyways is consistent with the results shown in Figure C1.

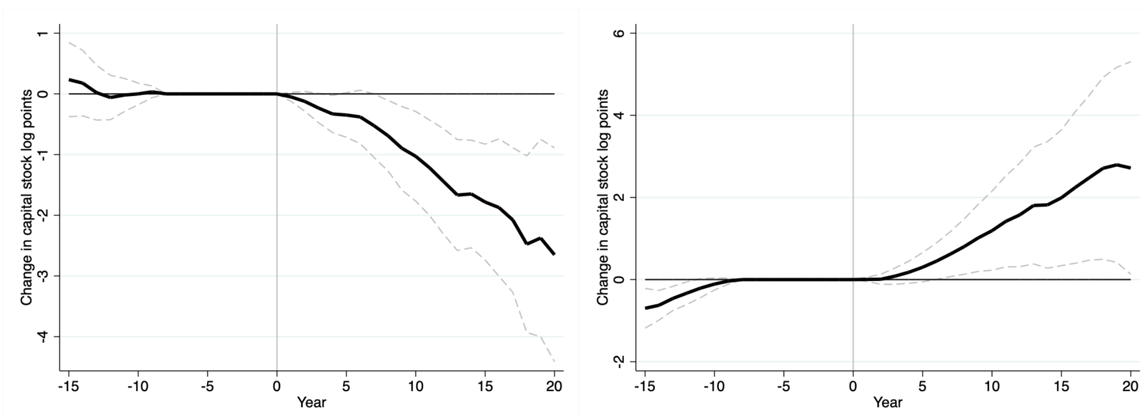
Figure 2.7: Average effects of tariff reductions on labor productivity



(a) Nonmanufacturer countries **(b)** Manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure 2.8: Average effects of tariff reductions on capital accumulation

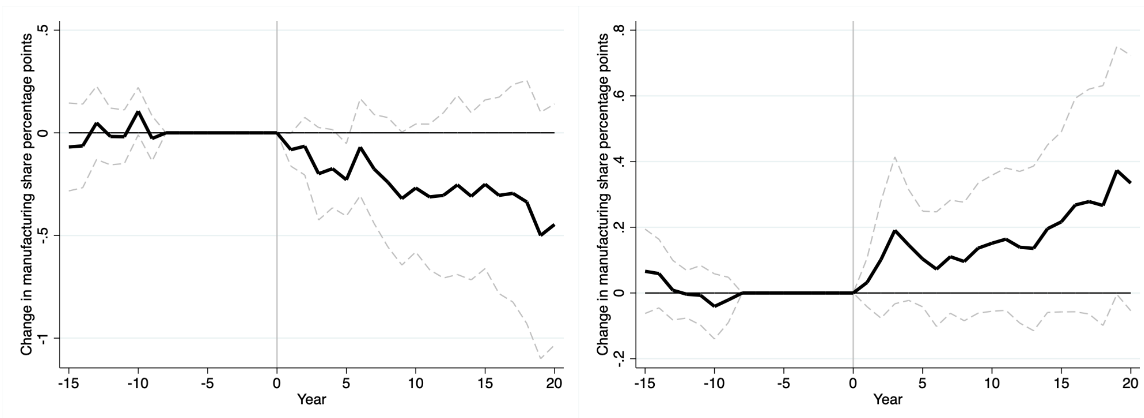


(a) Nonmanufacturer countries **(b)** Manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

According to theory, the effect heterogeneity is ultimately driven by changes in the pattern of production specialization for each type of country. Figure 2.9 presents evidence in support of this mechanism. Tariff reductions lead to lower manufacturing shares of GDP for nonmanufacturer countries, but higher for manufacturer countries. Although the results are not significant, the direction of the effects is consistent across the whole horizon of analysis. These results suggest that tariff reductions make nonmanufacturer countries to specialize more on non-manufacturing production, while manufacturer countries to strengthen its manufacturing specialization[30]. This respecialization mechanism can be also thought as the driver of the heterogeneous effects in both productivity and capital accumulation.

Figure 2.9: Average effects of tariff reductions on the manufacturing share of GDP



(a) Nonmanufacturer countries **(b)** Manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

The heterogeneous effects of tariff reductions on manufacturing shares of GDP also relate to other strands of the literature on macroeconomics of development. First, developing economies have experienced premature reductions in their manufacturing shares of GDP in the last thirty years, arguably driven by globalization as suggested by Rodrik (2016). The evidence here presented for nonmanufacturer countries, arguably a similar group to developing countries, might be understood as backing this argument. Second, the evidence suggests manufacturing is the more dynamic sector in the economy, as analytically considered in theory. In that sense, the evidence might also be in line with that presented by Rodrik (2013), according to which manufacturing is different to all other broad economic sectors in that it is characterized by unconditional convergence at the cross-country level.

Finally, I also explore the dynamics of the share of imports in GDP after tariff reductions, as revealed in Figure C2. Results reveal that the share of imports in GDP does not significantly change after tariff reductions, for both nonmanufacturer and manufacturer countries. A priori, an increase in the share of imports is expected for both types of countries, given that imports are now relatively cheaper for both.

[30]Although manufacturing shares of GDP provide a good proxy, the ideal data to test the relocation mechanism are manufacturing shares of employment. Cross-country data on sectoral shares of employment is however scant.

The relocation mechanism discussed above might provide a way to understand why this is not the case. As nonmanufacturer countries deindustrialize, import demand for intermediate and capital goods might also fall, given the manufacturing sector is more reliant on them, so that even though imports of these type of goods are now cheaper the volume imported nonetheless falls. For manufacturer countries, on the other hand, the strengthening of the manufacturing sector might lead to a reduction of the import elasticity of demand, so that even though imports of manufacturing goods are now cheaper, the volume imported does not increase. Nevertheless, more work is needed to test the validity of these reasonings.

2.7 Conclusion

In this paper, I establish that the relationship between tariffs and growth is characterized by sharp heterogeneous effects by economic structure. In other words, I unveil the existence of heterogeneous effects of tariffs on GDP per capita depending on the initial share of manufacturing exports. More precisely, I show that the widespread reduction in tariffs around the world since 1960, particularly strong in the last 30 years, has reduced GDP per capita for nonmanufacturer countries, but increased GDP per capita for manufacturers. I establish this result by making use of a local projections difference-in-differences (LP-DiD) estimator, by which I am able to calculate the dynamic effects of tariff reductions and also control for the surge in GDP that precedes tariff reductions, to avoid it to bias the estimates. Overall, the estimates suggest that a one-standard-deviation reduction in tariffs (i.e., 3.65 percentage points) leads to an average fall (increase) of more than 2 percent in GDP per capita fifteen years later for nonmanufacturer (manufacturer) countries. The effects persist even twenty years after tariff reductions.

Although establishing causality is always difficult, the multiple robustness checks that I perform point to a solid heterogeneous relation running from tariffs to economic growth. I provide a detailed discussion of potential confounders that might be behind the effect heterogeneity documented in the paper, and reassuringly on all these robustenss the effect heterogeneity holds. Moreover, I also address recent challenges to estimating average treatment effects as highlighted in the recent difference-in-differences literature, deploying the idea by de Chaisemartin et al. (2022) of comparing movers and quasi-stayers through the LP-DiD specification.

I also show some evidence on the potential channels underpinning these heterogeneous effects of tariffs on growth. On the one hand, tariff reductions lead to lower productivity and capital accumulation for nonmanufacturer countries. On the other, tariff reductions lead to higher productivity and capital accumulation for manufacturer countries. I also show that both these changes and those on GDP might at the end be explained by changes in the manufacturing share in

GDP, although results are not statistically significant. In particular, the evidence in this paper can be interpreted as supporting Rodrik (2016)'s story of premature deindustrialization, according to which developing countries have experienced early reductions—in relation to their status of development—in their manufacturing shares in GDP due to globalization in the last 30 years.

The empirical evidence that I find in this paper calls for a more nuanced view on the effects of tariffs on growth. The common view in economics, according to which a liberal trade regime is the best policy option, is not warranted. The evidence suggests that for nonmanufacturer countries trade liberalization has had a negative impact on their incomes. The paper suggests that trade protection would have impeded deindustrialization and allowed better productivity dynamics in these countries. Although the empirical evidence does not show any discernible effect of increasing tariffs, it might be possible that trade policy, hand in hand with other measures of so-called industrial policy, might encourage production in more dynamic sectors and thus higher productivity levels for nonmanufacturer countries. More work, however, is needed to clarify the validity of this argument. More generally, bridging this trade policy literature with the burgeoning one on industrial policy provides, in my opinion, an interesting venue for future research.

Appendix

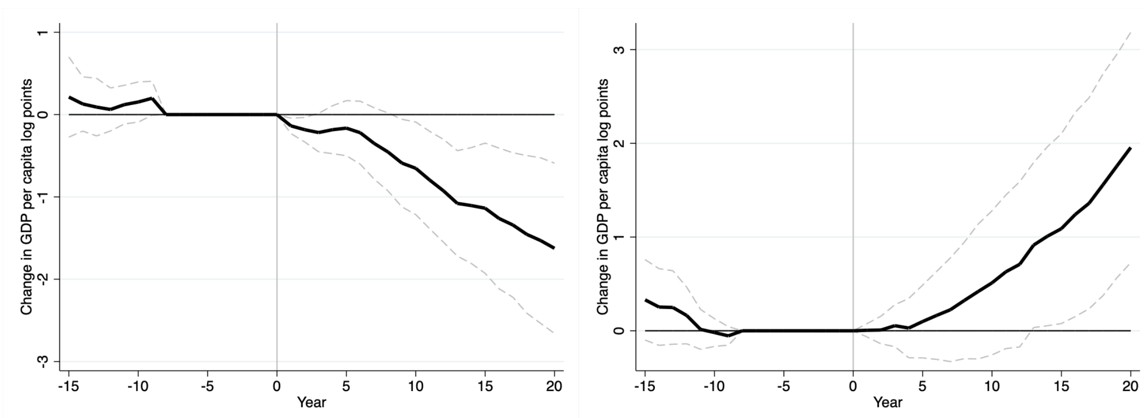
The Appendix is structured using the same section structure of the main text. In other words, each section in the main text has a corresponding one here in the Appendix, and the order is the same as in the main text.

A Baseline results

Effects of increases and decreases of tariffs

The following two graphs present the average results associated to decreases of tariffs, on the one hand, and increases, on the other.

Figure A1: Average effects of tariff reductions on GDP per capita

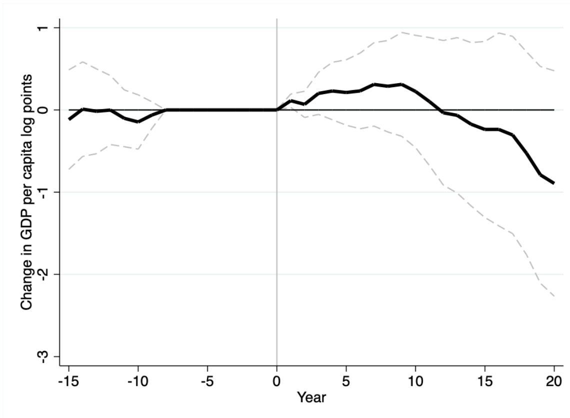


(a) For nonmanufacturer countries **(b)** For manufacturer countries

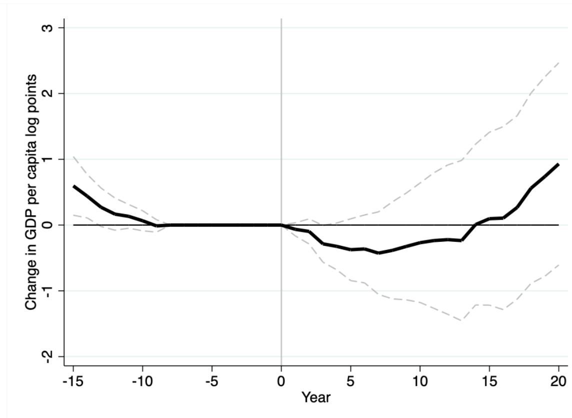
Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

As it can be observed in Figure A1, tariff reductions are associated with GDP falls for nonmanufacturer countries and GDP increases for manufacturer countries. On the other hand, the effect of tariff increases, show in Figure A2, is not significant across the whole period for both type of countries.

Figure A2: Average effects of tariff increases on GDP per capita



(a) For nonmanufacturer countries



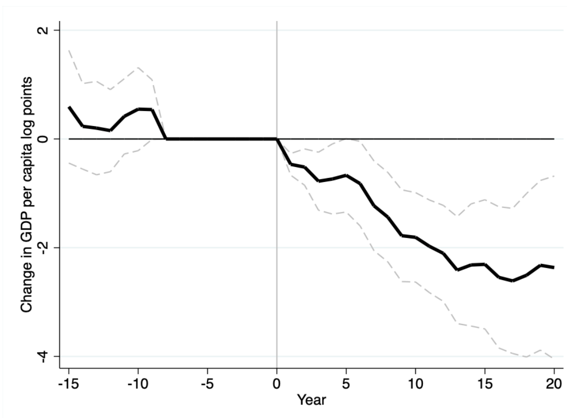
(b) For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

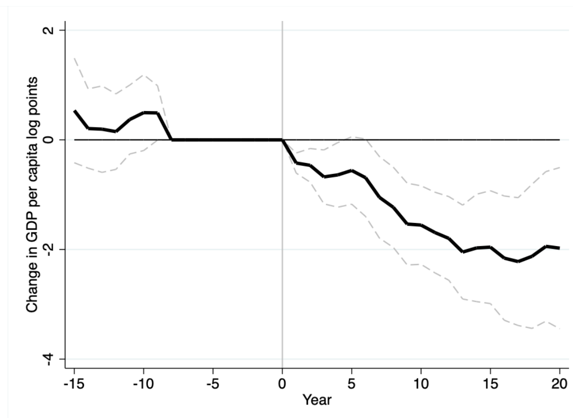
Effects at different level of initial shares of manufacturing exports

In the main text, I present the effects of a decrease in tariffs on growth for countries with two different levels of initial shares of manufacturing exports—what can be called manufacturer and nonmanufacturer countries. Here I show the impact for different levels of manufacturing exports, given the linear specification of the heterogeneous effects specified in equation 2.3.

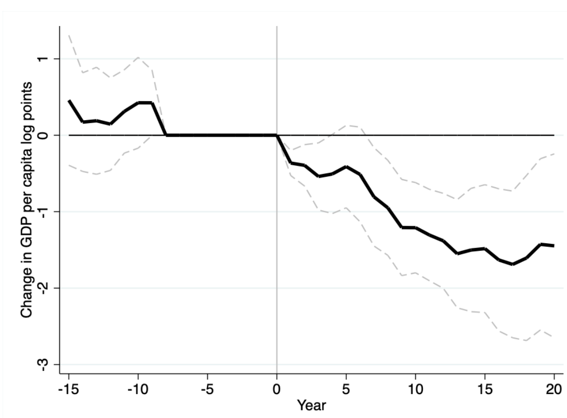
Figure A3: Average effects of decreases in tariffs on GDP per capita at different level of initial manufacturing exports, part 1



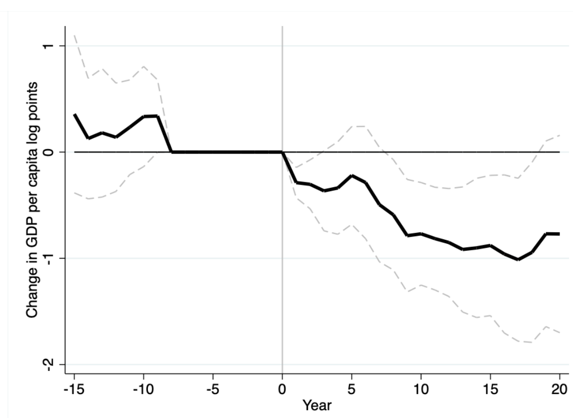
(a) 10th percentile



(b) 20th percentile



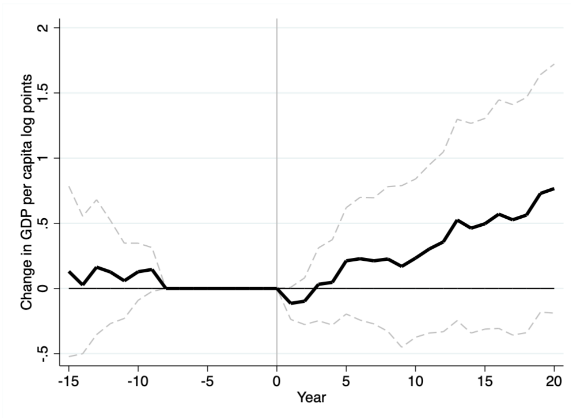
(c) 30th percentile



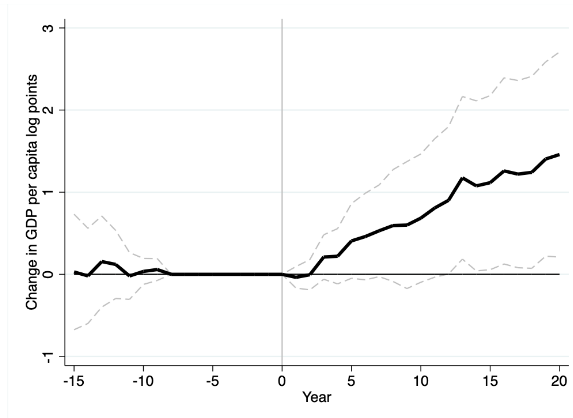
(d) 40th percentile

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

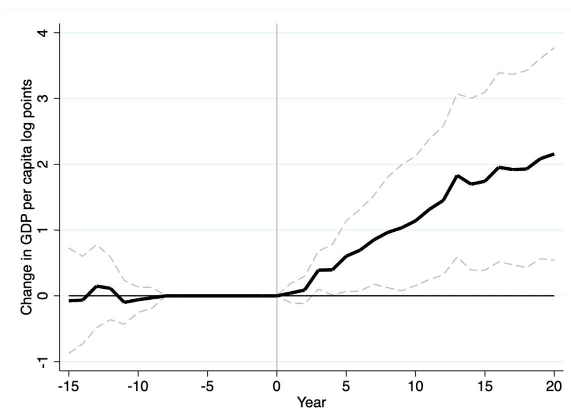
Figure A4: Average effects of tariffs on GDP per capita at different level of initial manufacturing exports, part 2



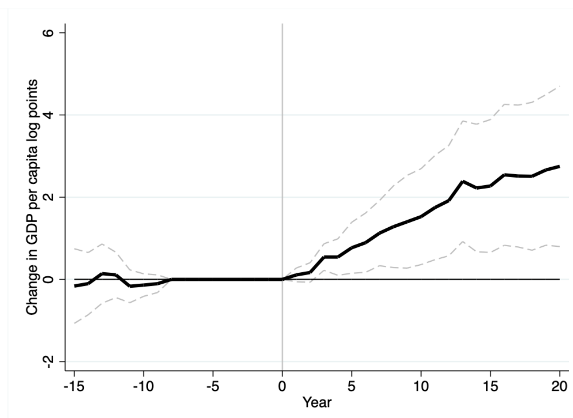
(a) 60th percentile



(b) 70th percentile



(c) 80th percentile



(d) 90th percentile

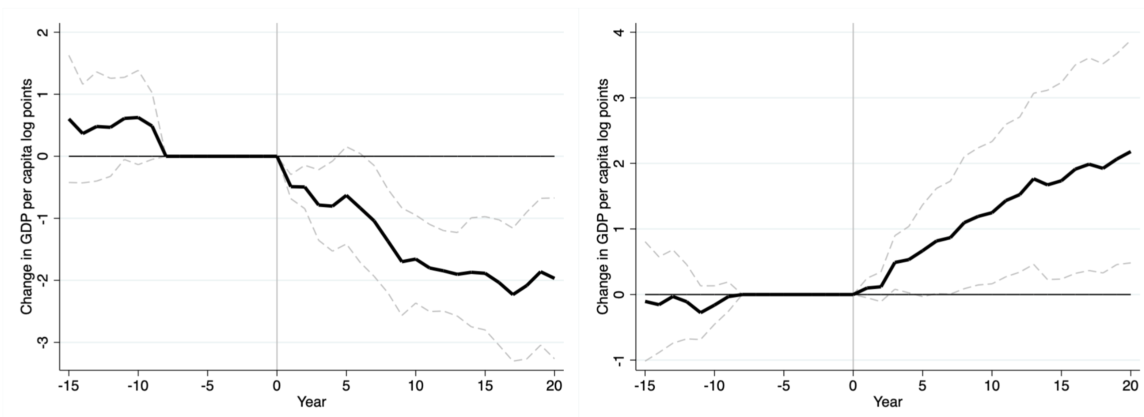
Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figures A3 and A4 show that at least for the top 30 percent of the distribution of manufacturing exports, there is a positive effect on GDP of tariff reductions , while for the bottom 40 percent of the distribution, the impact is negative.

Alternative specifications of initial economic structure

I show here that the results are robust to different specifications of the initial economic structure. In the baseline specification, I define the initial economic structure as the average of the previous five years of the share of manufacturing exports, following the broad classification of goods in the SITC. Here, I replace this definition with six alternative ones. First, I use the average of the previous five years of the share of manufacturing exports, following Lall's (2000) classification. Second, I use the average of the previous five years of the revealed comparative advantage in manufacturing exports, using the broad category classification. Then, following the specifications proposed by Acemoglu et al. (2019) in a similar exercise, I define the initial economic structure as the first lag of the share of manufacturing exports, the value of manufacturing exports in 1962 (the first year for which trade data are available), the value of manufacturing exports in 1970, and, finally, the value in 1980.

Figure A5: Average effects of tariff reductions on GDP per capita, using Lall's (2000) classification

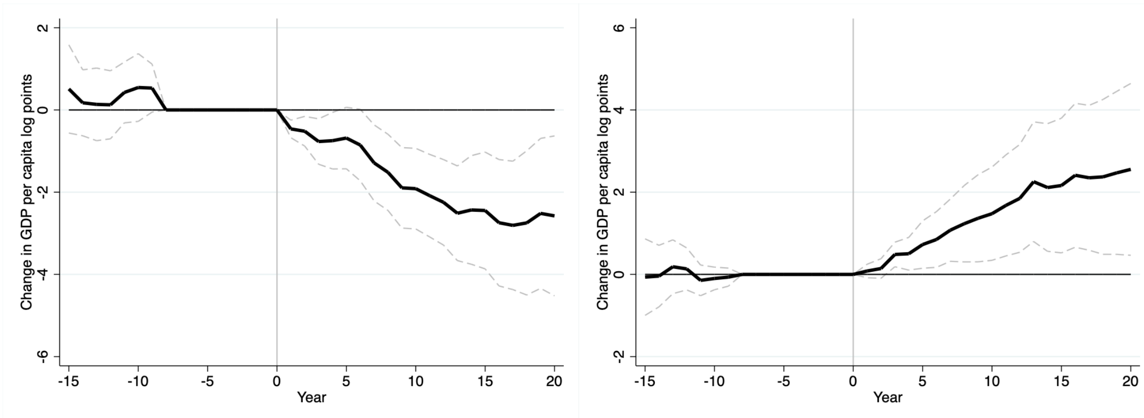


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: Initial economic structure is defined as the average of the previous five years of the share of manufacturing exports, using Lall's (2000) classification. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A5 reveals the result of using the initial economic structure defined using manufacturing exports with Lall's (2000) classification. The effect heterogeneity is still significant.

Figure A6: Average effects of tariff reductions on GDP per capita, using revealed comparative advantage

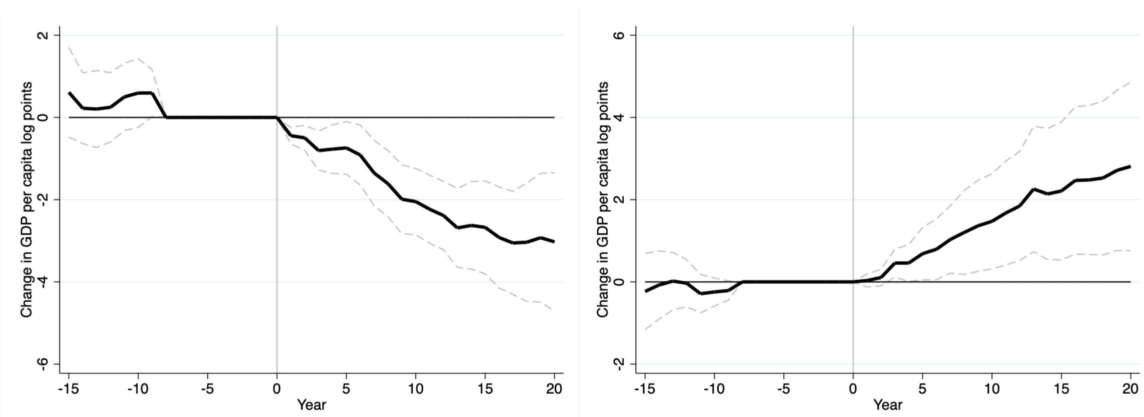


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: Initial economic structure is defined as the average of the previous five years of revealed comparative advantage in manufacturing exports. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A6 reveals the results when I use revealed comparative advantage instead of the share of manufacturing exports. The results are virtually the same as those in the baseline.

Figure A7: Average effects of tariff reductions on GDP per capita, 3rd alternative definition of initial economic structure

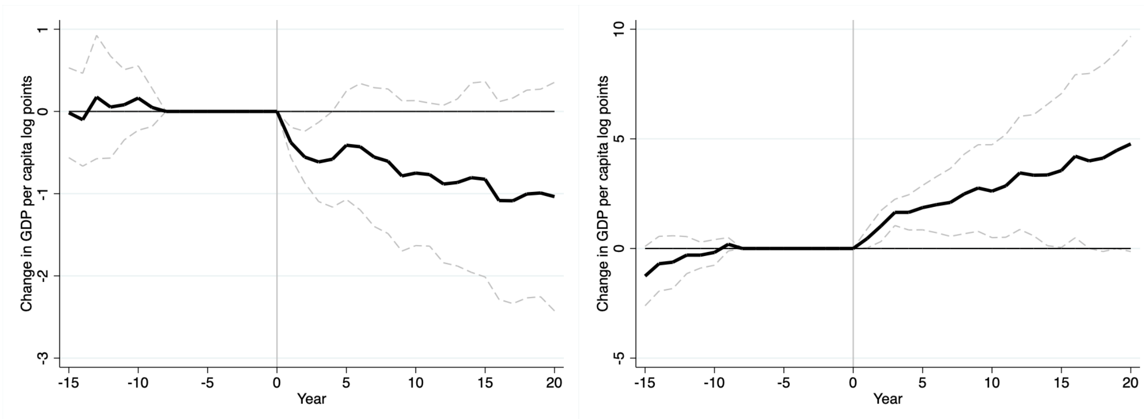


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: Initial economic structure is defined as the first lag of the share of manufacturing exports. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A7 reveals the results where the initial economic structure is defined by the first lag of the share of manufacturing exports. The heterogeneity in the results still holds.

Figure A8: Average effects of tariff reductions on GDP per capita, 4th alternative definition of initial economic structure

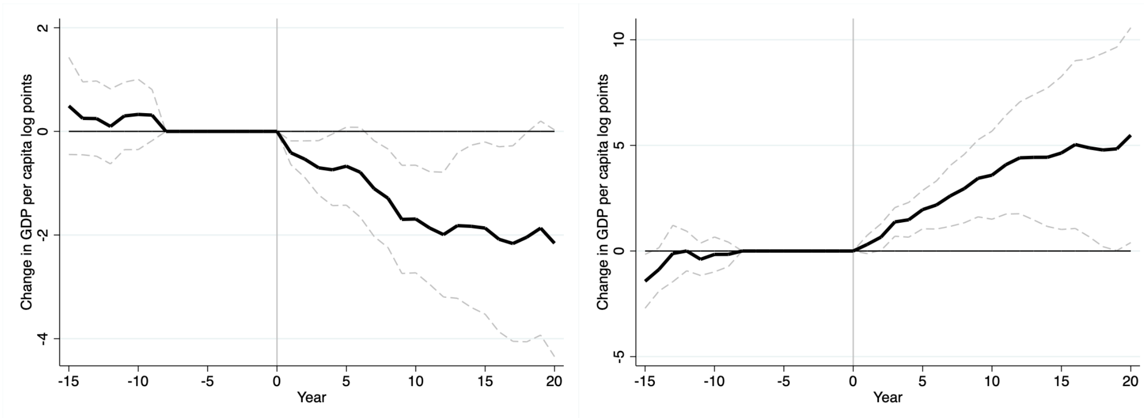


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: Initial economic structure is defined as the the share of manufacturing exports in 1962. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A8 reveals the results where the initial economic structure is the value of the share of manufacturing exports in 1962, the initial year of the trade data. The heterogeneity still holds, but the results are less precise, as the data for 1962 is scarcer.

Figure A9: Average effects of tariff reductions on GDP per capita, 5th alternative definition of initial economic structure

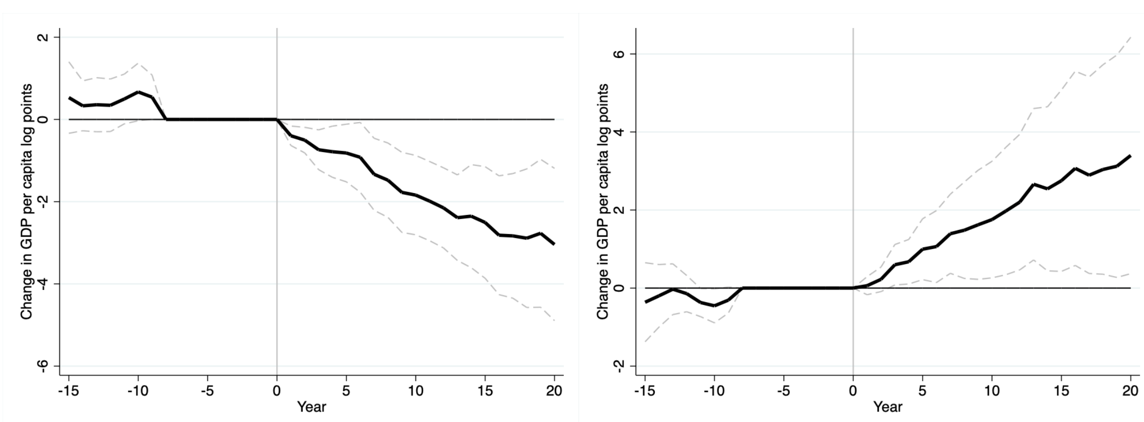


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: Initial economic structure is defined as the the share of manufacturing exports in 1970. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A9 reveals the results where the initial economic structure is the value of the share of manufacturing exports in 1970. The heterogeneity still holds.

Figure A10: Average effects of tariff reductions on GDP per capita, 6th alternative definition of initial economic structure



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: Initial economic structure is defined as the the share of manufacturing exports in 1980. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

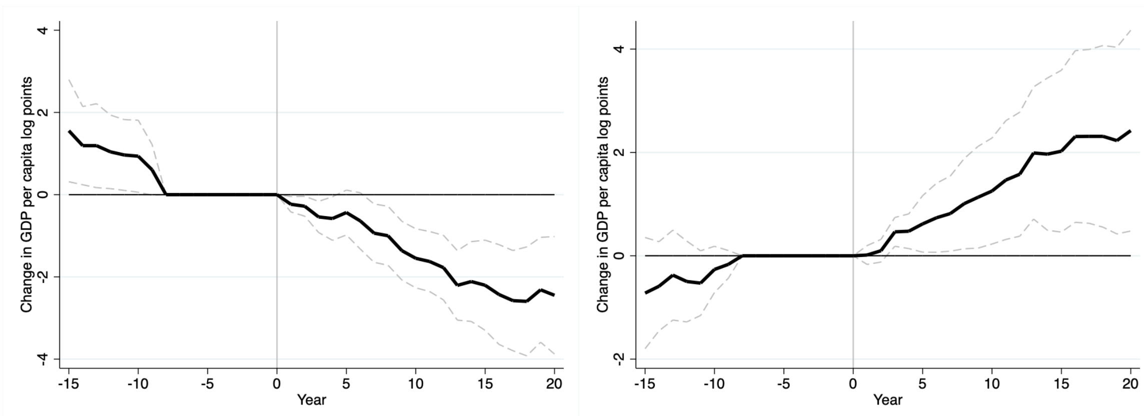
Figure A10 reveals the results where the initial economic structure is given by the value of the share of manufacturing exports in 1980. The heterogeneity in the results is still significant, and the magnitudes of the effects are even bigger.

Alternative GDP data for growth rates

I show here that the baseline results are robust to alternative GDP data and that the heterogeneous effects of tariffs do not rely on the specific data used in the baseline.

Figure A11 reveals the results when I use GDP per capita from the World Development Indicators (WDI) in constant national prices. The effect of reducing tariffs is negative and significant for nonmanufacturer countries and positive and significant for manufacturer countries.

Figure A11: Average effects of tariff reductions on GDP per capita, data from WDI

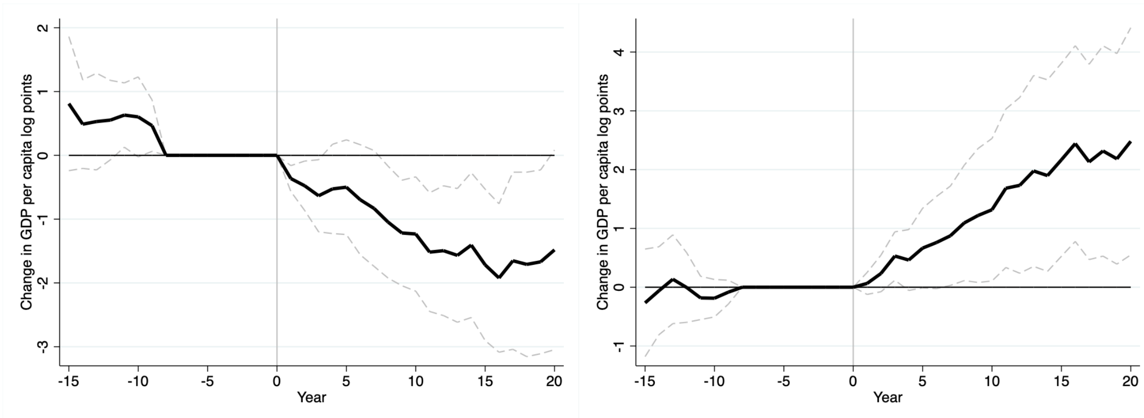


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The GDP per capita data used for this figure are in constant national prices from the WDI. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A12 reveals the results when I use data from the Maddison Project (Bolt & van Zanden, 2020). The estimates are more erratic but still point to significant heterogeneity in the effects of tariffs on growth depending on the initial economic structure.

Figure A12: Average effects of tariff reductions on GDP per capita, data from the Maddison Project

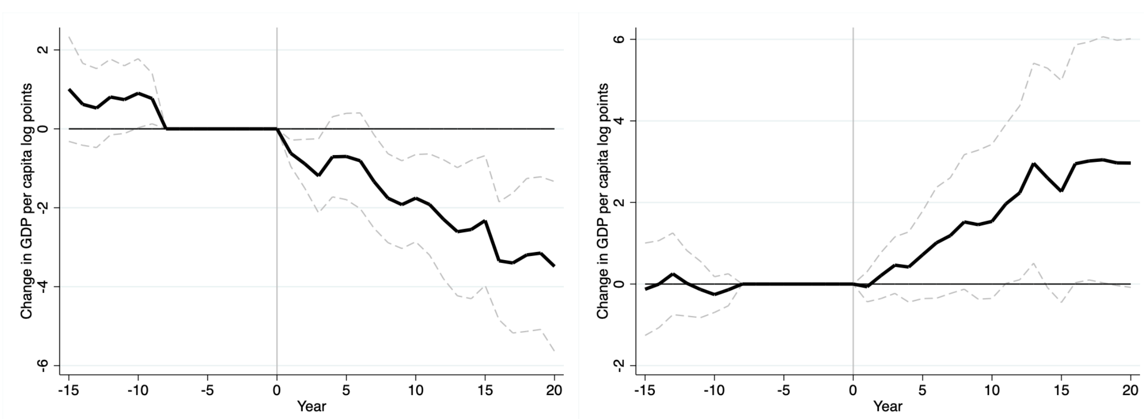


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The GDP per capita data used for this figure are in constant national prices from the Maddison Project. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Finally, in Figure A13 I present the results based on GDP per capita data in purchasing power parity (PPP) constant terms from Penn World Table (PWT) 10.0. The results are negative and significant for nonmanufacturer countries and positive but mostly insignificant for manufacturer countries.

Figure A13: Average effects of tariff reductions on GDP per capita, data in PPP from PWT



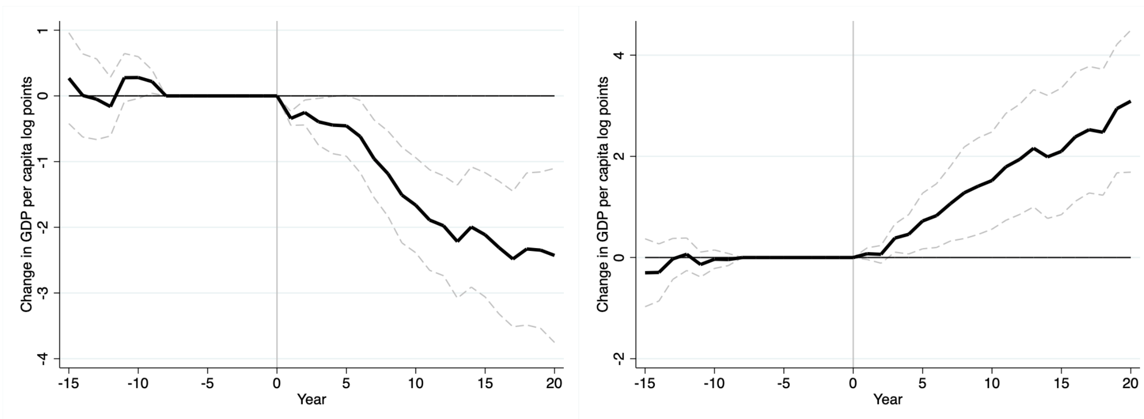
(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The GDP per capita data used for this figure are in PPP constant terms from PWT 10.0 The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Robustness to outliers and leverage points

I show here that the results are robust to the use of robust regression methods and consideration of the influence of leverage points.

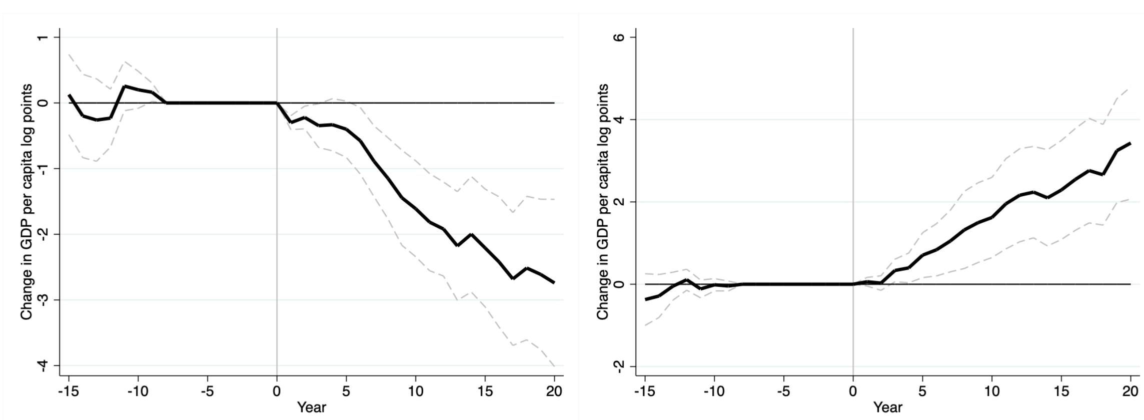
Figure A14: Average effects of tariff reductions on GDP per capita, regression with Huber weights



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A15: Average effects of tariff reductions on GDP per capita, Li's robust regression

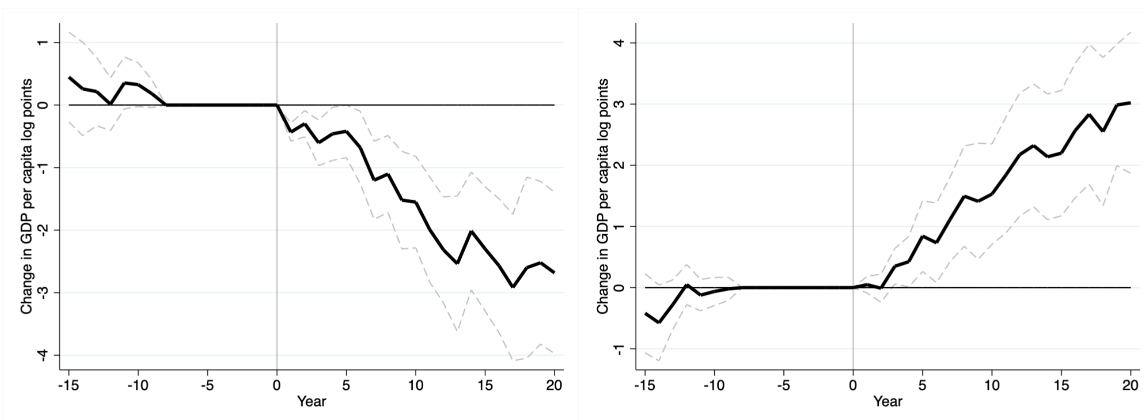


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A14 reveals the results of using Huber (1964) weights and Figure A15 shows the results of using G. Li (1985)'s robust regression, deemed an improvement on Huber weights. The heterogeneity in the results is still significant and the magnitude of effects is bigger.

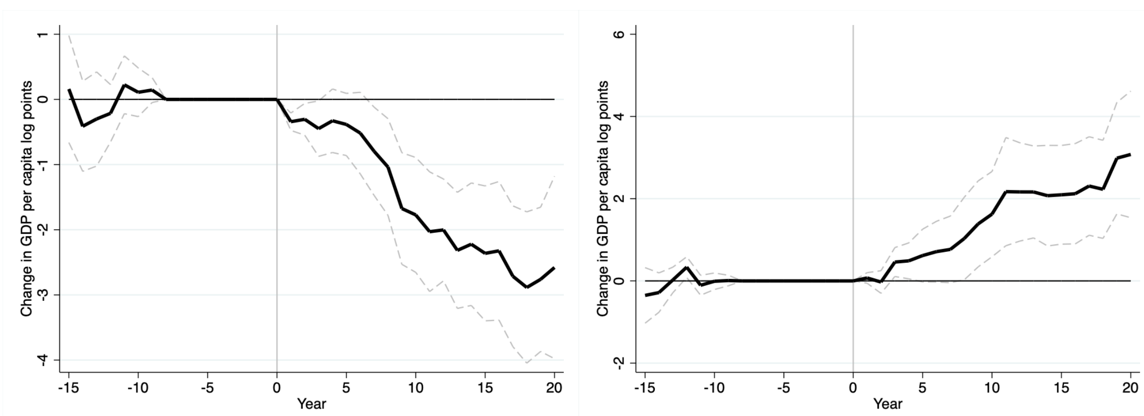
Figure A16: Average effects of tariff reductions on GDP per capita, removing Cook's distance leverage points



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A17: Average effects of tariff reductions on GDP per capita, removing R-standardized leverage points

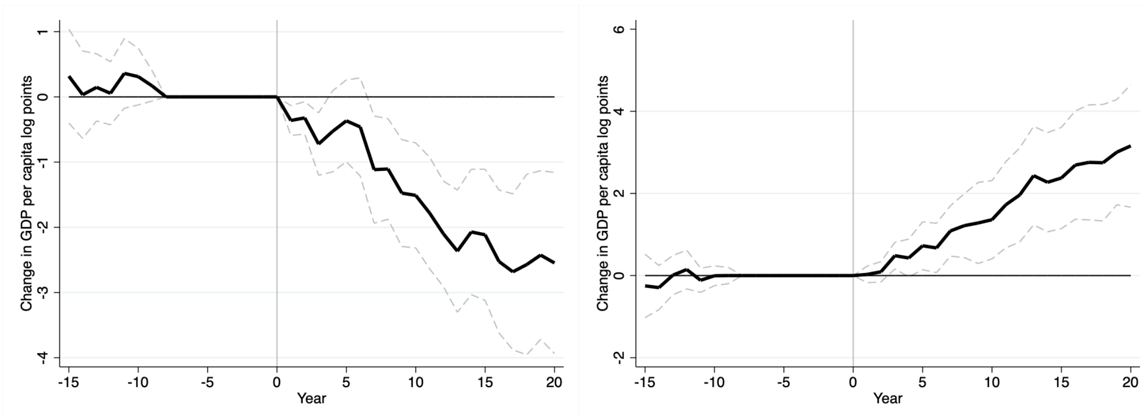


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

I also consider the influence of leverage points by following the methods of deletion proposed by Belsley et al. (1980). Figures A16, A17, A18, A19 and A20 reveal that the results are robust to deletion of Cook's, R-standardized, Dfits, Hat and Covratio outliers, respectively.

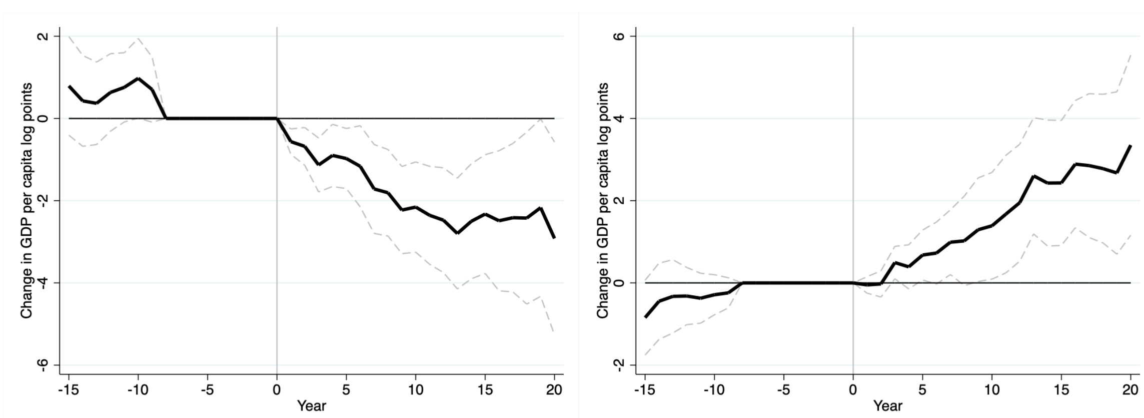
Figure A18: Average effects of tariff reductions on GDP per capita, removing Dfits leverage points



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

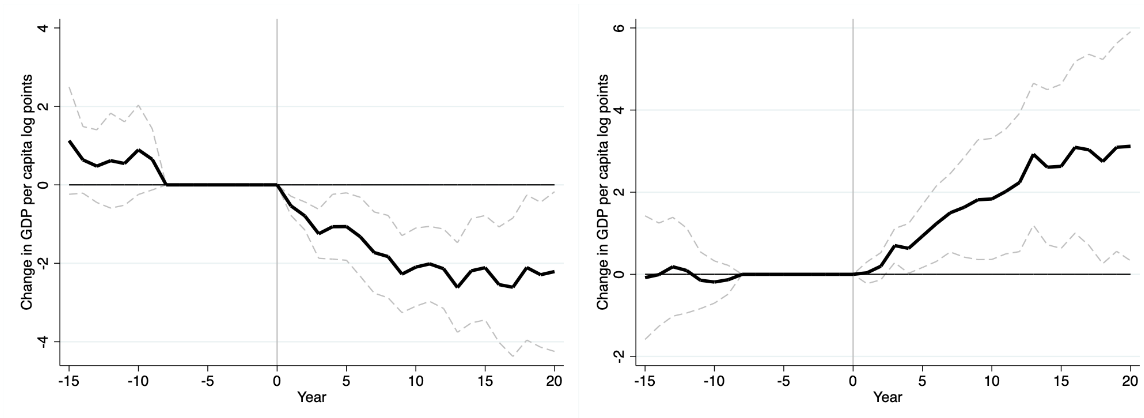
Figure A19: Average effects of tariff reductions on GDP per capita, removing Hat leverage points



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure A20: Average effects of tariff reductions on GDP per capita, removing Covratio leverage points



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

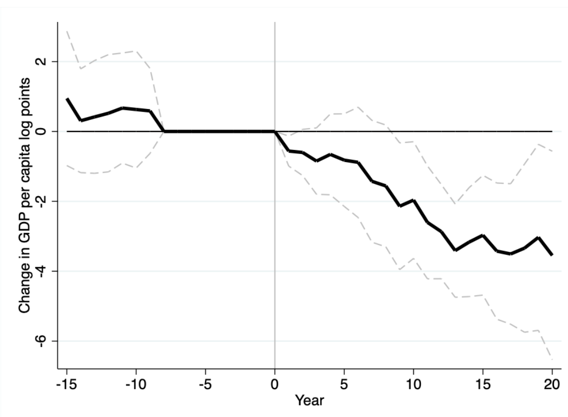
B Robustness

Confounders

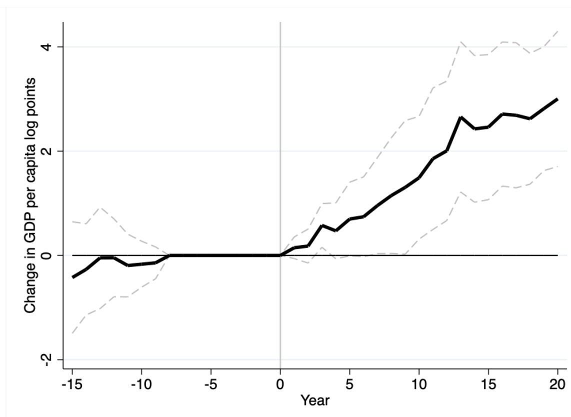
The following graphs show the average effects of tariff reductions, controlling once at a time for all relevant covariates discussed in the main text, and as summarized in Figure 2.5. Effect heterogeneity is preserved in all cases.

Endogenous tariffs

Figure B1: Average effects of tariff reductions on GDP per capita, controlling for the change in the growth forecast



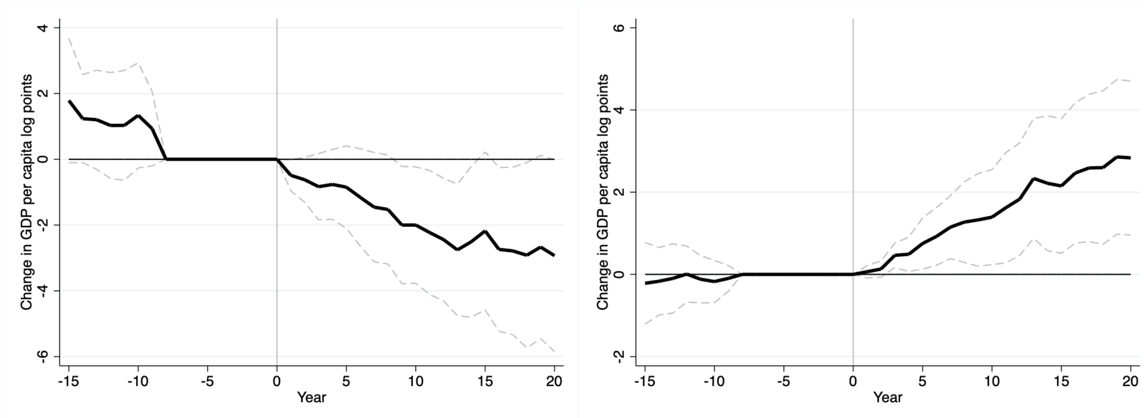
(a) For nonmanufacturer countries



(b) For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

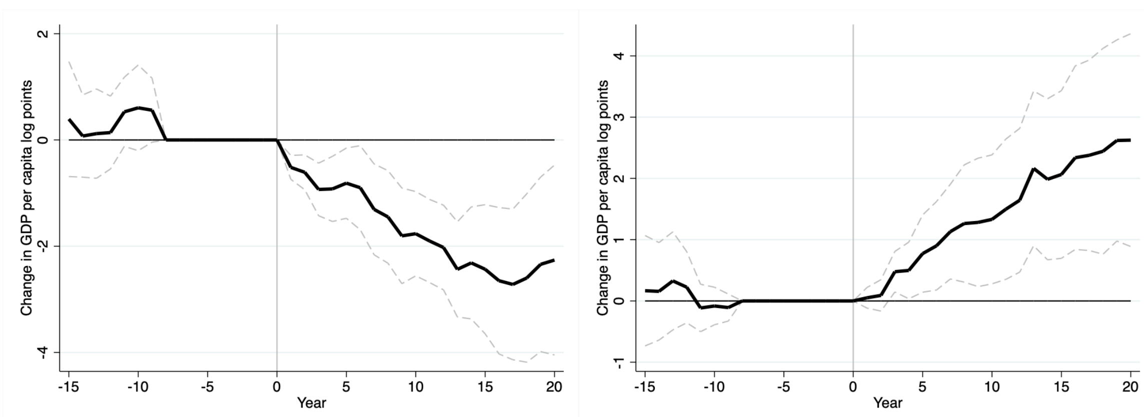
Figure B2: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in the Gini coefficient



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B3: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in import penetration

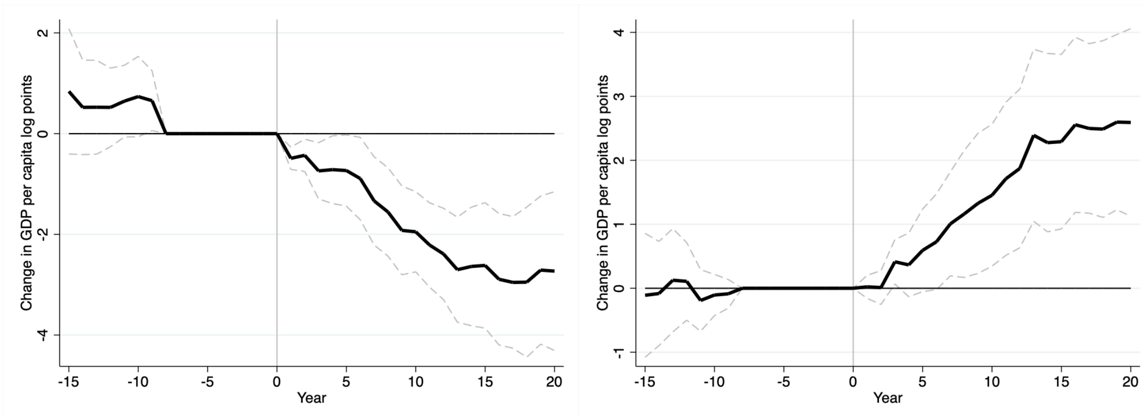


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Other policies

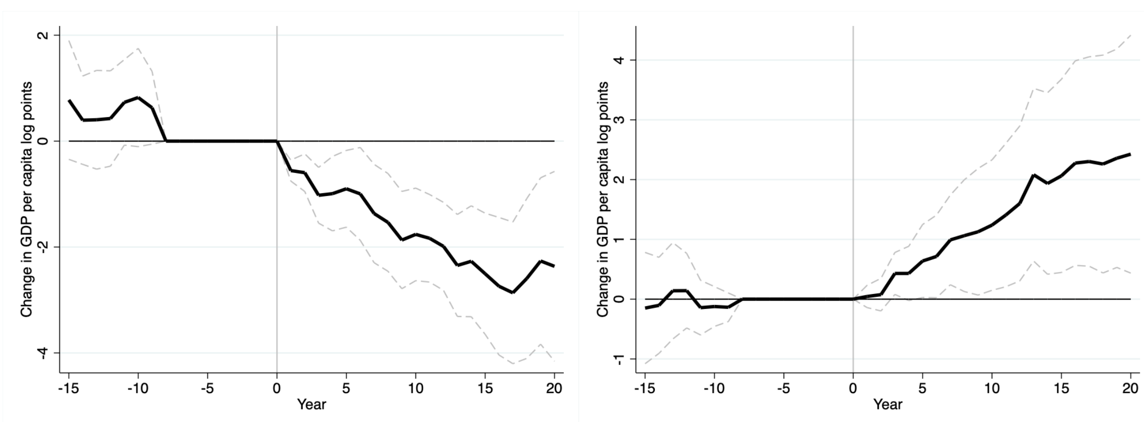
Figure B4: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in nontariff barriers



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

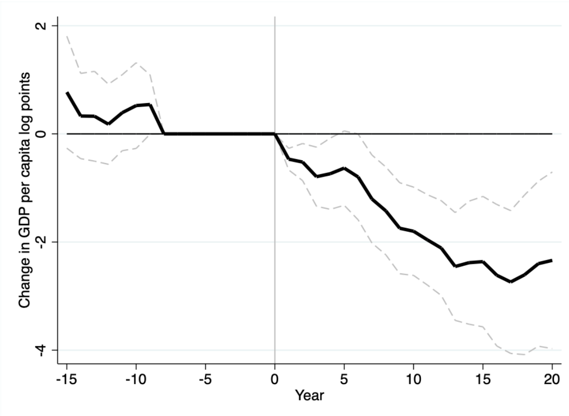
Figure B5: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in capital account openness



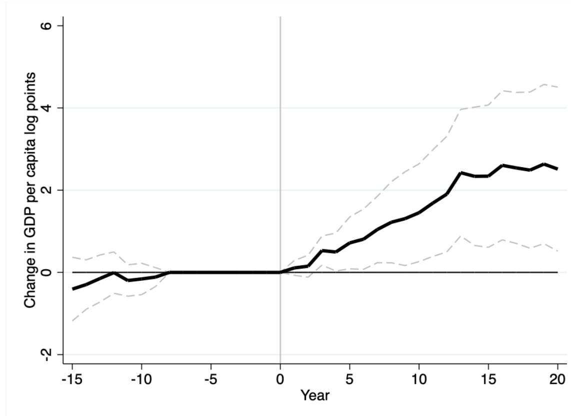
(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B6: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in Polity



(a) For nonmanufacturer countries

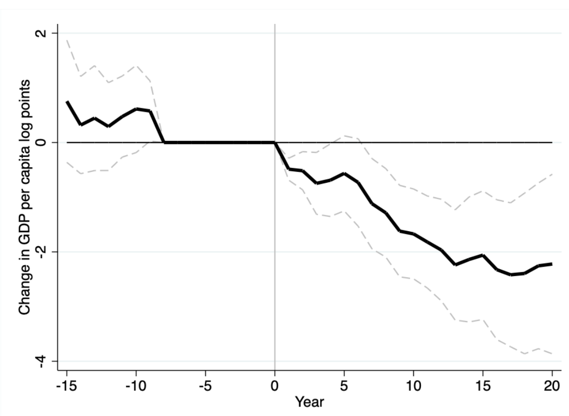


(b) For manufacturer countries

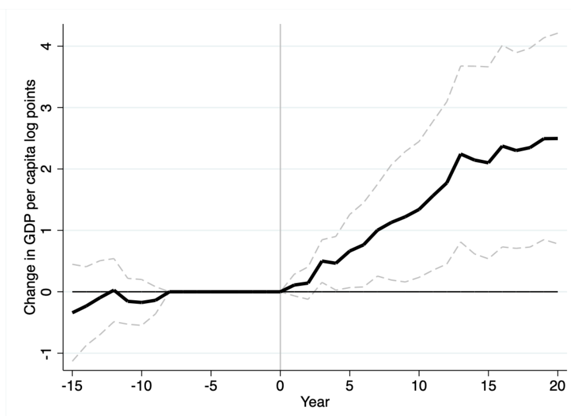
Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Relevant covariates

Figure B7: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in human capital



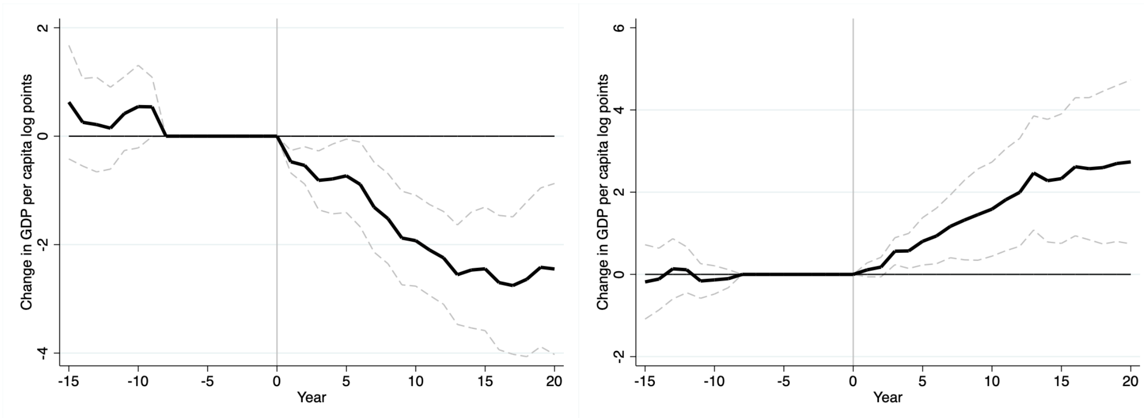
(a) For nonmanufacturer countries



(b) For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

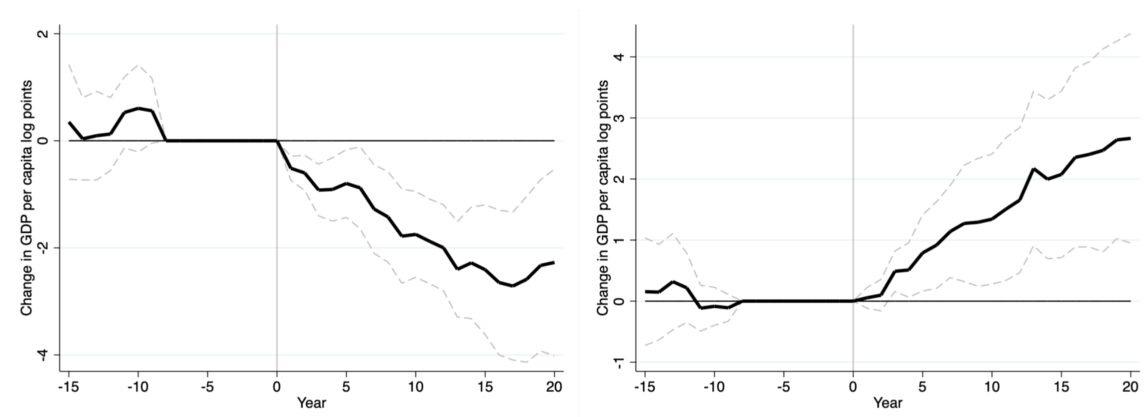
Figure B8: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in population size



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

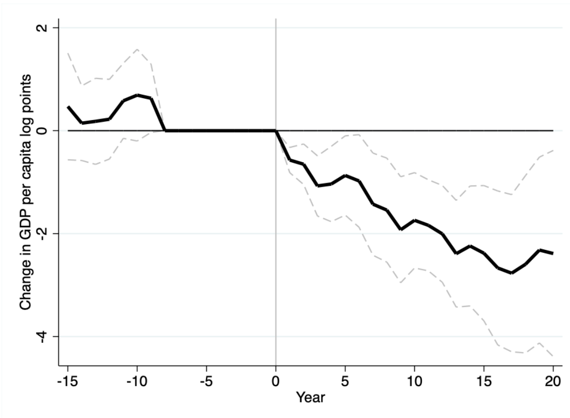
Figure B9: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in trade as share of GDP



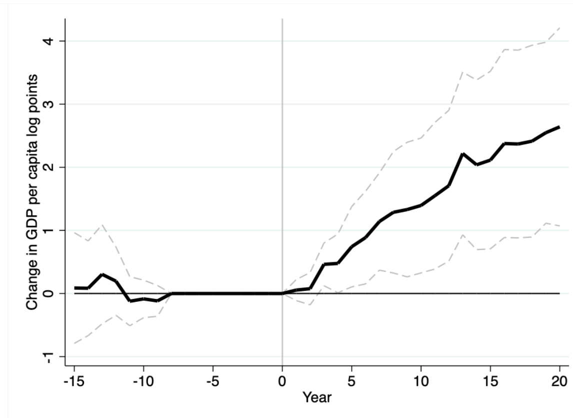
(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B10: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in investment



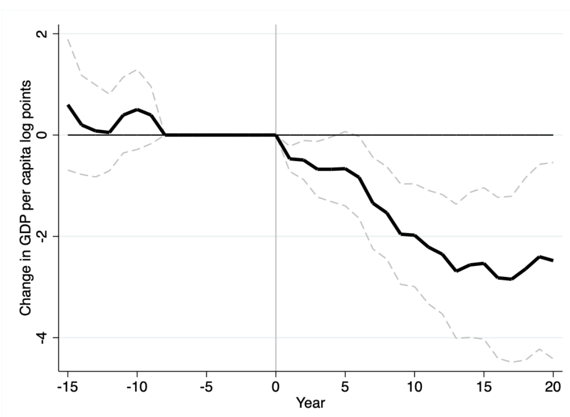
(a) For nonmanufacturer countries



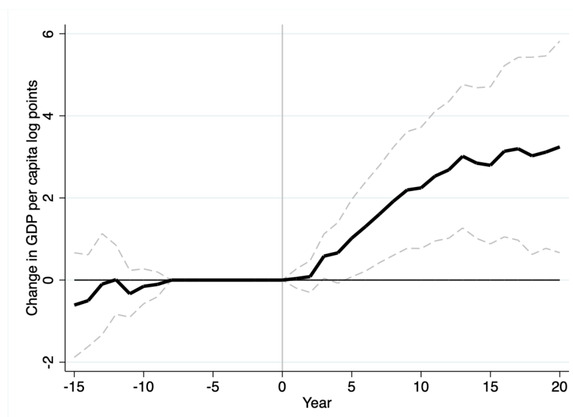
(b) For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B11: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in real exchange rates



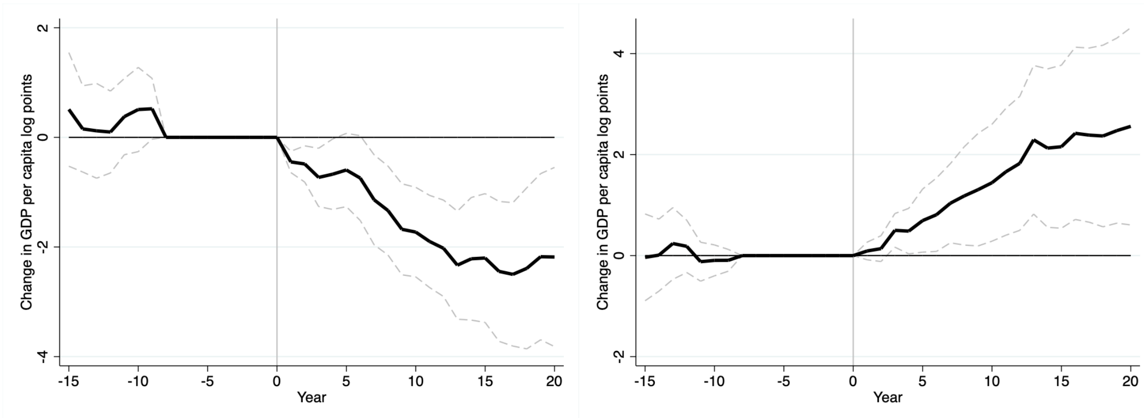
(a) For nonmanufacturer countries



(b) For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B12: Average effects of tariff reductions on GDP per capita, controlling for four lags of the change in terms of trade

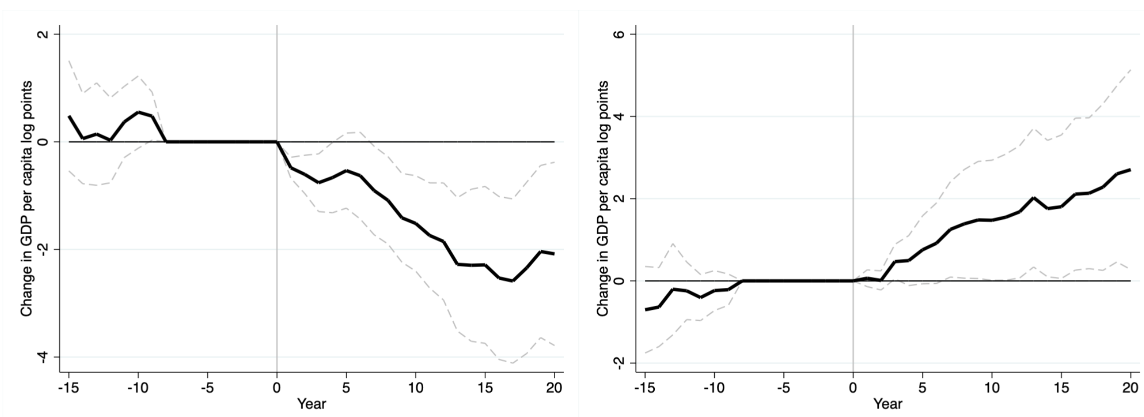


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Other heterogeneous effects

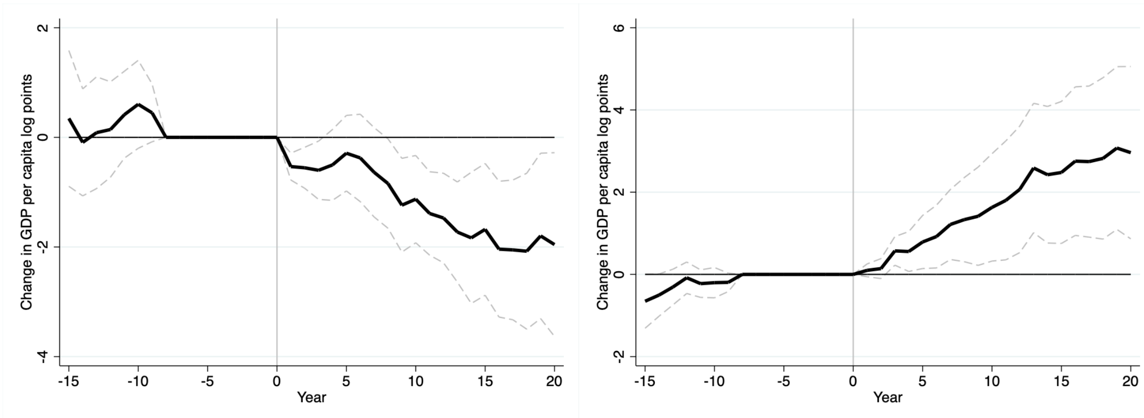
Figure B13: Average effects of tariff reductions on GDP per capita, controlling for heterogeneous effects from income



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B14: Average effects of tariff reductions on GDP per capita, controlling for heterogeneous effects from human capital

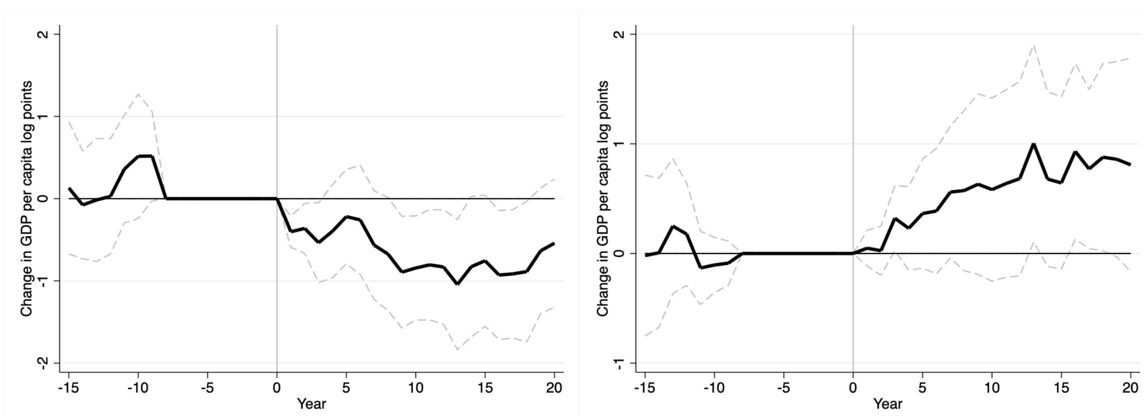


(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Different trends

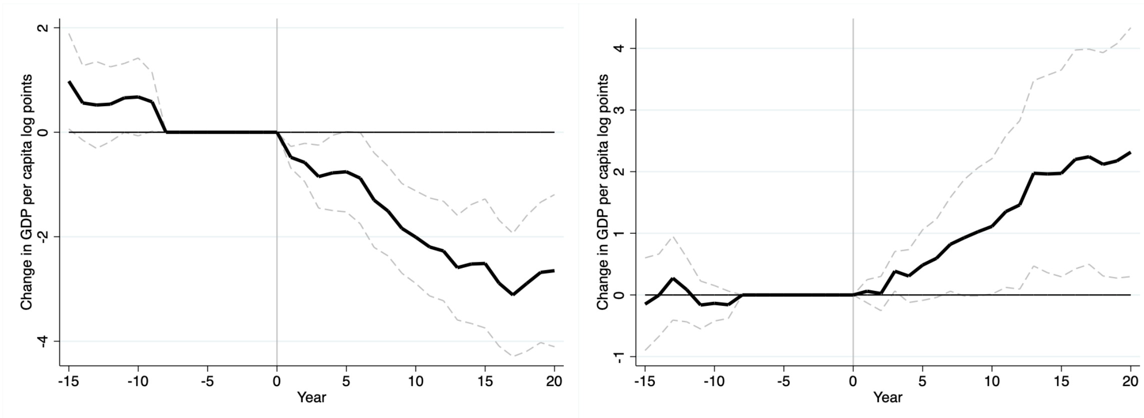
Figure B15: Average effects of tariff reductions on GDP per capita, with country fixed effects included



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

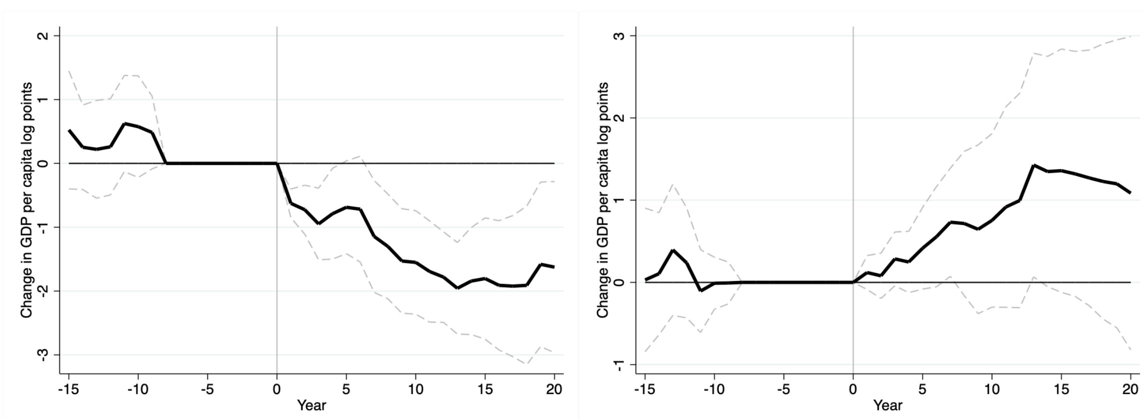
Figure B16: Average effects of tariff reductions on GDP per capita, controlling for trends in different country income groups



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B17: Average effects of tariff reductions on GDP per capita, controlling for trends in different regions of countries



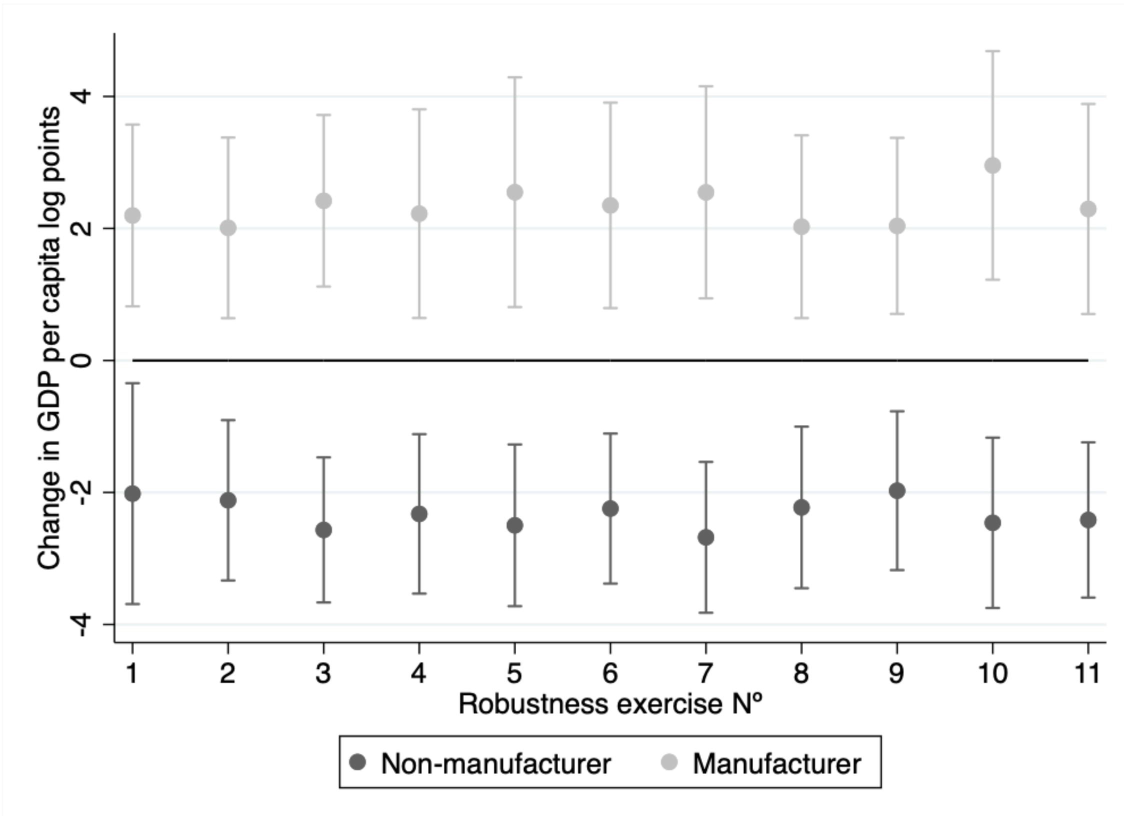
(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Robustness to contemporaneous changes in covariates

In the main text, I use a specification with four lags of the changes in covariates to account for potential confounding variables. Here, I simply summarize the results obtained if, instead, I include the contemporaneous change in each covariate. Figure B18 shows the results, confirming the effect heterogeneity of tariffs on growth.

Figure B18: Robustness of heterogeneous effects of tariff reductions on GDP per capita, average effect 13-17 years after, and based on contemporaneous changes in relevant covariates

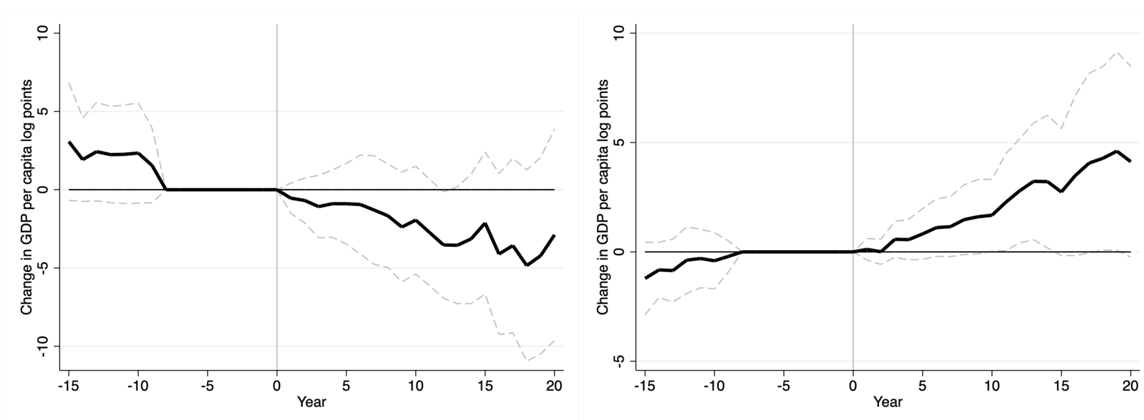


Note: The estimates presented are the predicted values for the 10th and 90th percentiles of the distribution of initial manufacturing exports. The coefficients show the average of the effect 10-14 years after the change in tariffs. The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level. Exercise 1 is the outcome of estimating equation 2.3 with the change in the Gini coefficient. Exercise 2 is the outcome of estimating equation 2.3 with the change in import penetration. Exercise 3 is the outcome of estimating equation 2.3 with the change in nontariff barriers. Exercise 4 is the outcome of estimating equation 2.3 with the change in capital account openness. Exercise 5 is the outcome of estimating equation 2.3 with the change in Polity. Exercise 6 is the outcome of estimating equation 2.3 with the change in human capital. Exercise 7 is the outcome of estimating equation 2.3 with the change in population size. Exercise 8 is the outcome of estimating equation 2.3 with the change in trade openness. Exercise 9 is the outcome of estimating equation 2.3 with the change in investment. Exercise 10 is the outcome of estimating equation 2.3 with the change in the real exchange rate. Exercise 11 is the outcome of estimating equation 2.3 with the change in the terms of trade.

Robustness with all controls included at the same time

In the main text, I control for several covariates that might affect the validity of the estimates, by including each of them in turn. The validity of the results, therefore, may still be subject to the criticism that it is driven by correlations between covariates, not really captured in the regressions when controlling for each of them in turn. I now present the results of including all covariates at the same time. This exercise is extremely demanding in terms of statistical power, as the sample is importantly reduced, given that for each covariate I include four lags of first differences and information is not equally available for all countries. Results are presented in Figure B19. The direction of the heterogeneity is still in line with the main findings, and although significance is importantly decreased, I still observe a significant effect around 12-13 years after tariff reductions.

Figure B19: Average effects of tariff reductions on GDP per capita, all control variables included

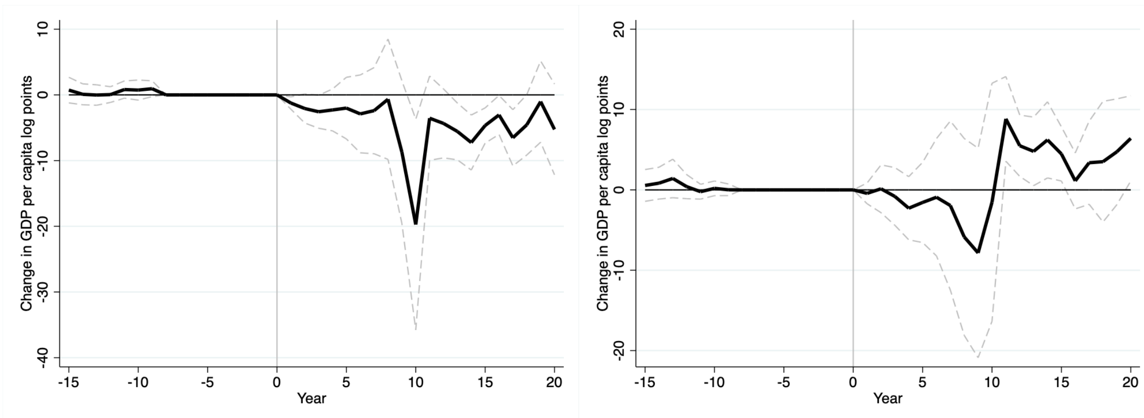


(a) For nonmanufacturer countries   **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Clean controls analysis

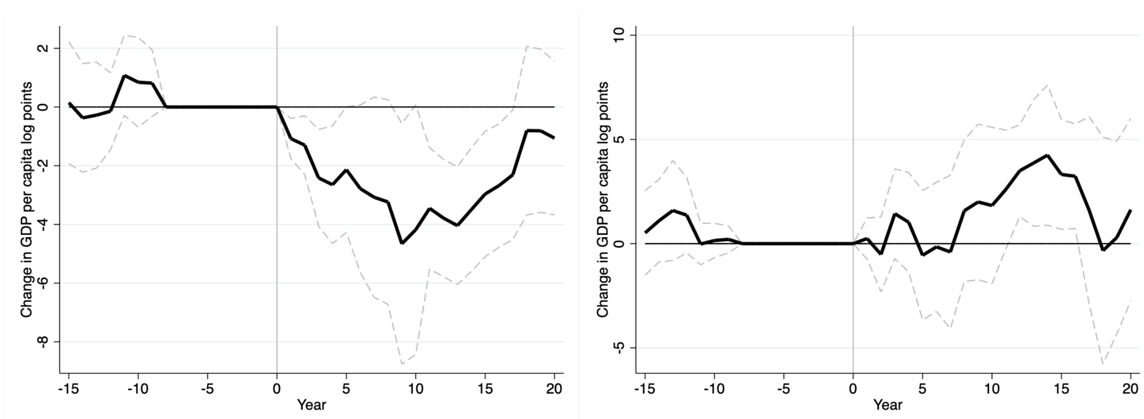
Figure B20: Clean controls analysis with threshold defined as half standard deviation from the mean tariff change



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

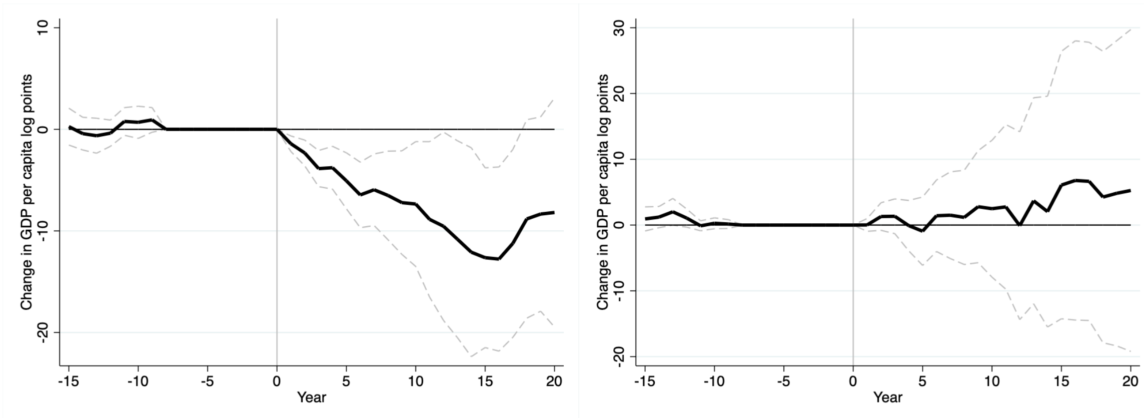
Figure B21: Clean controls analysis with threshold defined as two standard deviation from the mean tariff change



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B22: Clean controls analysis with a twenty-year rule for quasi-stayers



(a) For nonmanufacturer countries

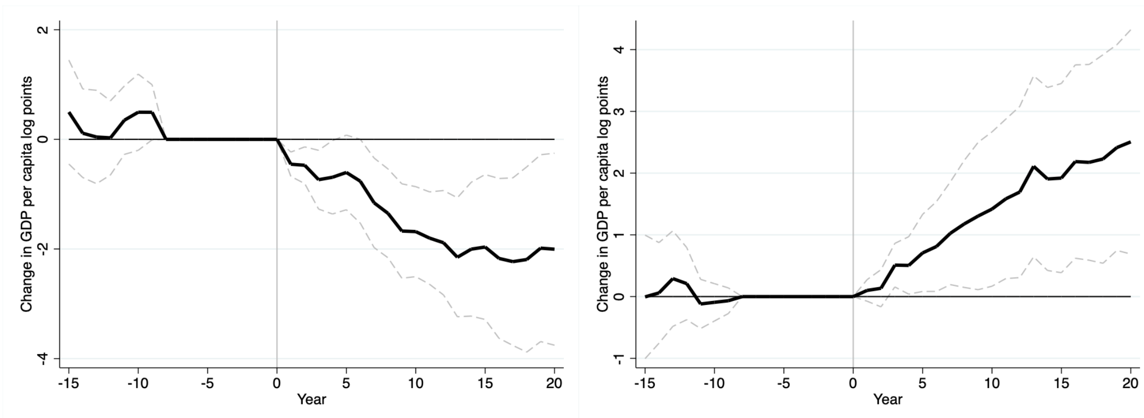
(b) For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Additional robustness

The following graphs reveal the results associated to the subsection in the main paper called additional robustness. The results presented confirm once again the robustness of the heterogeneous effects of tariffs on growth.

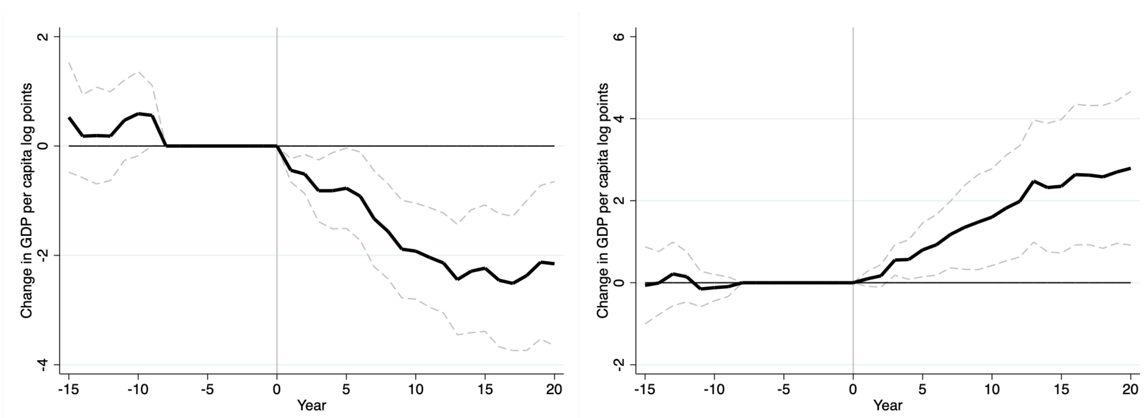
Figure B23: Average effects of tariff reductions on GDP per capita, controlling for interactions between past growth and the initial economic structure



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

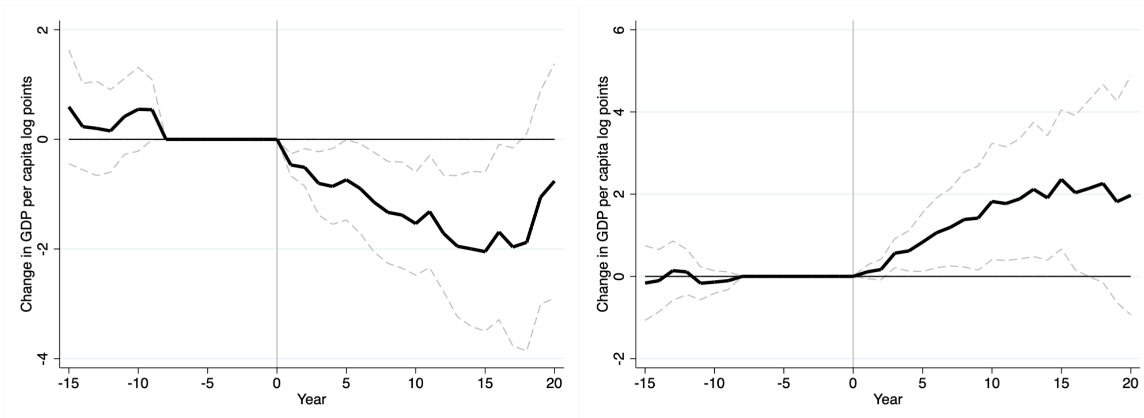
Figure B24: Average effects of tariff reductions on GDP per capita, controlling for interactions between year fixed effects and the initial economic structure



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure B25: Average effects of tariff reductions on GDP per capita, controlling for other tariff changes



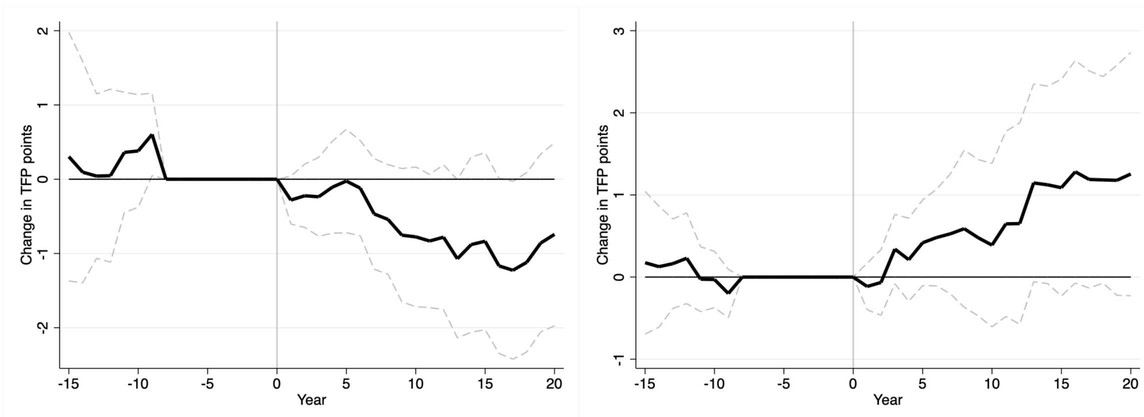
(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

C Mechanisms

Finally, I show results of effect estimates of tariff reductions on TFP, as an alternative to labor productivity, and on the share of imports in GDP. Direction of the effects for TFP go in line with the results documented with labor productivity, although the results are not significant at the 90 percent level of confidence. Results for the share of imports in GDP are not clearly different to zero, as discussed in the main text.

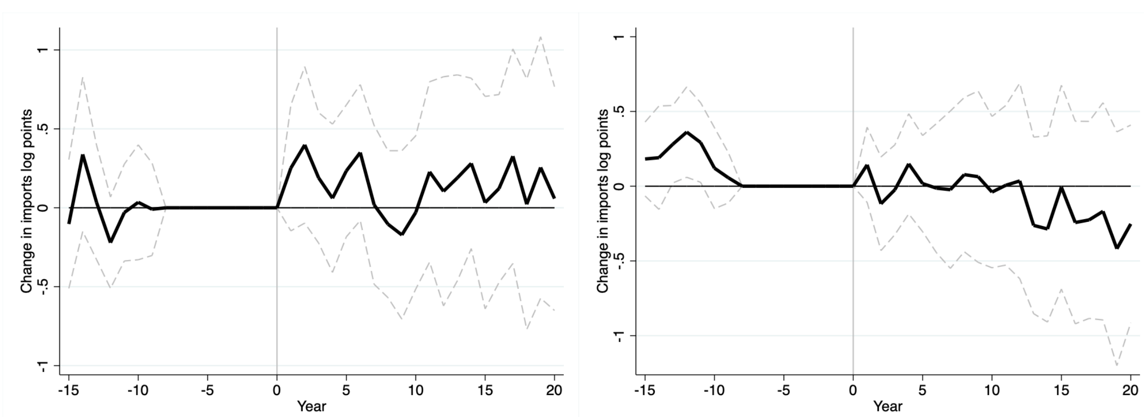
Figure C1: Average effects of tariff reductions on TFP



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

Figure C2: Average effects of tariff reductions on the share of imports in GDP



(a) For nonmanufacturer countries **(b)** For manufacturer countries

Note: The standard errors used for the figure are two-way robust to heteroskedasticity and correlation on the country and year dimensions. Confidence intervals are calculated to the 90% significance level.

CHAPTER 3

NORTH-SOUTH TRADE, TECHNOLOGY DIFFUSION, AND UNEVEN DEVELOPMENT

3.1 Introduction

An idea from the classic development literature suggests that North-South trade could be detrimental to development of the South. Trade leads the South to specialize in traditional activities, with little or no prospects for technical progress, and ultimately leads to a lower real income relative to the North, uneven development.

Two sets of empirical evidence seem to back up this classic idea. First, in the first chapter of this dissertatio I showed that the relationship between tariff reductions and growth is contingent on economic structure. More specifically, I show that for nonmanufacturers, countries with low manufacturing exports, which can be interpreted as the South, GDP per capita falls after tariff reductions. The manufacturing sector thus appears to be the modern sector, as opposed to traditional activities. Trade opening, as portrayed by tariff reductions, particularly strong in the last thirty years, has been accompanied by lower real income for the South. Second, according to Agosin, Alvarez, and Bravo-Ortega (2012), trade liberalization is robustly associated with lower diversification, which might be interpreted as a lower technological level.

But what about theory? Recent surveys of the trade and growth theoretical literature propose a consensus that this insight rests on a crucial but likely unrealistic assumption: that there is no international technology diffusion. Both according to Grossman and Helpman (2015) and Melitz and Redding (2021), the theoretical literature on trade and innovation from the last thirty years show that trade can lead the South to lower growth (and welfare) as compared to autarky if and only if there are no international knowledge spillovers. In other words, the condition is that technological progress in each country is entirely independent from that in other countries. As there is evidence of international knowledge spillovers the idea of the classical development literature, from the point of view of the recent consensus, is a theoretical curiosity.

In this paper, I present a model of North-South trade, innovation and diffusion (or imitation) showing that trade may still harm the South even if international technology diffusion does exist. Throughout the paper, the North refers to developed economies, the South to developing economies, and development refers to closing both technological and income gaps. In particular, I show that trade leads the South to experience a lower (technological) proximity to the frontier and a lower relative income, thus also matching the empirical evidence mentioned. The argument rests fundamentally on recognizing qualitative sectoral differences, as was also emphasized in the classical literature. First, technology, modeled as varieties of intermediate goods in the modern sector, does diffuse from the North to the South, but its effective imitation occurs through the manufacturing or modern sector and only later spills over to the rest of the economy. Then, trade implies for the South a lower relative price of the modern good, leading the South to specialize more in the traditional sector (i.e., less in the modern sector). Finally, with resources relocated from the modern towards the traditional sector, the steady state depicts a South that is farther from the North both in terms of technology and real income. By opening up to trade, the South ends up worse off than under autarky. Diminishing returns to labor in the traditional sector guarantee that trade does not lead the South to completely stagnate and thus absolutely diverge from the North but only to a reduction in relative income, which I call uneven development. My model thus confirms that technology diffusion promotes convergence, but that trade, separated from diffusion, can harm the South.

Formally, the model consists of embedding the technology diffusion component from the model by R. Barro and Sala-i-Martin (1997) in a structuralist North-South trade model, like that by Greenwald and Stiglitz (2006). On the one hand, R. Barro and Sala-i-Martin (1997) present a one-sector model of endogenous growth through increasing varieties, following the seminal work by Romer (1990), where they study diffusion North-South interactions, abstracting from trade. On the other, Greenwald and Stiglitz (2006) present a model of North-South trade where technological progress happens as learning-by-doing in the manufacturing (modern) sector and then spills over to the agricultural (traditional), abstracting from international technology diffusion. In my model, the modern sector has a constant returns to scale production function that uses labor and several varieties of intermediate goods, and the traditional sector only uses labor as a production factor, and with diminishing returns. Innovation and imitation are the outcome of R&D investments to invent and copy new designs of the intermediate goods respectively. I further assume, in clear structuralist fashion, that the South is intrinsically inferior for innovation than the North (i.e., the cost of innovation in the South is higher), so that the South always imitates the North, as in product cycle theory. After constructing the diffusion component of the model, I study trade following Greenwald and Stiglitz (2006) in assuming the South as a small open economy to study trade that the South's comparative advantage remains always in the traditional sector. This last assumption allows me to clearly focus on the impact going from comparative advantage to growth, without confounding it with the potentially relevant reverse causality.

Needless to say, the model is simple so it should be interpreted with caution. A crucial assumption of the model is that technology diffusion is independent of trade, which means that even in autarky the South enjoys it. In other words, diffusion occurs through channels other than trade. Although this simplifies the analysis and allows to identify separately the impact of trade and the impact of diffusion, in practice it is very likely that trade is one of the channels of technology diffusion, as the seminal evidence by Coe, Helpman, and Hoffmaister (1997) suggests. If trade is the channel of diffusion, meaning positive trade is required to learn foreign technologies, it cannot be the case that autarky is better both in terms of technological development and real income than trading. Therefore, an interesting venue for future research is to study in a combined setting the insights from qualitative sectoral differences, as portrayed in this model, with trade as a channel of diffusion. In other words, due to this limitation, the model should not be interpreted as suggesting that autarky is good for the South. In my opinion, the model should be simply interpreted as showing only one possible mechanism by which trade can lead developing countries to "bad" patterns of specialization that may reduce their growth prospects.

This paper is related to important strands in the literature. First, it is closely linked to the trade and learning-by-doing literature from the 1980s-1990s. Earlier models like those by Krugman (1981), A. K. Dutt (1986), Succar (1987) and Young (1991) showed that trade was harmful for the South as they led to deindustrialization and lower technological advancement. Matsuyama (1992) presents a similar model and emphasizes that agricultural productivity is crucial in that outcome. Later, Redding (1999) showed the precise conditions by which deindustrialization from trade can also lead to lower welfare levels. The last model in this tradition is precisely that by Greenwald and Stiglitz (2006). As compared to this literature, I model technological progress as innovation, as the invention of new designs of intermediate goods used in the production of the modern sector, and also introduce international technology diffusion, which is achieved exactly the same as innovation but cheaper.

The model also engages with the early literature on trade, innovation and diffusion. The seminal models that led to the recent consensus are those by Grossman and Helpman (1991b, particularly ch. 8) and Feenstra (1996). In particular, Feenstra (1996) explicitly shows that if and only if international technology diffusion exist, then trade leads to convergence. As compared to those models, diffusion is conceptualized here differently. International technology diffusion is that the pool of knowledge is international in scope. In other words, once a design of an intermediate has been invented, no matter where, the knowledge will be available worldwide (and will increase the R&D productivity everywhere). Diffusion in my model, on the other hand, as in R. Barro and Sala-i-Martin (1997), requires R&D investments, but is assumed to be cheaper than innovation. More precisely, the cost of diffusion-imitation is increasing in the proximity to the frontier, which makes the model display some sort of advantage of backwardness. As acknowledged by R. Barro and Sala-i-Martin (1997), diffusion is therefore conceptualized in a similar way as in the product cycle theory on trade, thus also being related to that strand of the literature (Krugman, 1979; Grossman & Helpman, 1991a).

The model has an important difference as compared to some more recent literature on trade, innovation, and diffusion. The models by Sampson (2020) and Cai, Li, and Santacreu (2020) display multi-sector multi-country economies where innovation is modelled as more productive techniques and diffusion is either characterized by sector specific parameters determining its speed or as a function of the proximity to the frontier. The model by Buera and Oberfield (2020) is similar to the previous ones but interestingly introduces trade as a channel of diffusion. Nevertheless, all of them share the assumption that all sectors are qualitatively equal to each other (i.e., innovation can occur in all of them, and diffusion is not a property of only some of them), which Buera and Oberfield (2020) for instance recognize. As compared to these models, my model is neither multi-sector nor multi-country, but introduces a clear sectoral qualitative difference, such that international technology diffusion occurs first through the modern sector.

Finally, my model therefore also connects to literature emphasizing that qualitative sectoral differences matter for the relationship between trade and growth and welfare. On the one hand, there is ample evidence that manufacturing seems to be qualitatively different to the rest of the economy, thus suggesting the modern sector can be called manufacturing. Backus, Kehoe, and Kehoe (1992) show evidence that the scale effects, standard in the first-generation endogenous growth models, do hold for manufacturing. More recently, Rodrik (2013) presents evidence that, as compared to other sectors, manufacturing is characterized by unconditional convergence. The author interpret this as suggesting manufacturing might be the locus of technology diffusion, which is precisely the idea formalized in my model. On the other, there is an increasing recognition that sectors differ in their complexity or innovative potential, so that the trading pattern may affect growth. Hausmann, Hwang, and Rodrik (2007) and Hidalgo and Hausmann (2009) showed that GDP growth is positively correlated with the level of sophistication or complexity of exports. Starting from that insight, Atkin et al. (2021) have recently proposed a model of multi-sector trade that formalizes the idea that trade can generate substantial dynamic welfare losses for most countries, by leading them to specialize in sectors with low complexity. That model has the same motivation and conclusion as the model here, with the important difference that their model abstracts from innovation and thus from technology diffusion, while here they are central to the model.

The rest of the paper is organized as follows. In section 2, I present the environment of the model and show how growth is the outcome of innovation in the North. The production functions, demand and input relations are the same for the

South as for the North, so that the presentation of the environment also informs later sections for the South. In section 3, I show how diffusion in the South, in a setting without trade, autarky, is indeed a force for technological and income convergence. In section 4, I study the impact of trade on Southern relative levels of technological capabilities and income, demonstrating a negative effect on both as compared to autarky. In section 5, I conclude.

3.2 Innovation and growth in the North

3.2.1 The environment

I study a two-countries two-sectors economy, n referring to North, s to the South, 1 to the modern sector and 2 to the traditional. The economy might be simply understood as that presented by R. Barro and Sala-i-Martin (1997) with an addition of a traditional sector. The traditional good is produced only with labor. The modern good is produced with labor and intermediate goods. One unit of each intermediate good costs one unit of the traditional good. The traditional good can be thought as a primary good used intensively as input in modern (manufacturing) production.

Growth in the economy is the outcome of innovation or imitation, modeled as increasing varieties (Romer, 1990). In other words, innovation refers to the invention of new designs of intermediate goods and imitation refers to the copy by the South of designs of intermediates already existing in the North. Once a design has been either invented or copied, intermediates of that type start being produced and used for modern sector production. Inventing one new design of an intermediate costs η_n units of the modern good, and imitation costs $v_s < \eta_s$ units of the modern good. Throughout, I assume that labor supplies are fixed. All wages are consumed, and I assume a Cobb-Douglas utility function, so that a proportion θ of wages is consumed in the modern good. Profits, on the other hand, are all invested, dedicated to R&D to come up with new or to copy designs of intermediates.

In structuralist fashion, I assume that the North and the South differ in two fundamental aspects: the South is relatively more productive in traditional production, which in turn defines comparative advantage, but intrinsically inferior for innovation. I also allow different sizes of population throughout. Apart from this, the North and the South are characterized by the same production functions and the same assumptions already mentioned.

Let's now turn to the specifics of the North. The production function of good 1 follows the specification used by R. Barro and Sala-i-Martin (1997), an adaptation from Ethier (1982) and Dixit and Stiglitz (1977):

$$Y_{n1} = L_{n1}^{1-\alpha} \sum_{j=1}^{N_n} (x_{nj})^{\alpha} \tag{3.1}$$

where N_n refers to the number of intermediate goods available at each moment in time, and x_{nj} to the amount of each intermediate used in the production of the modern good. Taken N_n as given, this production function presents constant returns to scale[1].

The production function of the traditional good, good 2, takes the following form:

$$Y_{n2} = b_n L_{n2}^{1-\beta} \tag{3.2}$$

where b_n represents a parameter specific to the North affecting labor productivity in the traditional sector, and L_{n2} the labor allocated to traditional production. The production of the traditional good has diminishing returns to labor, captured by β.

An important -and simplifying- feature of the model is that labor productivity in the traditional sector will be proportional to the productivity in the modern sector. This assumption implies that technical progress occurs in the modern good, but it then spills over instantaneously to the rest of the economy. It also implies that comparative advantage is fixed, doesn't change in time. The assumption therefore allows me to clearly focus on the comparison between the laissez-faire and autarky (i.e., trade policy) cases, without confounding the effect of trade with that of changes in comparative advantage. On the other hand, these inter-industry spillovers are relevant both theoretically and empirically. Some examples in the literature studying these spillovers are A. K. Dutt (1986), Succar (1987), and Greenwald and Stiglitz (2006)[2]. According to Wade (1990), the existence of these spillovers was the rationale behind most of the industrial policy implemented (arguably successfully) in the miracle East Asian economies between 1960-1990. Formally, this assumption is simply given by:

$$b_n = a_n N_n \tag{3.3}$$

where a_n may be interpreted as a 'natural' productivity component in the production of the traditional good.

[1]In this setting, the parameter determining substitution among intermediates equals the one guaranteeing constant returns to scale for inputs in the production function. This assumption simplifies the analysis, but also implies that the marginal product of intermediate j is independent of the use of j', meaning the intermediates are not direct substitutes or direct complements. This implies that new intermediates don't create obsolescence in old ones.

[2]Nevertheless, none of these models studies innovation and technology diffusion occurring in the modern sector and then spilling over to the rest of the economy.

I assume that the price of the traditional good is the numeraire, so that p_{n1} will be the relative price and, later, the terms of trade.

3.2.2 Static equilibrium

Total output in the traditional sector is shared equally between all workers, so that the wage in the traditional sector is equal to the average product of labor. That is:

$$w_{n2} = \frac{a_n N_n}{L_{n2}^{\beta}} \tag{3.4}$$

On the other hand, the maximization problem of producers of the modern good implies choosing both the amount of labor and the amount of intermediates optimal for production. The first order conditions are therefore:

$$w_{n1} = p_{n1}(1-\alpha)\frac{\sum^{N_n}(x_{nj})^{\alpha}}{L_{n1}^{\alpha}} \tag{3.5}$$

and,

$$p_{nj} = \alpha p_{n1}\left(\frac{L_{n1}}{x_{nj}}\right)^{1-\alpha} \tag{3.6}$$

where expression 3.5 is the inverse demand for labor in the modern sector, and expression 3.6 refers to the inverse demand for intermediates.

I now proceed to analyze the maximization problem for the producers of the intermediate goods used in the production of the modern good. Following Romer (1990), I assume that the inventor (more precisely the producer) of a new intermediate retains a monopoly over the production of that intermediate. Therefore, each monopolist faces the demand from the final goods sector and maximizes accordingly. Each monopolist will produce the following amount of each intermediate:

$$x_{nj} = x_n = L_{n1}\alpha^{\frac{2}{1-\alpha}} p_{n1}^{\frac{1}{1-\alpha}} \tag{3.7}$$

and will charge a price for each intermediate good of:

$$p_{nj} = \frac{1}{\alpha} \tag{3.8}$$

given that the price of the traditional good has been normalized. As the price for each intermediate is the same, the amount of each intermediate used in production of the modern good will be the same, x_n.

I then plug expression 3.7 into expression 3.5, to get a new expression of the wage in the modern sector.

$$w_{n1} = (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} N_n p_{n1}^{\frac{1}{1-\alpha}} \tag{3.9}$$

From expression 3.9, we can observe that the marginal product of labor in the modern sector is constant, neither increasing or decreasing on the labor allocation to the sector.

I assume perfect labor mobility, so that the wages in both sectors are equalized, $w_n = w_{n1} = w_{n2}$. By using this equilibrium condition I am able to pin down a relation between the relative price and the labor allocation between sectors. Formally, using expressions 3.4 and 3.9, I get:

$$L_{n2} = \frac{a_n^{\frac{1}{\beta}}}{(1-\alpha)^{\frac{1}{\beta}} \alpha^{\frac{2\alpha}{(1-\alpha)\beta}} p_{n1}^{\frac{1}{(1-\alpha)\beta}}} \tag{3.10}$$

where we can observe that the labor allocation in the traditional sector is decreasing on the price of the modern sector relative to the traditional. Given that $L_{n1} = L_n - L_{n2}$, this simply implies that the labor allocated to production of the modern sector is increasing in its relative price.

An essential component of the model is total profits, as they are equal to R&D investments and will therefore drive the technological evolution in the economy. Formally, using expressions 3.7 and 3.8, I get:

$$\begin{aligned} \Pi_n &= N_n \pi_{nj} \\ &= (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} N_n p_{n1}^{\frac{1}{1-\alpha}} L_{n1}(p_{n1}) \end{aligned} \tag{3.11}$$

where we observe that profits are increasing in the state of technology, the relative price, and the labor allocated to the modern sector.

I am now able to write down an expression for real GDP. Contrary to the standard two-countries two-sectors Ricardian model, GDP here is not the sum of production of both goods. GDP measures the value of final goods production. In this model, a part of the traditional good is used as input in the production of intermediates, meaning that part must not to be counted in GDP. An easier way to approach GDP is to estimate it from the income standpoint, as the sum of total wages and total profits in the economy. I also express it in real terms, relative to the modern good. Thus, using expressions 3.9 and 3.11, and the fact that $L_{n2} = L_n - L_{n1}$, I get:

$$\begin{aligned} Y_n &= \frac{L_n w_n + N_n \pi_{nj}}{p_{1n}} \\ &= (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} N_n p_{n1}^{\frac{\alpha}{1-\alpha}} L_n + (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} N_n p_{n1}^{\frac{\alpha}{1-\alpha}} L_{n1}(p_{n1}) \end{aligned} \tag{3.12}$$

where I express GDP as a function of the relative price and the labor allocated to the modern sector, which by equation 3.10 is in turn a function of the relative price.

Finally, to close the static equilibrium, determine the allocation of labor, I bring in demand. I further assume the North to be a big developed economy, not affected at all by the small South. In other words, I assume the price in the North (and later with trade) to be entirely determined by domestic demand. In specific, market clearing in the modern good –which by Walras's law also guarantees market clearing and equilibrium in the traditional good– implies that demand for that good (i.e. the share of the wage bill dedicated to the consumption of the good) plus R&D investments (i.e., total profits of intermediate goods producers) must equal its production. Formally:

$$p_{n1} Y_{n1} = \theta w_n L_n + \Pi_n \tag{3.13}$$

Plugging expressions 3.9 and 3.11 for the wage and the profits respectively into the clearing equilibrium condition 3.13, and after some algebraic manipulation, I get that the labor allocation in the autarkic economy is determined by:

$$L_{n2} = \frac{1 - (\theta + \alpha)(1-\alpha)}{1 - \alpha(1-\alpha)} L_n \tag{3.14}$$

where we can observe that the labor allocated to the traditional sector is decreasing on the consumption share dedicated to the modern good.

Expression 3.14 shows that, given the assumptions about consumption demand and input demand, the autarkic allocation of labor depends uniquely on demand and technical parameters. In other words, if domestic production is the only way to satisfy domestic demand then labor allocation will be entirely determined by demand and technical requirements, and the relative price will in the end just be an accommodating variable, to satisfy that wages are equal in both sectors.

Using expressions 3.14 and 3.10 I pin down the price of autarky:

$$p_{n1} = \frac{a_n^{(1-\alpha)}}{L_n^{(1-\alpha)\beta}} \cdot \frac{[1-\alpha(1-\alpha)]^{(1-\alpha)\beta}}{(1-\alpha)^{(1-\alpha)}\alpha^{2\alpha}\,[1-(\theta+\alpha)(1-\alpha)]^{(1-\alpha)\beta}} \tag{3.15}$$

The price of autarky in expression 3.15 closes the static equilibrium of the model for the North. It is interesting to note that, first, the relative price of the modern good is inversely related to total population, due to diminishing returns to labor in the traditional sector, and, second, the price is positively related to the 'natural' productivity in the traditional sector.

3.2.3 Innovation and growth

The R&D production function is an adaptation of the lab-equipment specification in Rivera-Batiz and Romer (1991) and R. Barro and Sala-i-Martin (1997). The production of one new intermediate costs η_n units of the modern good. Formally:

$$\dot{N}_n = \frac{\Pi_n}{\eta_n} \tag{3.16}$$

Plugging expressions 3.11, 3.14 and 3.15 into 3.16 I get the growth rate of intermediates, the rate of innovation of the North:

$$\hat{N}_n = \frac{a_n L_n^{1-\beta}}{\eta_n} \frac{\theta\alpha(1-\alpha)}{[1-\alpha(1-\alpha)]^{1-\beta}\,[1-(\theta+\alpha)(1-\alpha)]^{\beta}} \tag{3.17}$$

A few things are worth noting about expression 3.17. First, the growth rate of the economy will increase in response to an improvement of the 'natural' productivity in the traditional sector. An increase in this productivity leads to a higher relative price of the manufacturing good, which in turn imply higher profits and therefore higher R&D investments. Second, the innovation rate will increase if population increases, meaning that the model has the traditional scale-effect from first-generation endogenous growth models[3]. Third, if the consumer preferences shift from the traditional to the modern good, the growth rate will also be higher. Fourth, the cost of innovation affects negatively the rate of growth. Fifth, an increase in β reduces growth, by making the traditional sector more productive. And finally, the impact of α on growth is ambiguous[4].

It can also be shown that this growth rate will be equal to the growth rate of GDP and consumption. GDP, as derived in expression 3.12, is proportional to the

[3] As shown by R. Barro and Sala-i-Martin (2003), the cost of innovation can be made to increase with the size of the population, and that way the scale effect disappears. Nonetheless, this possibility is not relevant for the main point of the current model.

[4] This might be related to the assumption that α is both the parameter of diminishing returns to intermediates and of substitution between them.

level of technology, so that its growth rate will be equal to that of technology. GDP per capita grows at the same rate given the assumption of no growth in population. Consumption will entirely depend on wages, and as the wage is tied to the number of intermediates in the economy (expressions either 3.4 or 3.9), consumption will grow at the same rate g_n. Formally:

$$g_n = \hat{Y}_n = \hat{y_n} = \hat{N}_n \tag{3.18}$$

where y_n is the output per capita in the North. The growth rate of innovation, of the intermediate inputs invented and available to produce, equals the growth of output and the growth of output per capita of the North.

3.3 Imitation and growth in an autarkic South

The autarkic version of the South means that the economy does not trade, so that the relative price will be determined by domestic demand conditions, but the economy will still enjoy international technology diffusion, meaning that the South can imitate technologies from the North. In other words, this means that even though the two economies do not trade, technology is flowing internationally through channels other than trade, as in R. Barro and Sala-i-Martin (1997).

3.3.1 Static equilibrium

The South is characterized by the same production functions and demand relations as the North, where differences are simply given by differences in the size of population, the 'natural' productivity, and the cost of innovation. Therefore, I proceed to put down the equations that characterize the static equilibrium for the South, without solving again. I write down three expressions: the wage, total profits and GDP, all of them as functions of the price and the labor allocated in the modern sector. I also write down final expressions under autarky for the labor allocation and the relative price. As these expressions characterize the static equilibrium, the state of technology is assumed for now as given.

$$w_s = (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} N_s p_{s1}^{\frac{1}{1-\alpha}} \tag{3.19}$$

$$\Pi_s = (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} N_s p_{s1}^{\frac{1}{1-\alpha}} L_{s1}(p_{s1}) \tag{3.20}$$

$$Y_s = (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} N_s p_{s1}^{\frac{\alpha}{1-\alpha}} L_s + (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} N_s p_{s1}^{\frac{\alpha}{1-\alpha}} L_{s1}(p_{s1}) \tag{3.21}$$

$$L_{s2} = \frac{1 - (\theta + \alpha)(1 - \alpha)}{1 - \alpha(1 - \alpha)} L_s \tag{3.22}$$

and,

$$p_{s1} = \frac{a_s^{(1-\alpha)}}{L_s^{(1-\alpha)\beta}} \cdot \frac{[1 - \alpha(1 - \alpha)]^{(1-\alpha)\beta}}{(1 - \alpha)^{(1-\alpha)} \alpha^{2\alpha} [1 - (\theta + \alpha)(1 - \alpha)]^{(1-\alpha)\beta}} \tag{3.23}$$

An interesting and simple expression I can now analyze is that of the relative wage, which is the one I use to discuss about relative income. Wages capture in this model the median GDP per capita of the economy, and given the assumption that profits are all invested, they are also in a sense the best measure of welfare linked to consumption. Formally:

$$\frac{w_s}{w_n} = \frac{a_s N_s L_n^{\beta}}{a_n N_n L_s^{\beta}} \tag{3.24}$$

Expression 3.24 tells us that differences in median income per capita are fundamentally due to technological differences. Although both relative population size and relative 'natural' productivity in the traditional sector matter, from a long-run perspective what matters the most is technological differences.

Throughout this paper I assume that $a_s > a_n$. This assumption is important and deserves a good explanation. What I am saying with this assumption is that the South is 'naturally' more productive in the traditional sector compared to the North. Although labor productivity in the traditional sector evolves with the state of technology N_i, assuming an equal level of technology for both the South and the North, the South will be more productive in the traditional sector (and this determines its comparative advantage). We can think of the traditional sector as being related to natural resources exploitation or agricultural products where the South, in practice generally placed near the tropics, is said to have a natural advantage with respect to the North. As long as this 'natural' advantage makes the opportunity cost of producing other manufacturing goods (the modern good) higher than in the North, then the intuition behind this model is meaningful.

3.3.2 Imitation and steady-state proximity to the frontier

Imitation or diffusion requires investments, but is assumed to be cheaper than innovating. The cost of imitation is therefore defined as a lump-sum outlay of v_s, where $v_s < \eta_s$. The amount of intermediates that can be copied by the South is given by the difference between N_s and N_n. Therefore, as N_s approaches N_n, the cost of imitation v_s may rise. Or, in other words, imitation may be cheaper if the South is more distant technologically with respect to the frontier. This is a property that can be understood as an advantage of backwardness, so that it becomes harder to imitate as the South gets closer to the North in technological terms. Formally, this is given by:

$$v_s = v_s(N_s/N_n) \tag{3.25}$$

where $v_s' > 0$. I further assume that $v_s(1) = \eta_s$, so that the cost of imitation in the South becomes equal to the cost of innovation when the technological gap gets closed.

The R&D production function in the South is therefore given by:

$$\dot{N}_s = \frac{\Pi_s}{v_s} \tag{3.26}$$

Following R. Barro and Sala-i-Martin (1997), I adopt a constant-elasticity function for the cost of imitation, such that:

$$v_s = \eta_s P^\sigma \tag{3.27}$$

where $\sigma > 0$ and $P = N_s/N_n$, capturing what I call proximity to the frontier, so that if P increases is because the South is getting closer to the North in technological terms.

Plugging expression 3.20 into 3.26, and dividing the expression by N_s to get a growth rate, I get:

$$\hat{N}_s = (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} \frac{p_{s1}^{\frac{1}{1-\alpha}} L_{s1}(p_{s1})}{\eta_s P^\sigma} \tag{3.28}$$

Expression 3.28 determines the growth rate of the South as a function of the relative price of the modern sector. This shows that the growth rate of the economy increases with the price of the modern sector, as it positively influences the profits that fund R&D as well as the labor allocated to the modern sector.

Given that the cost of imitation depends on the proximity to the frontier, I can analyze the previous differential equation as a function of the proximity to the frontier, making use of the fact that $\hat{P} = \hat{N}_s - \hat{N}_n$, such that:

$$\hat{P} = (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} \frac{p_{s1}^{\frac{1}{1-\alpha}} L_{s1}(p_{s1})}{\eta_s P^\sigma} - g_n \tag{3.29}$$

and,

$$\dot{P} = (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} \frac{p_{s1}^{\frac{1}{1-\alpha}} L_{s1}(p_{s1}) P^{1-\sigma}}{\eta_s} - P g_n \tag{3.30}$$

I now use expressions 3.22, the labor allocation, and 3.23, the relative price of autarky, to express the differential equation in terms of only exogenous parameters. Formally:

$$\dot{P} = \frac{a_s L_s^{1-\beta} P^{1-\sigma}}{\eta_s} \frac{\theta\alpha(1-\alpha)}{[1-\alpha(1-\alpha)]^{1-\beta}[1-(\theta+\alpha)(1-\alpha)]^{\beta}} - P g_n \tag{3.31}$$

And finally, I can now get the steady-state value of the proximity to the frontier P^*, by making $\dot{P} = 0$ and using expression 3.17 for g_n:

$$P^* = \left[\frac{a_s L_s^{1-\beta} \eta_n}{a_n L_n^{1-\beta} \eta_s}\right]^{\frac{1}{\sigma}} \tag{3.32}$$

where it will depend only on the exogenously given parameters for the 'natural' productivity, population sizes and the cost of innovation. The differential equation in 3.31 also has the trivial solution given by $P = 0$.

I have assumed so far, in structuralist fashion, that the South always imitates and never engages in innovation, so that $v_s < \eta_s$ applies along all the path. With simple algebraic manipulation, using expressions 3.27 and 3.32, I get that:

$$v_s^* = \frac{a_s L_s^{1-\beta} \eta_n}{a_n L_n^{1-\beta}} \tag{3.33}$$

so that,

$$\eta_s > \frac{a_s L_s^{1-\beta} \eta_n}{a_n L_n^{1-\beta}}$$

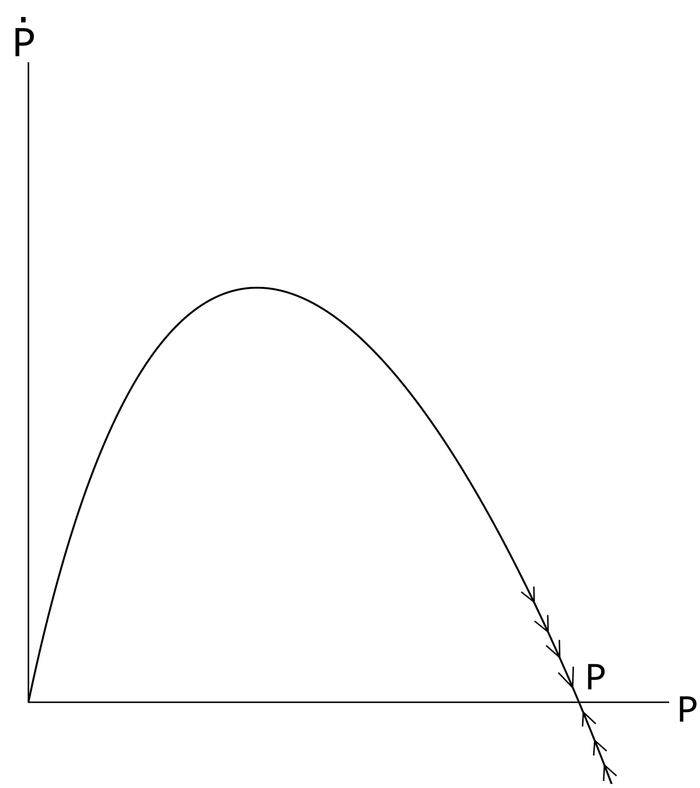
$$1 > \frac{a_s L_s^{1-\beta} \eta_n}{a_n L_n^{1-\beta} \eta_s} \tag{3.34}$$

which simply implies that the South is assumed to be intrinsically inferior for innovation than the North. Moreover, assuming equal sizes of both economies, and remembering the fact that $a_s > a_n$, this means that η_s has to be sufficiently bigger to η_n to compensate for the 'natural' advantage of the South.

The previous point also implies that $P^* < 1$, so that in the steady-state, given the previous assumption, the South doesn't fully technologically catch up with respect to the North. And by the same token, using expression 3.24, the wage in the South is also likely to fall short with respect to that of the North[5]. As in the model by Verspagen (1991), an imitation strategy may contribute to catching up but will not guarantee full convergence.

As we can observe in Figure 3.1, if the South starts with a technological level lower to that of steady-state, so that $P < P^*$, then the South will grow faster than the North and there will be convergence (up until the technological gap of steady-state). The fact that learning to use the wheel is different to inventing the wheel makes room for catching up growth for the South. Once the South reaches its full technological potential through imitation, the South then remains growing at the same rate of the technological frontier, the North.

Figure 3.1: Dynamics of convergence without trade



[5]The relative wage of steady-state may be lower to one depending on the specific values of a_s and a_n. It is realistic to assume that it is lower to one, even in the case that the South enjoys a 'natural' advantage in traditional goods production.

3.4 The impact of trade on the South: uneven development

3.4.1 Static equilibrium

I study trade by assuming the South transits from autarky to be now a small open economy. As a small open economy, the South cannot affect the terms of trade of the world economy. In other words, the terms of trade become those dictated by the internal conditions of the North, p_{n1}, taken from equation 3.14. Essentially, opening to trade implies for the South facing a lower relative price for the modern good, due to the fact that $a_n < a_s$.

Intuitively, in static terms, the new relative price implies that the wage in the traditional sector will be higher than that in the modern sector, so that workers will start moving to the traditional sector up until the point the wage in both sectors equalizes again. Formally, the new labor allocation is given by:

$$L_{s2} = \frac{a_s^{\frac{1}{\beta}}}{(1-\alpha)^{\frac{1}{\beta}} \alpha^{\frac{2\alpha}{(1-\alpha)\beta}} p_{n1}^{\frac{1}{(1-\alpha)\beta}}} \tag{3.35}$$

so that labor allocated to the traditional sector increases, given that $p_{n1} < p_{s1}$.

Another crucial point from the static equilibrium with the new price is that the amount of profits falls, both directly because of the fall in the price but also because the labor allocated to the modern sector falls. The direct effect is intuitive, so that a change in the price makes less profitable the production in the modern sector. The indirect effect occurs due to the mark-up pricing in the intermediate sector, according to which the intermediate producers produce proportionally to the level of employment in the modern sector to maximize profits. As the level of employment in the modern sector falls, production of each intermediate also falls, and total profits thus fall. Formally:

$$\Pi_s = (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} N_s p_{n1}^{\frac{1}{1-\alpha}} L_{s1}(p_{n1}) \tag{3.36}$$

But what about GDP in terms of the modern good? Do we still observe the static gains from trade standard in Ricardian trade models, in terms of the imported good? Formally, I have that GDP in terms of the modern good is now determined by:

$$Y_s = (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} N_s p_{n1}^{\frac{\alpha}{1-\alpha}} L_s + (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} N_s p_{n1}^{\frac{\alpha}{1-\alpha}} L_{s1}(p_{n1}) \tag{3.37}$$

As a very interesting result, the model shows that southern GDP in terms of the modern good, the imported good, falls as a consequence of trade. This result runs contrary to the standard result from the two-countries two-sectors Ricardian model. It therefore makes sense to pay close attention to the mechanisms at play, which in some sense lead to static welfare losses from trade. Formally the effect happens because both wages and profits (expressions 3.19 and 3.20) respond more than proportionally to changes in the relative price. Why is this the case? Taking a closer inspection to expression 3.7, we can see that the reason is that the production of intermediates responds more than proportionally to changes in the relative price. A reduction in the price reduces the income stream of intermediate producers while leaving the costs unaffected. Then, to preserve the same markup, maximize profits, intermediate producers have to reduce production more than proportionally, given that the modern good production has diminishing returns to intermediates. Both because it is in the interest of intermediate producers to preserve a constant markup over the cost of each intermediate and because that cost is one unit of the traditional, I obtain a static reduction in real GDP in the South as a consequence of trade.

Another way to see this is by observing relative wages. Using the expressions for wages for both the North and the South, equations 3.9 and 3.19, I get:

$$\frac{w_s}{w_n} = \frac{N_s}{N_n} = P \tag{3.38}$$

Trade, by reducing the relative price of the modern good, has led to a lower relative wage in the South. By comparing expression 3.38, the relative wage with trade, with expression 3.24, the relative wage without trade, assuming equal sizes of population, it can be observed the first expression is bigger. The 'natural' advantage positively affects the wage when the South is under autarky, but not anymore when it opens up to trade. Even more, if the North is assumed to be bigger than the South, which may reduce its wage due to diminishing returns to labor, then trade reduces the relative wage by even more.

3.4.2 Imitation and steady-state proximity to the frontier

Now I perform the dynamic analysis for the small open Southern economy. To do so, I simply change the price in expression 3.28 for that of the North, to express the growth rate of intermediates in the South in terms of that price and also in terms of the labor allocated to the modern sector.

$$\hat{N_s} = \frac{(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} p_{n1}^{\frac{1}{1-\alpha}} L_{s1}(p_{n1})}{\eta_s P^{\sigma}} \tag{3.39}$$

And then I can express the dynamics of the proximity to the frontier as follows:

$$\dot{P} = \frac{(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}}}{\eta_s} p_{n1}^{\frac{1}{1-\alpha}} L_{s1}(p_{n1}) P^{1-\sigma} - P g_n \tag{3.40}$$

Now I can find the steady state equilibrium by making $\dot{P} = 0$, still in terms of the labor allocated to the modern sector and the price.

$$P^* = \left[\frac{(1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}}}{\eta_s g_n} p_{n1}^{\frac{1}{1-\alpha}} L_{s1}(p_{n1}) \right]^{\frac{1}{\sigma}} \tag{3.41}$$

The price has fallen due to trade and the labor allocation to modern sector has also fallen, by which the proximity of steady state is now lower. In other words, the technological gap has increased, and therefore the income gap has also increased. By taking a look to expression 3.40 we can also observe that the level of the proximity to the frontier where it grows faster is now lower as compared to the autarkic case, and the growth at that point also lower. The change is represented graphically in Figure 3.2, where the subscript T refers to the small open economy situation, trade, as compared to the situation of autarky denoted by the subscript A.

Figure 3.2: The impact of trade on the dynamics of convergence

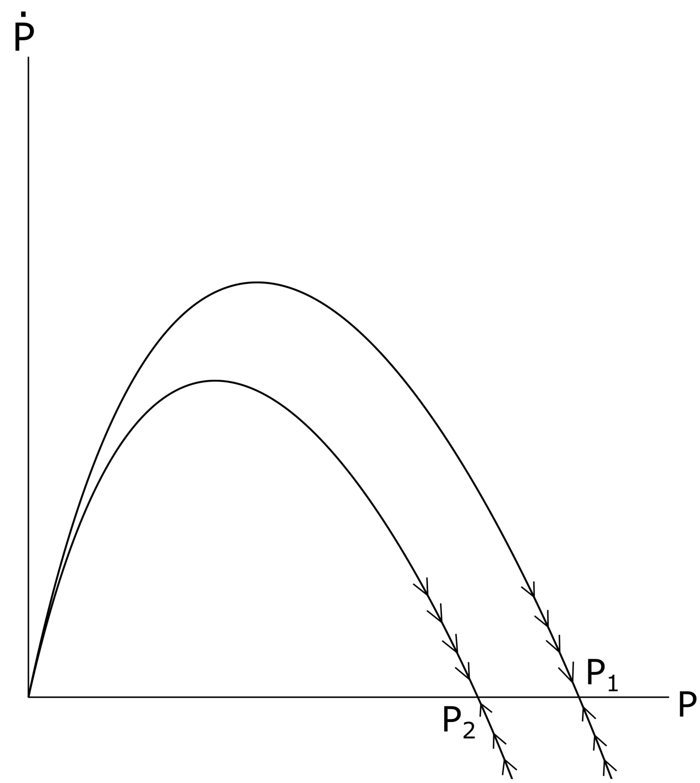
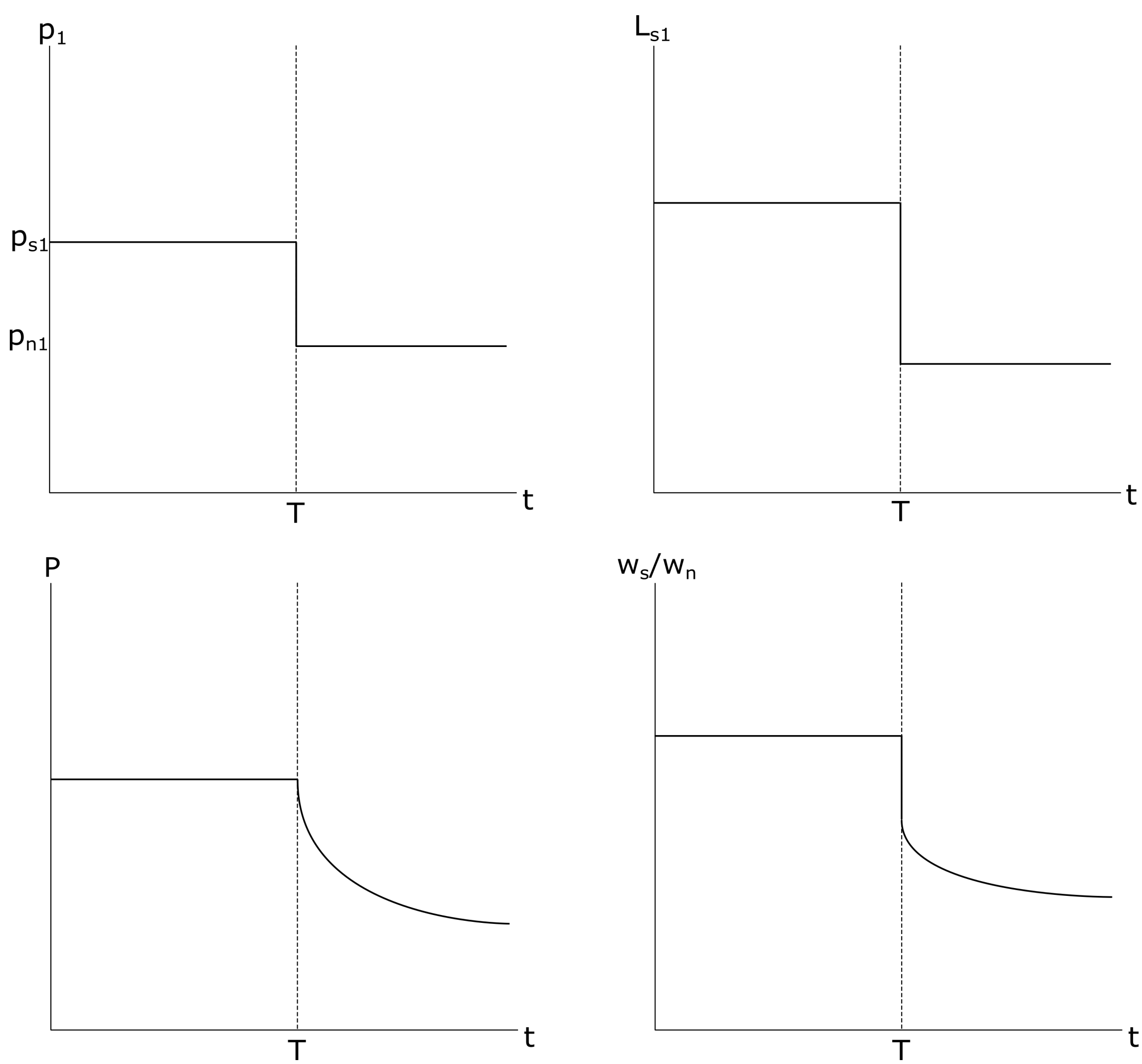


Figure 3.3 summarizes the dynamics of the impact of trade on selected Southern variables. The South opens to trade in time T. Trade is captured by a reduction in the relative price of the modern good, displayed in the upper left quadrant. This leads to a fall in the labor allocated in the modern sector, displayed in the upper right quadrant. As discussed before, both the fall in the price and in the labor allocated to the modern sector lead to a reduction of profits, so that the proximity to the frontier starts falling, as displayed in the lower left quadrant. After some time, the proximity reaches a new lower steady state, so that the South ends up farther from the North in technological terms. Finally, the relative wage, the relative income per capita, is first hit negatively by the change in price, so it jumps to a lower level. And then, it keeps falling progressively following the dynamics of the proximity to the frontier.

Figure 3.3: Dynamics of the impact of trade on selected Southern variables



The model therefore delivers the following insights. Growth in steady state is still the same in both the South and the North. However, trade leads the South to shift resources (labor) to the traditional sector, by which profits decrease and the amount of imitation decreases. The new proximity of steady state is lower, so that the income gap of steady state is higher. Trade therefore enlarges the income differences by enlarging the technological differences between the South and the North. In a sense, the outcome is qualitatively equal to that in Greenwald and Stiglitz (2006). The mechanism, however, is different. In that model the growth mechanism is due to learning-by-doing, while here growth is the outcome of private R&D investments. Also, here there's no absolute divergence but transitional divergence, up until the point there's now a higher income gap. Uneven development is therefore the outcome of North-South trade, even in the presence of international technology diffusion.

3.5 Concluding remarks

The question about the impact of trade on development is one of the most intriguing and debated in the history of economics. However, recent surveys on the trade and endogenous growth theoretical literature propose a consensus that seem to close the debate. The argument is that trade may harm the South only if international technology diffusion does not exist, which is unrealistic. If international technology diffusion exists, trade either does not decrease or increases the relative income, but cannot create uneven development.

This paper presents a model that challenges the consensus and study a specific mechanism by which trade may harm the South even if international technology diffusion exists. I show that qualitative sectoral differences, meaning that international technology diffusion occurs only through the modern sector, trade leads to a lower relative income, uneven development. Specialization according to comparative advantage leads to a reallocation of labor towards the traditional sector, which in turn means lower profits in the modern sector, so that technology diffusion immediately falls after trade opening. The economy progressively adjusts to reach a new lower technological proximity to the frontier, which in turn implies a lower relative income. The model therefore provides a mechanism consistent with the empirical evidence presented in the first chapter of this dissertation and by Agosin et al. (2012).

Although the model does show a mechanism by which trade may impair economic development, it should be interpreted with caution. The model does not warrant autarky to be a good policy stance for developing economies. The assumption that technologies can trespass borders even under autarky is at odds with the evidence. If trade is the channel of technology diffusion, or FDI, as evidence seems to suggest more strongly (Keller, 2010), then autarky does not make sense for a developmental strategy. A more integral approach to the relationship between trade, technology diffusion and development should study together the qualitative sectoral differences in this paper with trade as a conduit for technology diffusion. Such a project is pending for future research.

CHAPTER 4

STRUCTURAL OUTCOMES OF INVESTMENT SURGES

4.1 Introduction and motivation

Capital accumulation is typically seen as the key to growth and structural change. There are several potential mechanisms through which investment promotes growth, and the relative importance of these mechanisms is likely to vary with the nature of the economy, the starting income level of the country, and the sectoral allocation of capital. At low initial levels of income and small modern industrial sectors, economies are likely to benefit from the migration of labor from the low productivity traditional agrarian sectors to the higher productivity modern industrial sectors. At higher levels of income, other mechanisms such as internal and external economies of scale and learning externalities assume greater importance. Although structural change is normally equated to the movement of resources mainly from agriculture to manufacturing, in this paper we understand positive structural change as increases in sophistication, complexity and diversification of tradable activities[1].

Regardless of the mechanism through which it promotes growth, economic diversification and structural change are often seen as both a cause and an outcome of capital accumulation. This makes sense in a development context. Private or public firms planning to enter new sectors often require capital investment to execute their plans. One would, therefore, expect to see investment surges to be followed by greater structural complexity in economies. This may, however, not always be the case. Consider, for example, an investment surge that follows a positive terms of trade shock for a primary commodity exporting economy. As documented by a large amount of literature on the Dutch disease issue, such a shock may then lead to further specialization in the commodity sectors experiencing the positive shock at the expense of other tradable goods-producing sectors. Alternatively, an initially labor-abundant country like South Korea that industrializes and evolves into a capital-abundant country may then specialize as it moves across cones of diversification and lose

[1] In principle, we expect that structural change, as traditionally defined, may lead to increases in sophistication, complexity and diversification. Nevertheless, as they are not the same thing, this clarification is needed.

the older labor-intensive sectors. As is well-known, this latter possibility has been documented by Imbs and Wacziarg (2003) for economy-wide production structures, and by Cadot, Carrère, and Strauss-Kahn (2011), for the composition of exports.

We investigate how economies typically evolve during high investment episodes by taking advantage of 143 episodes of investment surges identified by Libman et al. (2019)[2]. We use the local projections method proposed by Jordà (2005) to explore the evolution of export diversification, sophistication and complexity during investment episodes. Our main statistically robust finding is that, consistent with the emphasis of much structuralist development literature, the composition of country imports shifts toward capital goods during investment episodes. For primary commodity exporters, episodes accompanied by rising terms of trade tend to lead to specialization while those accompanied by declining terms of trade lead to diversification. We also find that most episodes end with a higher proportion of medium- and high-tech products in total exports, and that for East and Southeast Asia, the export share of primary commodity exports declines (although it is small to begin with). However, we generally fail to find robust effects of investment surges on the degree of export sophistication and diversification. In addition, investment episodes do not seem to reliably affect the degree of economic complexity. This may be due to the low power of our tests and possibly because investment episodes have heterogeneous effects depending on the structure of the economy and the nature of the investment surge. Our analysis suggests that diversification and increase in complexity are likely to require innovative activities. High investment may constitute a necessary but not sufficient condition to enable such activities.

The next section carries out the econometric analysis, starting with a description of the data sources and methodologies employed. Section 3 compares our results with our a priori expectations. This inspires a closer look which we undertake in Section 4 with the help of a few country case studies. Section 5 concludes.

4.2 Analysis

As a basis for our analysis of the relationship between periods of high investment and structural change, we need to identify surges. We utilize the episodes of investment accelerations identified in an earlier study by Libman et al. (2019). Inspired by Hausmann, Pritchett, and Rodrik (2005), the baseline specification of that study specified the following three criteria to identify investment surges that lasted for a minimum of 8 years:

[2]The number of episodes in the baseline specification of Libman et al. (2019) is 175, but trade flows data availability only allows us to study 143 of them, and even fewer when adding some control variables like the terms of trade.

1. the annual per capita capital stock growth over an 8-year period must exceed 3.5 percent;
2. the annual per capita capital stock growth must have accelerated by at least 2 percentage points during the 8-year period; and
3. the level of capital per capita 8 years after the end of the acceleration episode must be above its historical peak.

Table 4.1: Definition of the variables of the analysis

Variables	Definition
Share of medium and high-tech exports	Using the taxonomy proposed by Lall (2000), each product is matched with one of the six technological categories and then the shares of trade are obtained. Lall (2000) classifies goods in six categories: commodities, natural resource-based manufactures, low-technology manufactures, medium-technology manufactures, high-technology manufactures and other transactions.
EXPY	Following Hausmann et al. (2007), we first calculate the level of sophistication of each product (PRODY), as a weighted average of the GDP per capita of countries exporting it (the weights being the revealed comparative advantage figures). Second, we calculate the sophistication of each country (EXPY) as a weighted average (where the weights are simply the share of the product in exports) of the PRODY of all the products a country's exports.
ECI	We take the Economic Complexity Index (ECI) from the Atlas of Economic Complexity, calculated as proposed originally by Hidalgo and Hausmann (2009). The authors use 2 measures to calculate the level of complexity of a country's exports: first, diversification, i.e., the number of products the country is specialized in (with revealed comparative advantage greater than 1), and, second, the ubiquity of a product, i.e., the number of countries exporting it (with revealed comparative advantage greater than 1).
Theil	Following Cadot et al. (2011), we calculate the Theil index, used as a measure of redundancy or lack of diversity. The Theil index is 0 when all products have the same share on the exports of a country (interpreted as diversification), and log(N) when a country's exports is only one product (interpreted as perfect specialization, N being the number of products available).
Gini	Following Cadot et al. (2011), we calculate the Gini index of inequality where 0 represents perfect equality of shares of exports (diversification) and 1 perfect inequality, or a product representing all exports (specialization).
HHI	Following Cadot et al. (2011), we calculate the Herfindahl-Hirschman Index normalized between 0 and 1, where 0 represents diversification in a sense of the share of exports being equal for all products, and 1 when a country's exports is concentrated in only one product.
Share of capital goods imports	Using the Broad Economic Categories taxonomy, we classify each product according to their function (consumption, intermediate or capital good), and then calculate the shares using import data.

Source: authors' elaboration.

The first criterion is meant to ensure that the capital stock per capita grows at a rapid rate while the second criterion ensures that the growth rate deviates significantly from the pre-episode average. The third criterion helps avoid episodes that are pure recoveries from periods of capital stock destruction due to events such as civil wars and natural disasters. Following these criteria, the authors identify 175 episodes over the period 1950-2014 and an unconditional probability of occurrence of 2.1%. The episodes are more likely to occur in middle-income countries, and the region with the highest number of episodes since 1960 is East Asia and Pacific, while the ones with the fewest are Europe and North America.

Having identified our investment accelerations, we next turn to formal econometric analysis and case studies to explore the evolution of our variables of interest during and after these episodes.

4.2.1 Data sources and descriptive statistics

We mainly investigate the evolution of the export and import structure during and after the investment episodes. The analysis is based on some indicators (described below) built from trade data. The source of the data is the Atlas of Economic Complexity from Harvard University. The trade raw data come from COMTRADE but is then cleaned by researchers while compiling the Atlas to increase reliability. The export and import data are classified following the Standard International Trade Classification, revision 2, which allows us to have information for approximately 700 goods. Although there are classifications that allow us to have more disaggregated data (more products), the classification used provides the longest possible coverage in terms of years, which is crucial to analyze the majority of investment episodes identified by Libman et al. (2019). In particular, the trade data we use covers most of the countries in the world and spans the period 1962 to 2017.

The analysis uses three types of indicators based on trade data (Table 1 presents the precise definitions of the variables).

1. First, we use three indicators to measure the sophistication or complexity of exports. We use the technological categories proposed by Lall (2000), defined according to the R&D expenditures of each economic sector. To capture sophistication, we use the export share of medium and high-technology manufactures.

   The second indicator we use to capture sophistication is the EXPY, as proposed by (Hausmann et al., 2007). The EXPY indicator is calculated as an average of the revealed measure of sophistication (associated income per capita) of each product a country is specialized in[3]. A country exporting goods that are only exported by rich countries will have a high EXPY value.

Finally, we also use the Economic Complexity Index (ECI), as proposed by Hidalgo and Hausmann (2009). The ECI index measures how diversified and complex the export basket of each country is. A complex product is one only exported by a few but highly diversified countries. A complex economy is one that is highly diversified and exporting products that only a few economies can produce (complex products).

2. The second set of indicators used in the analysis incorporates diversification of exports directly. Following Cadot et al. (2011), we use the trade data from the Atlas of Economic Complexity to calculate three indicators of concentration of exports: the Theil, the Gini, and the Herfindahl Hirschcman Index (HHI).

3. The final set of indicators we use are those applied to import data. First, based on the Broad Economic Categories (BEC) classification, we calculate the share of imports of capital goods to study its evolution during and after the investment episodes. Second, we also calculate the Theil, Gini and HHI indices to evaluate the evolution of concentration of imports during and after investment episodes.

Table 2 provides some summary statistics for these variables which are often employed in the trade and development literature. We now proceed to discuss some of their characteristics and show their relevance for the analysis of development problems.

Table 4.2: Definition of the variables of the analysis

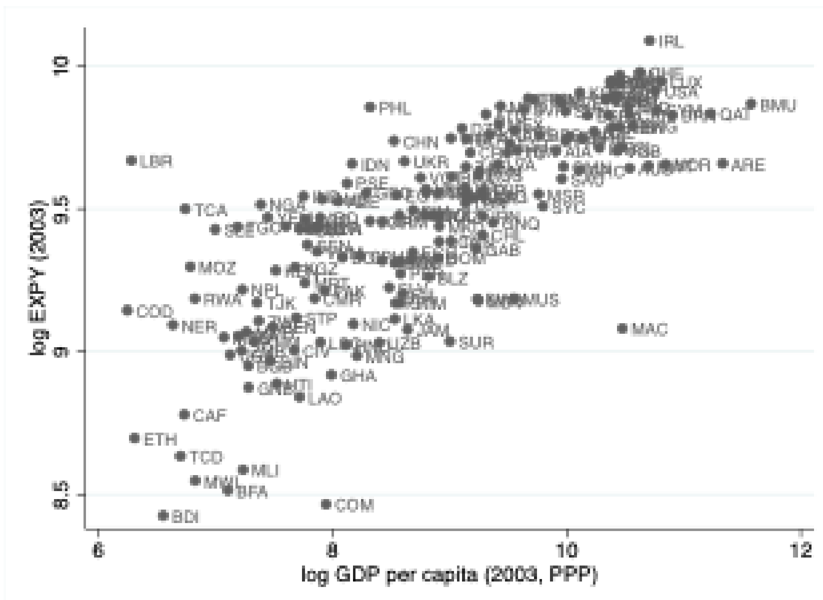
Variables	Obs.	Mean	St. Dev.	Min	Max	p1	p99
Share of medium and high-tech exports	11512	0.190	0.218	0.000	1.000	0.000	0.840
EXPY	11512	12627	4603	2632	27308	3700	21281
ECI	11520	0.036	0.970	-4.465	3.321	-2.052	2.201
Theil	11426	2.865	1.099	0.000	6.195	0.810	5.483
Gini	11426	0.907	0.084	0.049	0.997	0.637	0.994
HHI	11426	0.217	0.219	0.000	0.998	0.007	0.890
Share of capital goods imports	11468	0.191	0.115	0.000	0.998	0.019	0.747
Theil imports	11453	1.700	0.700	0.127	5.923	0.858	4.663
Gini imports	11453	0.795	0.065	0.286	0.996	0.629	0.967
HHI imports	11453	0.052	0.102	0.003	0.944	0.006	0.590

Source: author's elaboration based on data by the Atlas of Complexity (2019).

[3] A country is specialized in a product if it exports the product with revealed comparative advantage.

Figure 1 shows a scatterplot of EXPY against the GDP per capita for 2003. As expected, the correlation between the two is positive and significant. This means that rich (poor) countries tend to export products that other rich (poor) countries also export. Table 3 shows the five less and most sophisticated countries according to the EXPY in 2003. The less sophisticated economies are all low-income countries in Africa while the most sophisticated economies are mainly European and Asian. These results coincide with those reported by Hausmann et al. (2007).

Figure 4.1: Relationship between EXPY and GDP per capita, 2003



Source: authors' elaboration based on data by the Atlas of Complexity (2019).

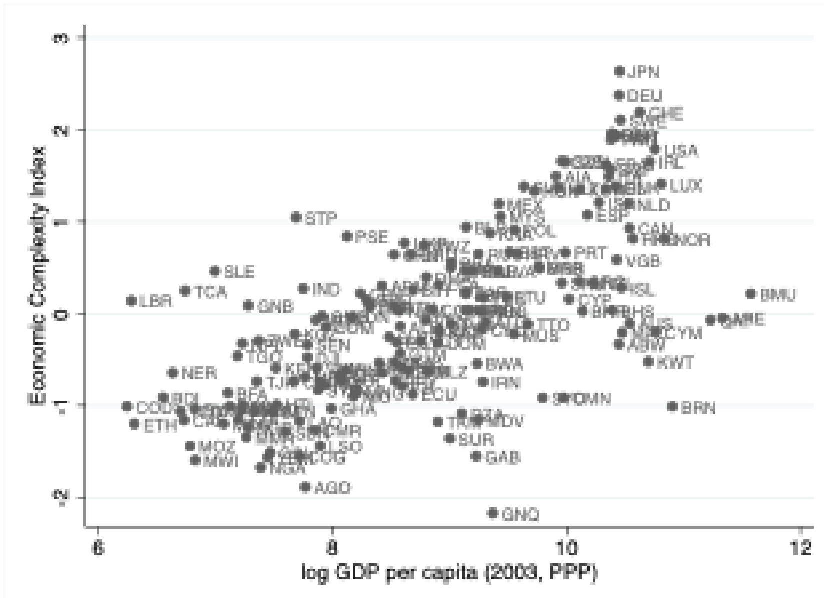
Table 4.3: Countries with the lowest and highest EXPYs, 2003

	Country	*EXPY*		Country	*EXPY*
Smallest	Burundi	4562.8	Largest	Ireland	24086.7
	Comoros	4746.9		Switzerland	21558.5
	Burkina Faso	4986.8		Japan	21352.8
	Malawi	5155.1		Finland	20915.4
	Mali	5359.0		Singapore	20882.7

Source: author's elaboration based on data by the Atlas of Complexity (2019).

Figure 2 reveals the relationship between ECI and GDP per capita for the same year, 2003. The correlation is positive as expected and significant. This means that rich countries tend to be diversified and export complex products that only a few diversified economies also export. Table 4 reveals the less and most complex economies in 2003. Consistent with our previous findings using EXPY, the less complex economies are mostly African, while the most complex economies are European countries and Japan.

Figure 4.2: Relationship between ECI and GDP per capita, 2003



Source: authors' elaboration based on data by the Atlas of Complexity (2019).

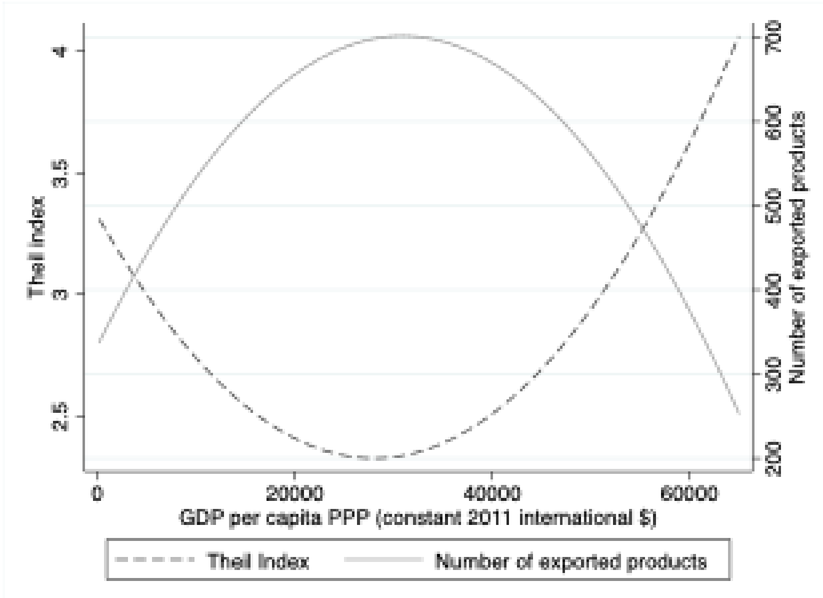
Table 4.4: Countries with lowest and highest ECI, 2003

	Country	*ECI*		Country	*ECI*
Smallest	Equatorial Guinea	-2.17	Largest	Japan	2.64
	Angola	-1.88		Germany	2.37
	Nigeria	-1.67		Switzerland	2.19
	Malawi	-1.59		Sweden	2.11
	Yemen	-1.56		Finland	1.97

Source: author's elaboration based on data by the Atlas of Complexity (2019).

We now turn to the indices of export concentration. According to Imbs and Wacziarg (2003) and Cadot et al. (2011), the relationship between diversification and development follows a hump- or inverted U-shaped form: countries at lower levels of income tend to be specialized in a few products. As they develop, they become more diversified up to a point after which they start to specialize again. As seen in Figure 3, we find a similar pattern. Moreover, our turning point in the relationship, approximately equal to the income per capita of Ireland in 1996, coincides with the one reported by the above-cited studies. The graphs using Gini and HHI look pretty much the same.

Figure 4.3: Predicted relationship between Theil index and number of exported products with GDP per capita



Source: authors' elaboration based on data by the Atlas of Complexity (2019).

According to Libman et al. (2019), investment surges are more likely at low- and middle-income levels. The unconditional probability of an investment episode taking place varies between 2.5% and 3.4% for the first four quantiles (with average incomes per capita of 1262, 2611, 5,959 and 12,194 constant international US$), while it is only 0.9% for those in the uppermost quintile (with an average income per capita of 34,556 constant international US$). The turning point in Figure 3 coincides with the average income of those countries where an investment episode is the least likely to take place (abstracting from the influence of other confounding variables) Hence, the combined evidence suggests that on average, countries that are in the diversification zone are also more likely to experience capital accumulation and growth at fast pace.

4.2.2 Econometric approach

Next, we explore more formally the relationship between investment acceleration episodes and various measures of trade-related structural change. We use the method of local projections as proposed by Jordà (2005) to evaluate the evolution of the trade indicators already described. The method consists of estimating local projections (regressions) at each period of interest, in this case the years of the episode and some years after. We run at each point of interest a two-way fixed effects regression to adjust for unobserved country-specific and year-specific confounders at the same time. The simple OLS regression calculated at each point of interest has the following form:

$$y_{i,t+h} = \alpha + \beta_h Episode_{i,t} + \lambda_h GDPPC_{i,t} + f_t + f_i \epsilon_{i,t} \tag{4.1}$$

where $y_{i,t+h}$ represents the cumulative change in each of the trade indicators at the year h, f_t represents time fixed effects, f_i represents country fixed effects, $GDPPC_{i,t}$ represents the GDP per capita, and $Episode_{i,t}$ is a dummy for the year of start of investment episodes.

The cumulative change is calculated with respect to four years before the episode, to avoid capturing pre-existing trends. Additionally, in the baseline setting we also include three years after the end of the episode to be able to see trends after the end of the episode. In other words, the equation is estimated for $h = -3, -2, ..., 0, 1, 2..., 9, 10$. The variable of interest is the dummy of the investment episode, meaning the coefficient of interest is β_h, capturing differences in the evolution of each of the trade indicators during episodes compared to normal times.

4.2.3 A priori expectations

Traditionally, development theory has emphasized that the process of capital accumulation in developing countries involves, to a large extent, the mobilization of resources from the traditional to the modern sector, which has a higher level of labor productivity and is the locus of technical progress. As capital accumulates and a large share of the labor force is re-allocated, income per capita increases (see Ros (2013), especially chapters 7 and 8). While the connection between the structure of domestic production and the composition of foreign trade during the process of economic development is not clear-cut, it seems plausible to expect certain changes in the type of goods that are exported and imported during a typical episode. Let's consider some specific indicators.

Diversification and sophistication of exports: The relationship between income per capita and the degree of diversification of production is likely non-linear. Following Imbs and Wacziarg (2003) Cadot et al. (2011), the degree of diversification seems to follow a U-shaped pattern. Production first diversifies, but late in the development process there is re-specialization again. Although the volume of exports depends on the dynamics of production and domestic absorption, one would therefore expect the degree of diversification of exports to depend on the level of income per capita at the beginning of the investment surge. However, as the large share of the episodes in our sample takes place at low- or middle-income levels, countries are typically below their diversification peak, and thus we are more likely to observe an increase in diversification during episodes. Iacovone and Javorcik (2010), for example, find that export diversification in Mexico is preceded by a rise in firm investment.

The degree of sophistication of the export basket, measured for example by the proportion of high-tech exports, or the shares of homogeneous goods and of differentiated goods, may also change during the process of economic development and consequently during episodes. Some empirical findings suggest that countries that produce and export more sophisticated goods tend to grow faster (Hausmann et al., 2007), and fast-growing economies also exhibit a large number of episodes. To export complex goods, a strong modern sector that employs highly qualified workers and adopts cutting-edge technologies is likely required. Because the expansion of the modern sector is an important engine of economic development, it is plausible to observe a positive correlation between export complexity (or its change) and economic growth.

Composition of Imports: Episodes often take place in low- and middle-income countries and production in their modern sectors often requires imported intermediate inputs and capital goods that are hard to substitute with local production. During a typical episode it is plausible to expect a noticeable increase in imports of intermediate inputs and capital goods, especially in those episodes where manufactures are the main driver of growth. In contrast, episodes triggered by the expansion of natural resource intensive sectors may exhibit a lower dependency on specific imported intermediate inputs and capital goods.

Manufactured vs. Natural-Resource Based Episodes. More complex (and diversified) export baskets provide a steadier stream of foreign exchange, contributing to a more robust balance of payments position. Exports of simpler goods can also help to relax the external constraint, but their prices are usually more volatile and constitute a less reliable source of foreign exchange. International capital markets are far from perfect and they usually cannot be tapped for funds when most needed, as eagerness to lend goes hand in hand with the prices of commodities (Kaminsky, Reinhart, & Végh, 2004).

While countries may be able to cushion the effects of volatile terms of trade and capital flows, for instance, by the adoption of appropriate macroeconomic policies, low- and middle-income country typically have less room to implement countercyclical policies. It is thus not surprising that, barring some exceptions, exporters of homogeneous commodities display slow growth subject to frequent interruptions and experience a smaller number of episodes. However, it is still possible to identify many episodes that are either triggered by an increase in the price of a natural resource or a large inflow of capital. In those episodes, complex and diversified manufacturing sectors can be hurt by the high relative price of non-tradable goods, reducing the diversification and the complexity of the export basket. Likewise, the composition of imports may react differently, depending on whether manufactures or natural-resources or services are the main drivers of the episode, as the former are highly dependent on specific imported inputs.

Short/Long Episodes & Low/High Growth Episodes. The sustainability of an investment episode may depend on the evolution of consumption and investment, and thus the composition of imports may also vary according to the duration of an episode or the speed at which capital accumulates. For instance, episodes that are long and/or exhibit a high rate of growth may deliver a stronger increase in the imports of investment goods (compared to consumption goods) than episodes that are short and/or where the rate of growth is low.

4.2.4 Econometric results

Our analysis proceeds in two steps, beginning with some less formal statistics and then providing the results of the local projections described earlier.

Starting with some simple diagnostics, we classify the episodes according to the average change in the main indicators of interest during and after the investment episodes. We first calculate the average value of each variable for the 10 years after the start of the episode and compare it to the average value for the 5 years before the start of the episode. Table 5 presents these calculations and provides some preliminary answers.

Table 4.5: Structural change during investment episodes

	Diversification	Specialization	No change	Total
Increasing Complexity	36	30	0	**66**
Declining Complexity	23	53	1	**77**
No change	0	0	0	**0**
Increasing Sophistication	46	50	0	**96**
Declining Sophistication	12	32	1	**45**
No change	1	1	0	**2**
Increased proportion of medium and high-tech products in total exports	47	46	0	**93**
Reduced proportion of medium and high-tech products in total exports	9	28	1	**38**
No change	3	9	0	**12**
Total	**59**	**83**	**1**	**143**

Source: author's elaboration based on data by the Atlas of Complexity (2019).

Consider first the number of episodes that led to both increased complexity and diversification. This number is 36, or about a quarter of the total number of cases (i.e., 143). The first result, therefore, that seems surprising is that most of the episodes (83) result in an increased specialization of the export basket. It is also surprising that most of the episodes (77) result in declining complexity. Using the sophistication indicator by (EXPY), on the other hand, reveals that most of the episodes (96) deliver increasing sophistication. As we see below, this may be true regardless of whether or not the countries experience rapid investment during their growth process. Finally, consistent with our expectations, an overwhelming number of countries (93) experience an increase in the share of medium- and high-tech exports in their baskets at the end of investment episodes and only 38 experience a decline. However, a higher share of medium- and high-tech products does not seem to go hand in hand with diversification and is in fact equally likely to coexist with specialization (there are 47 cases of diversification and 46 of specialization). This contrasts with the case of increasing (falling) complexity which is more likely to be associated with diversification (specialization).

The structure of trade may be important for explaining the previous results. Thus, using simple diagnostics again, we add to the analysis the evolution of terms of trade and the share of exports of commodities, and we focus our attention on changes in complexity and diversification. We divide episodes taking into account the share of exports of commodities at the beginning of the episode: the threshold to divide them is 33% (a higher share means the country is a commodity exporter). Table 6 presents the main results of this additional exercise.

Table 4.6: Investment episodes according to the sector of exports and terms of trade

	Manufacturing exporters		Commodity exporters	
	TOT up	TOT down	TOT up	TOT down
Diversification	10	12	8	22
Specialization	12	17	24	11
Increasing complexity	15	15	14	17
Decreasing complexity	7	14	18	16

Note: TOT means terms of trade. *Source:* author's elaboration based on data by the Atlas of Complexity (2019) and data on terms of trade from the IMF (2019).

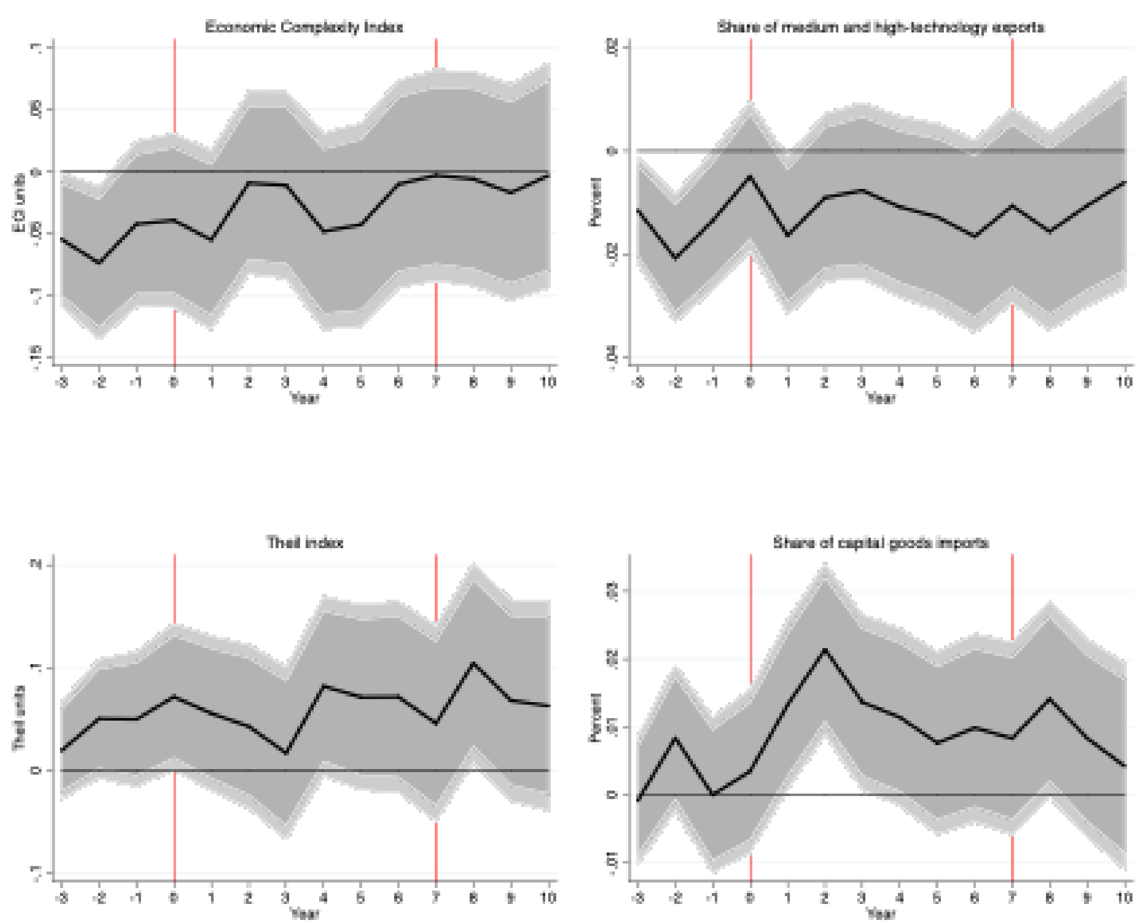
The majority of episodes in manufacturing exporters (30 out 51) show increased complexity, regardless of the evolution of terms of trade. There is no clear pattern of relationship between terms of trade, episodes and changes in complexity in commodity exporters. Now consider changes in diversification. A slightly higher proportion of episodes in manufacturing exporters tend to lead to specialization of exports, regardless of what happens to the terms of trade. An interesting pattern arises when we analyze diversification for commodity exporters during investment episodes. If the terms of trade for a commodity exporter are going down (up), an investment episode tends to lead to diversification (specialization). This exercise suggests that the impact of investment episodes on structural change patterns may be mediated by terms of trade and its interaction with the main sector of the exports of a country. We formally control below for these variables (terms of trade and share of commodity exports) and their interaction in our more formal exercise below.

Our simple diagnostics do not show how the indicators behave in comparison to normal times (when episodes are not occurring). To evaluate, in a more precise way, the evolution of trade flows during investment episodes we proceed to the analysis using the local projections method.

Local projections

The main results of the local projections, described earlier in section 2.2, are presented in Figure 4. The red lines represent the beginning and the end of an investment episode, while the light grey and dark grey areas represent the 95 and 90 confidence bands respectively.

Figure 4.4: Evolution of trade indices during and after investment episode



Note: These graphs represent the outcome of the coefficient β_h from the equation in section 2.2 for each h. *Source:* authors' elaboration based on data by the Atlas of Complexity (2019).

Two main lessons can be derived. On the one hand, the results suggest that there are no clear trends in complexity, sophistication, and diversification of exports during the episodes. There are also no clear trends in import diversification. On the other hand, the result show that there is a statistically significant increase in the share of capital goods imports in the first three years of the episode and a reduction in the share of consumption goods imports, considering the episode as a whole[4]. As mentioned before, we also ran projections including the terms of trade, the share of commodity exports and their interaction, to account for the influence of the structure of the economy on the impact of the episodes, and the squared GDP per capita to account for the U-shaped relation between diversification and development. Since the results are qualitatively similar we only show in Figure 4 the results following the specification presented in section 2.2. The entire results are available as an appendix and upon request.

Next, we explored how robust the results are to different samples and episode types. For instance, when we restrict the sample by region, the main differences are as follows. In Southern Europe there is an increase in sophistication (EXPY) and in complexity in the last year of the episode and one after, but these results do not hold for exports of medium and high-tech goods. In South-eastern Asia there is an increase in capital goods imports during the first half of the episode and by the end. In Northern Europe there is an increase in specialization during the episode using the Gini and the Theil indexes, a decrease in the share of medium and high-tech exports together (but not in high-tech only). In Latin America, there is a decrease in complexity in the first year of the episode and an increase in specialization at the end of the episode using Gini and Theil index. Finally, In Africa, Southern Europe, Northern Europe, Eastern Europe, Western Europe and Eastern Asia, there is no increase in the share of capital goods imports. Most results do not depend on the level of income, except that there is a significant increase in specialization using Gini in low income countries.

Following Libman et al. (2019), we also considered three different types of episodes that are of interest for our purposes: (1) Tradable episodes, (2) Sustained episodes, and (3) Manufacturing episodes. For (1) we separate episodes associated with investment booms in non-tradables from those in tradables, using data on capital accumulation in the construction sector and the machinery and equipment sector, respectively. Applying the filter to the disaggregated capital stock series, we identify

[4] In projections for countries where exports of commodities are more than 33% at the beginning of the episode the impact on capital goods imports almost disappears. Only in the first year of the episodes we observe a significant increase in imports of capital goods. That implies that the increase in capital goods is driven principally by the investment episodes in countries where exports of manufactures are more important.

147 episodes for non-tradable booms and 268 episodes of tradable booms. For (2) we identify as "sustained" those episodes where capital per person growth is at least 3.5 per cent in the 8-year window following the episode. According to this refined criterion, about half of the original episodes (85 out of 175) are classified as sustained. For (3), we combine information from the WDI on the manufacturing share of total value added and the manufacturing share of total exports for each country. When both the value added and the export shares for a country are larger than the world average for more than half of the sample period, we classify that country as a manufacturing one for the entire sample. The rest of the countries are de facto considered non-manufacturing producers, even if there are no WDI data for them[5]. The reasons to dig more deeply are, as discussed earlier in section 2, closely related to the special role that manufactures and tradable activities play in the process of development, and the stop-go nature of economic growth associated with improved terms of trade and capital flows bonanzas.

Considering tradable episodes only (which are those where the surge in investment takes place in machinery and equipment), we find that they end with specialization using HHI and Theil, and there is an increase in capital goods imports which is associated mainly with electric machinery. In contrast, when we consider non-tradable episodes, specialization in exports precede the episodes and there is a slight increase in the share of capital goods imports during the episode. There appears to be an increase in the share of high-tech exports after the end of typical episodes. On the other hand, if we consider 5-year episodes, we find that high-tech exports increase 10 years after end of the episode, the share of capital goods imports increases during the whole episode and after 5 years of the end, both the shares of imports of intermediate and consumption goods decrease during the episode.

For sustained episodes (those where growth remains at 3.5 percent in per capita terms, once the episode ends), there is a decrease in sophistication during the episode, an increase in specialization using Gini and Theil index, a significant fall in the share of medium and high-tech exports during and after the episode, and an increase in capital goods imports. For episodes that are constructed using a 5-year window, there is an increase in the share of high-tech exports in year 2 of the episode and an increase in the share of capital goods imports. Using a 9-year window there is also an increase in capital goods imports, while if we use a 12-year window there is no clear difference with respect to the baseline specification.

[5]When very little data are available, we only consider the longer series. When no data exist that country is excluded, except a well-known example: there is no data for Taiwan, but we include it in the group of manufacturing countries. The full list of manufacturing countries includes: Argentina, Bolivia, Brazil, Botswana, Chile, China, Colombia, Costa Rica, Denmark, Egypt, Ethiopia, France, Germany, Ghana, Hong Kong, India, Indonesia, Italy, Japan, Kenya, South Korea, Malawi, Malaysia, Mauritius, Mexico, Morocco, Netherlands, Nigeria, Peru, Philippines, Senegal, Singapore, Spain, Sweden, Taiwan, Tanzania, Thailand, United Kingdom, United States, and Venezuela. The rest is considered as non- manufacturing.

If we consider episodes where the share of manufacturing employment increases more than the median change during the episode, there is an increase in complexity during the first two years of the episode and an increase in diversification in the first year of the episode with the Gini. When we restrict the episodes to last only 5 years, we find that complexity increases one year before the episode until the second year, and that there is an increase in diversification using Gini and Theil index and an increase in capital goods imports by the end of the episode. We should notice that due to data limitation, only a small share of episodes was classified as "manufacturing" (44 out of a total of 203 episodes).

In sum, the local projections suggest three statistically significant and relatively robust results: (1) capital goods imports as a proportion of total imports increase (and consumption goods decline) during episodes, (2) most episodes end with a higher proportion of medium- and high-tech products in total exports, and (3) distinguishing countries by region, in East and Southeast Asian economies the share of primary commodity exports declines during episodes (although it is small to begin with).

4.3 A discussion of the match between expectations and results

Several of the results are not in line with our expectations and some of them are not entirely robust. This is particularly true for those results related to the dynamic of exports. For example, we do not find a statistically significant increase in diversification or economic complexity during investment episodes. In contrast, the results associated with the dynamics of imports confirm our priors. The overall picture thus suggests that there are few changes in terms of diversification or sophistication of foreign trade during and after investment episodes, while there is a clear connection between capital accumulation and imports of capital goods. This suggests that during a typical episode, foreign trade seems to experience little structural change, as the export basket does not become more complex and diversified, and the dependence of certain foreign inputs remains strong.

Let us consider some of the results in detail. There is no clear indication that investment episodes are associated with significant changes in export diversification or complexity, even if we consider different type of episodes, windows and groups of countries. Moreover, in some instances there is a decrease in complexity in the first year of the episode and an increase in specialization at the end, for example in Latin America. This may suggest that some episodes can be associated with natural resources discoveries, improvements of the terms of trade or capital flow bonanzas. However, in the East Asian and South Asian cases there are no clear indications that during episodes the countries experience significant changes in the complexity or diversity of their export baskets. In the same vein, considering episodes where the share of manufacturing employment increases more than the median change during the episode, there is a mild increase in complexity and diversification during the first years of an episode only. A similar lesson follows when we analyze tradable episodes.

When we compare tradable vs. non-tradable episodes, we find no clear differences in terms of changes in diversification and sophistication of the export baskets; in other words, during both type of episodes there are no clear trends. There is a slight difference: the reactions of imports of capital goods is somewhat weaker in the non-tradable case. This is what we should expect if tradable activities are those associated with complex input-output relations that imply low substitutability, while the non-tradable activities involve fewer imported goods. Notice that increases in the capital stock associated with construction, which is a non-tradable activity almost by definition, is precisely the variable that defines the non-tradable nature of an episode[6].

Regarding the sensitivity of the results with respect to changes in the time window, we did not find any consistent pattern either. For instance, if we consider longer windows for tradable episodes, there seems to be an increase in the share of high-tech exports some years after the end of the episode, which suggests that changing the export basket requires a span of time that exceeds the typical episode. However, when we considered sustained episodes, there is a decrease in sophistication during the episode, an increase in specialization using Gini and Theil index, and a significant fall in the share of medium and high-tech exports during and after the episode. Thus, the evidence that we were able to gather does not suggest the presence of clear trends that affect the composition of the export baskets.

Moving to the import side, the results clearly suggest that investment surges are associated with increases in the share of imports of capital goods during the first part of an episode, and a reduction of the share of consumption goods. This result is what we should expect, considering that most episodes take place in low- and middle-income countries, which are typically highly dependent on imports of specific goods in order to carry on regular production. This is a robust result that holds regardless of the region, the type of episode and the size of the window considered.

In some cases, the increase in capital goods imports is driven by specific groups of goods, such as electric machinery, telecommunications and specialized capital goods, but there is no clear additional pattern, other than the close connection between

[6]It is important to keep in mind that in some particular instances, manufacturing activities are non-tradable due to the presence of tariff and other barriers to trade. Thus, we cannot exclude the possibility that some of the episodes classified as non-tradable are heavily dependent on imported inputs. However, this concern is somewhat weakened because our dataset spans a period of time that starts in 1950. After the end of the 2nd World War, the increase in trade openness, associated with the emergence of global value chains and the progressive reduction in barriers to trade, may have significantly reduced the number of episodes where non-tradable manufacturing activities are the main driver of growth.

sustained surges in investment and large increases in imports of capital goods and other intermediated inputs.

The fact that we get few statistically robust results in line with our expectations from economic theory raises several possibilities. First, that there are no statistical relationships to be found, which may in turn suggest that diversification and sophistication may require not only investment but also innovative activities, among other things. This theoretical possibility is one of the main tenets of evolutionary literature on catching up growth and development Perilla-Jimenez (2019). A second possibility is that the low statistical power of our tests due to the limited number of investment episodes available does not allow us to capture the expected results. Third, that the direction of change in economic structure may vary with the factors that lead to an investment episode. For example, in some cases, a positive terms of trade shock that causes investment in the export sector of a primary commodity exporting economy is likely to be accompanied by specialization rather than diversification. And finally, consistent with Imbs and Wacziarg (2003) and Cadot et al. (2011), accelerated investment may be accompanied by diversification at lower levels of income but specialization at higher levels. While our limited sample size does not allow us to formally investigate these alternative explanations, the next section briefly turns to a few country case studies to take a closer look.

4.4 A few case studies for illumination

Let's briefly investigate a sample of factors that may influence the trajectory of structural change during episodes of accelerated investment. We chose 5 countries – Indonesia, South Korea, Peru, Turkey, and Uganda – with the following considerations in mind: (1) to enable within country comparison across time, the economies must have experienced more than one investment episode, (2) geographic diversity, (3) different initial starting conditions in term of economic structure (e.g., primary exporters versus manufacturing exporters).

We briefly discuss each country and then summarize a few broad lessons. Table 7 provides the summary statistics underlying our analysis.

South Korea

South Korea experienced three investment episodes beginning in 1962, 1972, and 1988. The first episode, coinciding with the first five-year plan (1962-67), occurred at an extremely low level of initial income ($976 in 2010 constant US dollars) and converted Korea into a manufacturing exporter. Starting at 18 percent the manufacturing share of exports increased by 65.4 percentage points during the episode. The second episode, overlapping with the beginning of the "Heavy-Chemical

Industry Drive," began when the share of manufacturing in exports was already very high at almost 84%, and resulted in more diversification and a larger shift of 19.5 percentage points toward medium- and high-tech exports.

Table 4.7: Structural changes in countries experiencing multiple episodes

	Begin year	GDP (constant 2010 US dollars)	*Initial_Man_X*	Δ*TOT*	Δ*Man_X*	Δ*MT_HT*	Δ*Man_M*	Δ*ECI*	Δ*EXPY*	Δ*Theil*
Korea	1962[a]	976	18.2	1.46	62.4	14.0	2.09	0.4	1496	-0.2
	1972	2,045	83.6	-35.3	11.1	19.5	-10.4	0.1	2529	-0.2
	1988	7,365	93.1	17.0	-0.3	18.6	2.7	0.1	2714	0.2
Indonesia	1970	737	1.2	17.5	1.2[b]	0.4	-13.7[b]	-0.4	3264	0.9
	1990	1,708	35.5	-5.8	23.3	18.7	-12.2	0.6	1805	-1.3
	2005	2,524	47.2	16.3	-11.2	-5.8	4.5	0.1	-1076	0.1
Peru	1993	2,673	16.9	2.4	5.1	0.0	5.0	-0.2	157	-0.1
	2004	3,603	19.2	47.5	-5.9	4.0	4.3	0.1	409	0.2
Turkey	1964[b]	3542	8.9	n.a.	5.3	1.3	2.2	0.3	853	0.0
	1983	5310	67.9	8.7	23.7	7.6	13.8	-0.2	1072	-0.3
	2003	8331	83.7	-9.3	-3.0	4.0	-5.2	-0.1	1618	-0.1
Uganda	1965[c]	n.a.	0.4	n.a.	n.a.	0.0	n.a.	0.0	-252	0.5
	1995	474	4.4	-15.1	-2.2	4.8	-6.7	0.5	3837	-1.1
	2003	608	11.7	6.0	18.1	9.5	-2.3	0.6	1225	-0.4

Source: authors' elaboration based on data by the Atlas of Complexity (2019) and data on terms of trade from the IMF (2019).
[a]Since data were unavailable for the years prior to 1962, the pre-period average for this episode is simply the value of the variable in 1962.
[b]Since data were unavailable for the years prior to 1970, the pre-period average for this episode is simply the value of the variable in 1970.
[c]Since data were unavailable for the years prior to 1970, the initial value for this episode is simply the value of the variable in 1976.
Initial_Man_X: Manufacturing share of total exports at the beginning of the episode
ΔTOT: Change in net export price (rolling weights) between 3-year average pre-episode and average during episode
ΔMan_X: change in manufacturing share of total exports between 3-year averages pre-episode and post-episode
ΔMT_HT: change in medium- and high-tech share of total exports between 3-year averages pre-episode and post-episode
ΔMan_M: change in manufactures share of total imports between 3-year averages pre-episode and post-episode
ΔECI: change in ECI between 3-year averages pre-episode and post-episode
ΔEXPY: change in EXPY between 3-year averages pre-episode and post-episode
ΔTheil: change in Theil index between 3-year averages pre-episode and post-episode

The first two episodes, which happened during times of declining or stable terms of trade led to diversification. The Theil index fell by 0.2 points during each episode, which is a major change considering that Korea's Theil index started at 1.9 in 1962 and ended at 2.3 in 2019. The third episode, which started when Korea was a middle-income country, and had an even higher level of manufactures' share of exports, occurred during a period of rising terms of trade. Although this episode did lead to a large increase in EXPY and another dramatic increase in the share of medium- and high-tech exports, but it was accompanied by specialization (the Theil index increased by 0.2 points), and a small decline in the overall share of manufactures in exports. While the level of income at which this change occurred is lower than the global threshold identified by Cadot et al. (2011), it is consistent with the overall story of initial diversification followed later by specialization.

Indonesia

Indonesia experienced all three episodes (1970, 1990, and 2005) at relatively low levels of per capita GDP, and as an economy where manufactures are less than 50% of total merchandise exports. Major commodity exports include crude oil, natural gas, coal, and minerals. The first and third episodes, which were accompanied by substantial positive terms of trade shocks ended in essentially unchanged (in the case of the first), or significantly lower (in the case of the third) shares of manufactured exports. Thus, positive terms of trade shocks involving rising primary commodity prices were accompanied by higher investment but lower export shares of manufactures.

The second episode, which was the only one that did not occur during a period of rising terms of trade, was also the only episode that led to diversification (the Theil index declined by 1.3 percentage points) and increasing economic complexity. Moreover, it is the only episode that saw a rise in the share of manufactured exports and a significant shift toward medium- and high-tech manufactures. The effects of the primary commodity shock of the early 2000s is visible in the declining proportion of medium- and high-tech exports and the dramatic decline in the EXPY index. This is consistent with the Dutch disease pattern whereby countries that mainly export primary commodities and experience positive terms of trade shocks are likely to see non-primary tradable sectors stagnate or contract.

Peru

Peru experienced two episodes (1993 and 2004) at relatively low levels of per capita GDP. At the beginning of the episodes, manufactures were less than a quarter of total merchandise exports. Major commodity exports include minerals (copper, gold and zinc) as well as some textiles.

The first episode, which did not occur during a period of rising terms of trade, led to some diversification and decreasing economic complexity and there was some expansion of manufactured exports. During the late 1980s Peru suffered from a hyperinflation in the context of the so-called Latin-American lost decade. The recovery during the 1990s included the combination of macroeconomic stabilization with structural reforms and liberalization. The episode took place during a period of large capital inflows and real exchange rate appreciation.

The second episode was accompanied by a substantial positive terms of trade shock which led to specialization but higher complexity. The positive terms of trade shock involved rising primary commodity prices and was accompanied by higher investment but lower export shares of manufactures.

Turkey

Turkey experienced three episodes (1964, 1983, 2003), all of them ending in diversification or no significant change; only during the first episode was there an increase in complexity. The second episode, accompanied by a global decline in primary commodity prices, led to the largest increase in the share of manufactures and, within manufactures, to the largest increase in the share of medium and high technology exports.

The terms of trade did not seem to play an important role, as they increase during the second episode, but they decrease during the third, without any noticeable trace on the exports basket. Turkey was already exporting a large share of manufactured goods and it does not have much potential to produce natural resources.

Uganda

Uganda experienced three episodes (1965, 1995, and 2003), starting from a low level of income and a small share of exports of manufactures (which were almost zero during the first episode in 1965, and slightly above 10% of total exports during the third one). Interestingly, terms of trade did not seem to play an important role, even though the Ugandan export basket includes mainly coffee, cotton, tobacco, tea, bananas, maize and beans (which is a relatively diversify basket for a commodity exporter). However, the third episode takes place right after the second one, which takes place with declining terms of trade.

Overall, the Uganda export sector has become more diverse and complex during the second and third episodes, which is an atypical outcome for a commodity exporter. The second episode took place after a structural adjustment process which reduced inflation and reorganized the public sector accounts, the liberalization of domestic and foreign trade, and with substantial support in the form of aid and loans from multilateral financial institutions, and these may have played a role in the outcomes.

To sum up this section, our brief case studies suggest a few broad themes. The first is that positive terms of trade shocks in primary exporters can lead to investment surges that do not result in structural change in terms of diversification or increasing complexity. Second, investment episodes at different levels of income may have different outcomes in terms of complexity and diversification[7]. Third, complexity and diversification often move in opposite directions. These factors along with our small sample size help at least partly explain why our statistical tests fail to capture robust trends in structural change following investment episodes.

4.5 Conclusions

Diversification of economic structures typically requires capital investment, especially in developing countries. Since less developed countries have to import much of their capital goods and sophisticated industrial inputs, episodes of high investment can create problems for the balance of payments. We find some support for this concern that has been traditionally highlighted by the structuralist literature.

One would also expect periods of atypically high investment to result in increased economic complexity and diversification of export structure. Focusing on a sample of 143 investment surges, we fail to find statistically robust econometric results consistent with these expectations. Apart from the low statistical power of our tests, this may be due to several other reasons, including the initial conditions, differences in the nature of changes that lead to investment accelerations, and the fact that export diversification and economic complexity do not always move in the same direction. Moreover, episodes of sustained high investment may not be sufficiently different in their effects on macro variables than less dramatic periods of significant investment. Our preliminary investigation employing less formal approaches suggests that some of these possibilities deserve further attention and that a more comprehensive research design should incorporate the heterogeneity of investment episodes as they interact with diverse economic structures. High investment may often be a necessary but not sufficient condition for structural change.

[7] We discussed South Korea here but a similar pattern of early diversification and later specialization emerges in the case of Taiwan, which had two episodes, one in 1960 and the other in 1988, and is the only other relatively large economy that went from being a low income country to a high income industrialized one during our sample period, and experienced episodes at different stages of its development.

CHAPTER 5

CONCLUSION

A common theme in the three Essays of this dissertation is that technological upgrading is at the core of growth and development. Trade (as discussed extensively in the first two Essays) becomes important as it might affect technological upgrading negatively. Investment is studied (in the third Essay) as it might not only lead to short-run growth but to technological upgrading embedded in new, more complex structures. Although the idea that technical change is behind growth and development is not new, approaching it from a view of complexity and economic structure is much more informative than simply as higher productivity levels, as most research in economics usually does. In other words, technical progress is not only a quantitative phenomenon, by which productivity increases, but also a qualitative phenomenon, by which economic structures are transformed into being more sophisticated but also more complex and diverse.

How does trade then affects technological upgrading and thus growth? Consistent with classical development literature and a strand in the trade and endogenous growth literature, the first Essay demonstrates that the relationship between trade liberalization and growth varies with economic structure. More specifically, I show that tariff reductions lead to lower GDP per capita for nonmanufacturer countries, which is in turn driven by a lower share of manufacturing in GDP. On the other hand, tariff reductions lead to higher GDP per capita for manufacturer countries, in turn also driven by an increase in the share of manufacturing in GDP.

The second Essay provides a rationale for the previous result, linking the structural changes observed to changes in technological capabilities. I present a model of North-South trade, innovation and international technology diffusion. In a sense, the model embeds the diffusion component from standard endogenous growth theory into a two-countries two-goods Structuralist model. The economy has two sectors, the traditional and the modern, and the modern is assumed to be the locus of international technology diffusion. Trade leads to an increase in Southern specialization on the traditional sector, thus transitionally losing some benefits of imitation in the modern sector, which reduces the Southern relative income and its technological proximity to the frontier of steady state. In other words, trade reduces the level of technological capabilities in the South by generating regressive structural change or deindustrialization.

In the last Essay, I depart a little from trade issues but remain focused on technological upgrading by exploring how aggregate investment might be connected to it. With coauthors Emiliano Libman and Arslan Razmi, we study how economic complexity, sophistication, diversification, imports composition, and other indices of economic structure behave during and after surges of sustained investment. We find that complexity and sophistication do not change significantly during the episodes. We nonetheless document that imports composition does change: the imports of capital good rise during investment surges. In our opinion, high investment may often be a necessary but not sufficient condition for structural change. Technological upgrading takes more than uptakes in investment in general, and might need specific policies aimed to channel investment into specific types of goods and industries.

The messages of this dissertation are particularly relevant for developing economies, invitations in a sense to rethink policy in those countries. The mainstream approach to developmental policy has been that the best is not to have one, echoing the words mentioned once by Gary Becker. In the same sense, the best trade policy is free trade, the reduction of tariffs, also judiciously applied worldwide especially since the creation of WTO. As it touches on trade policy first and foremost, this dissertation suggests that the policy developing economies have followed has been detrimental. Free trade has led to deindustrialization and to lower growth, thus reaffirming underdevelopment. Furthermore, developmental policies aimed to increase investment are still welcome, but a focus on structural change and technological upgrading is needed, as investment alone won't do the trick. As a first step, developing economies should stop trying to pursue further liberalization of trade policies, and as a follow-up start a discussion by which trade policies are again discussed hand-in-hand with industrial policies, which fortunately have returned to economics in the last couple of years.

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