

ESSAYS IN INTERNATIONAL ECONOMICS:  
CHINA'S EXPORTS, GROWTH, AND  
COMPARATIVE ADVANTAGE

**Dissertation**

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# Executive Summary

At the end of the 20th century, economic investigations in international trade have seen a return of presumed-dead, yet classical, theories. “Growth miracles”, which could be observed among several Asian economies, were the consequence of political reforms that facilitated the international division of labor. As low-wage countries were increasingly integrated into global production chains, comparative advantage in labor-intensive activities triggered the countries’ transformation from agricultural to industrial production. The consequences are felt in many industries in advanced economies, pushing politicians, firms, and workers to adjust. While certain groups in industrialized countries face real losses, at least in the short- and medium-run, the events enabled a substantial part of our world’s population to find a way out of poverty. The division of labor is one of the oldest and most widely diffused principles of economics, and promises wealth for anyone taking part in it. While the 1970s and 80s were dominated by alternative theories to rationalize trade, and its benefits, a revival of the classical forces is not exclusive only to popular public opinions.

This dissertation analyzes different aspects of the increased participation of low-wage countries in international trade. In synthesis, it points out why it is so difficult for some people to make a general statement about the desirability of international economic integration and trade liberalization. Trade is important for a country to escape poverty, whereas it implies that other countries will face painful adjustments. The thesis illustrates how technology, as an abstract driver of economic growth, contributes to a country’s ability to participate in international trade, and that this feeds back into a sustainable development path. The thesis also argues that the general export performance of a country may be inhibited, if it faces uncertainty in a major destination market. Finally, the thesis demonstrates that low-wage countries may contest the position of high-income countries, in third markets, which has implications for the evaluation of the competitive “threat” exerted by low-wage countries.

The thesis is comprised of three self-contained essays. The first essay investigates the relationship of a country's degree of export diversification and its stage of economic development. It addresses a debate in the empirical literature, which found alternative patterns for this relationship: (i) continuous diversification; and (ii) re-specialization at later stages of economic development. A contribution to this literature is provided by a theory-based assessment of either pattern, and by the derivation of a parametric specification. Another contribution is the investigation of causality. The analysis provides economic intuition for the measurement of export diversification, and for a parametric modeling strategy. Both the theoretical and the empirical analyses reject the case of re-specialization. Moreover, it is shown that diversification exerts a causal effect on a country's real GDP per capita, whereas a reverse effect cannot be confirmed, as a general pattern. The results suggest that new trade relationships facilitate economic development.

The second essay investigates China's export boom to the European Union (EU) since 2001. Because EU trade policies towards China did not change upon its WTO accession, in that year, it is hypothesized that a removal of tariff uncertainty in the United States (US) has triggered China's export boom. The article generalizes the findings of previous studies, which had explained China's exports to the US. A formal extension of a commonly used trade model is presented to establish the possibility of a US policy spillover. The extended model suggests economies of scale from exporting a good to several destinations. The econometric analysis cannot reject the predictions of the model. In fact, the structure, the magnitude, and the timing of the estimated effect conform to the characteristics of the US policy change. The results uncover an important dimension of trade policies, because even a bilateral design may exert at a multilateral level.

The third essay investigates competition between US and Chinese exports in third markets. The article contributes to a literature that, so far, has focused on low-wage import competition. The article shows that the presence of Chinese exports in destination markets of US exports depresses their average prices. In the context of the theoretical framework used in related studies on export prices, the results suggest that US exporters exit the market, as consumers shift parts of their expenditures to Chinese goods. In contrast to previous studies, it is found that "cost-" rather than "quality-competition" prevails. The effects are found in several manufacturing sectors, and, most prominently, in the machinery and electronics industry. Moreover, it is found that US

exports in exposed product categories decrease, when China enters the market, relative to similar non-exposed goods. The results underscore the forces of comparative advantage being at work, and complement patterns of structural adjustments found due to import competition.

Altogether, this dissertation aims at contributing to the understanding of the structural transitions taking place at the beginning of the 21st century. Its results suggest that the forces of comparative advantage from relative factor endowments are playing a vital role. Whether a country will be able to exploit them, appears to depend on its own, but also on other countries' policies that facilitate the operation of market forces. For China, it appears to have worked quite well, in terms of both its economic development and its role in international trade.

# Zusammenfassung

Klassische und tot geglaubte Theorien des internationalen Handels haben zum Ende des 20. Jahrhunderts wieder an Bedeutung gewonnen. Begünstigt durch liberale Reformen in einer Reihe asiatischer Länder, führte seit den 1960er und 70er Jahren die internationale Arbeitsteilung zu den sogenannten „Wachstumswundern“. Das Angebot arbeitsintensiver Produktionsdienstleistungen und die Integration in globale Wertschöpfungsketten haben zur Transformation dieser Länder von landwirtschaftlicher zu industrieller Produktion beigetragen. In Industrieländern führen die Entwicklungen zu einem Anpassungsdruck auf allen Ebenen des wirtschaftlichen und politischen Lebens. Während einzelne Gruppen, zumindest kurz- bis mittelfristig, stärker und negativ betroffen sind, haben die Entwicklungen auch dazu geführt, dass ein großer Teil der Weltbevölkerung der unmittelbaren Armut entkommen konnte. Die Arbeitsteilung ist seit jeher Bestandteil der ökonomischen Lehre und verspricht Vorteile für jeden, der an ihr teilnimmt. Während in den 1970er und 80er Jahren alternative Handelstheorien entwickelt wurden, scheint nun — und nicht nur in der herrschenden öffentlichen Meinung — eine Rückbesinnung auf dieses klassische Prinzip stattzufinden.

Die vorliegende Dissertation greift verschiedene Aspekte der Beteiligung von Niedriglohnländern am internationalen Handel auf. Zusammen stellen sie heraus warum es oftmals schwer fällt, wirtschaftliche Verflechtungen und Handelsliberalisierungen normativ zu beurteilen. Während einerseits die bedeutsame Rolle des Handels für wirtschaftliche Entwicklung dargestellt wird, zeigen sich auf der Gegenseite die unvermeidbaren Anpassungsprozesse an eine Überlassung bestimmter Produktionsleistungen an Niedriglohnländer. Insbesondere wird hervorgehoben wie Technologie als abstrakte Wachstumsdeterminante im Zusammenhang mit der Handelspartizipation eines Landes steht. Es wird außerdem argumentiert, dass wirtschaftliche Unsicherheit in einzelnen Zielmärkten die allgemeine Exportaktivität eines Landes behindern kann. Zuletzt wird analysiert, ob Niedriglohnländer die Position von Industrieländern in Drittmärkten beeinflussen.

Die Dissertation ist in drei eigenständige Aufsätze gegliedert. Der erste Aufsatz setzt sich mit dem Zusammenhang zwischen der Diversifikation von Exporten und der wirtschaftlichen Entwicklung eines Landes auseinander. Während einige empirische Studien auf eine kontinuierliche Erweiterung des Portfolios hindeuten, so wurde auch gezeigt, dass sich Volkswirtschaften nach anfänglicher Diversifizierung wieder spezialisieren. Durch die Darstellung theoriegestützter Überlegungen zu beiden Möglichkeiten und durch die Analyse eines parametrischen Modellrahmens wird ein Beitrag zu dieser Literatur geleistet. Darüber hinaus wird der Forschungsstand durch eine Analyse des kausalen Zusammenhangs erweitert. Sowohl die theoretischen als auch die empirischen Ergebnisse sprechen für einen kontinuierlichen Diversifikationsprozess. Es wird zudem gezeigt, dass Diversifikation das Einkommensniveau der Volkswirtschaft beeinflusst und nicht umgekehrt. Die Erschließung neuer Handelsbeziehungen scheint eine zentrale Bedeutung für die wirtschaftliche Entwicklung zu haben.

Der zweite Artikel beschäftigt sich mit dem Anstieg chinesischer Exporte in die Europäische Union (EU) seit 2001. Da sich die handelspolitischen Richtlinien der EU gegenüber China seit dessen WTO Beitritt nicht geändert haben, wird die Hypothese aufgestellt, dass eine Änderung der US-Handelspolitik gegenüber China ursächlich sein könnte. Der Aufsatz baut auf aktuellen Beiträgen zur Erklärung chinesischer Exporte in die USA auf. Mittels eines erweiterten Handelsmodells wird die Möglichkeit eines externen Effekts der US-Handelspolitik formal dargestellt. Die ökonometrische Analyse kann die daraus abgeleiteten Hypothesen nicht verwerfen. Sowohl die Struktur, als auch die geschätzte Größe und der Zeitpunkt des Effekts entsprechen den Ausprägungen des US-Politikwechsels. Die Ergebnisse heben das potenzielle Ausmaß bilateraler Handelspolitik hervor.

Im dritten Aufsatz wird eine Einordnung des Wettbewerbs zwischen chinesischen und US-Exporten in Drittmärkten vorgenommen. Der Aufsatz trägt zu der Forschung zu den Effekten von Niedriglohnwettbewerb bei, die sich bisher primär auf den Importwettbewerb beschränkt hat. Die empirischen Analysen ergeben, dass der Markteintritt chinesischer Exporteure Preisdruck auf etablierte US-Exporteure ausübt. Innerhalb des theoretischen Rahmens, der auch für andere Studien zu Exportpreisen verwendet wurde, bedeutet dies eine Verschiebung der Nachfrage zugunsten chinesischer Güter und den Marktaustritt einiger US-Firmen. Insbesondere sind Effekte im Maschinenbau- und Elektrogerätesektor zu beobachten. Im Gegensatz zu vergleichbaren Studien scheinen Preisstrategien die Qualitätsstrategien zu dominieren. Darüber

hinaus ist zu beobachten, dass US-Exporte in den betroffenen Produktkategorien relativ zu ähnlichen, aber nicht betroffenen Gütern zurückgehen. Die Ergebnisse heben die Wirkung komparativer Kostenvorteile hervor und zeigen, dass sich strukturelle Anpassungen nicht nur auf die heimischen Märkte von Industrieländern beschränken.

Insgesamt wird in dieser Dissertation der Versuch unternommen einen Beitrag zum Verständnis des Strukturwandels der globalen Wirtschaft im frühen 21. Jahrhundert zu leisten. Die Ergebnisse lassen den Schluss zu, dass komparative Kostenvorteile aufgrund relativer Faktorausstattungen eine zentrale Rolle spielen. Ob ein Land in der Lage ist aus diesen einen Nutzen zu ziehen, scheint sowohl von der eigenen Reformbereitschaft als auch von der Handelspolitik potenziell wichtiger Handelspartner abzuhängen. Im Falle Chinas ist es offenbar gelungen; sowohl hinsichtlich der eigenen wirtschaftlichen Entwicklung als auch im Hinblick auf dessen Rolle im internationalen Industriegüterhandel.



# Chapter 1

## INTRODUCTION

Recent decades have witnessed an increasing participation of low-wage countries in international trade. Through advances in transport and communication technologies, many of them were able to gauge the benefits of integrating their economies into global production chains. The most prominent example is China. Its economic reforms began in 1978, when the Communist Party, under Deng Xiaoping's leadership, initiated the program of "Socialism with Chinese Characteristics". This program encompassed initial de-regulations in the agricultural sector and bilateral agreements on economic cooperation with industrialized countries. Subsequently, in the 1990s, further steps were implemented, such as liberalizing prices and investment regulations, followed by a liberalization of the foreign exchange rate in 2005. In December 2001, China entered the World Trade Organization (WTO), and since 2012 it is considered an upper middle-income country, according to World Bank criteria. Since the reforms began, it took China about two decades to double its real GDP per capita, relative to the United States.<sup>1</sup> Another ten years later, by 2011, it had doubled again. Its huge population helped China become the second largest economy in the world, ranging at about 80

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<sup>1</sup>The figures presented in this paragraph are based on the author's calculations using the Penn World Tables 8.0 and UN Comtrade statistics.

percent of the US real GDP. During the same period, China increased its share in the commodity import markets of several high-income countries; from about two percent or less to 10-20 percent, and above.

Economic theories suggest that international trade and welfare are tightly connected. In its origins, this connection reaches back to the beginnings of the economics discipline, when Adam Smith (1776) and David Ricardo (1817) described the benefits from trade through the division of labor. But trade takes a prominent role also in more recent contributions. Krugman (1979a) and Eaton and Kortum (1999) suggest that new knowledge and technologies are developed in only a few places in the world, from which they diffuse to other countries by means of international trade. In a more general approach, Lucas (2009) depicts how “openness” facilitates the diffusion of technology, which can trigger transition dynamics, thereby transforming a developing country into an industrialized economy. Complementing the theoretical arguments, empirical research has shown that barriers to trade, and to other market forces, impede economic development (e.g. Sachs and Warner, 1995; Hall and Jones, 1999; Wacziarg and Welch, 2008). Although the widely used Sachs-Warner Openness Index classifies China as being a closed economy, its reforms appear to have triggered sufficient investments to turn it into the most dynamic economy of the past 20-30 years.

In contrast to the theories of technology diffusion, traditional trade models are static, and emphasize that the benefits of trade result from the exchange of different kinds of goods. The “Factor-Proportions Theory”, developed by Eli Heckscher (1919) and Bertil Ohlin (1933), suggests that a country exports those goods whose production requires much of the country’s relatively abundant factor.<sup>2</sup> The limitation to complementaries led to the rejection of the Heckscher-Ohlin (HO) model in its first empirical tests (e.g. Leontief, 1953).<sup>3</sup> Its inability to rationalize extensive trade of similar goods among similar countries gave birth to a “New Trade Theory” (Krugman, 1979b, 1980). In asking, more generally, ‘why do countries trade?’, economies of scale, product differentiation, and imperfect competition became the main characteristics of the new models. The benefits from trade were derived from the assumption that consumers appreciate variety (which followed Dixit and Stiglitz, 1977). The latest generation of trade models

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<sup>2</sup>A recent translation of their original work is provided by Flam and Flanders (1991). An older version was published as Chapter 13 in American Economic Association, *Readings in the Theory of International Trade*, Philadelphia: Blakiston, 1949, 272-300.

<sup>3</sup>The validity of the HO model in several extensions and their empirical applications is reviewed in Feenstra (2003).

expands on this structure and incorporates firm heterogeneity in terms of productivity (e.g. Melitz, 2003). The availability of increasingly disaggregated data has influenced these models, in particular Bernard and Jensen (1995), which brought them close to the industrial organization (IO) literature. Their microeconomic structure shifted the focus towards disaggregated and mostly bilateral trade relationships.

An exception from the monopolistic heterogeneous firms models is Eaton and Kortum (2002). Their theory generalizes the multi-product Ricardian model of Dornbusch et al. (1977) by incorporating comparative advantage and perfect competition into a multilateral trade framework. As a distinct feature, the Eaton-Kortum (EK) model defines two dimensions of technology. While comparative advantage governs the relative productivities for a continuum of goods, the overall state of technology in a country determines its “absolute advantage” in international competition. The EK model, thus, incorporates a parameter that links a country’s export performance to its state of technology, and thereby provides an additional link between trade and economic development.

Yet, the rise of low-wage countries’ exports to industrialized countries renewed academic interest in the patterns of comparative advantage. Theoretical contributions relate to the fragmentation of production. Production steps are divided according to their respective factor requirements and will be carried out in the location where these factors can be employed most efficiently.<sup>4</sup> In fact, empirical research suggests that HO mechanics play an important role in the success of emerging low-wage countries (e.g. Amiti and Freund, 2010). Exports from such countries are typically cheaper than the comparable good produced and exported by a high-income country. Along these lines, Schott (2004) suggests that production in industrialized and developing economies yields different product qualities. Comparative advantage is, thus, not revealed by the set of goods countries export, but by the technology they use to produce them. Following this new sub-field of international trade, subsequent work outlined alternative ways to infer product quality (Khandelwal, 2010; Baldwin and Harrigan, 2011; Hallak and Schott, 2011; Kugler and Verhoogen, 2012; Feenstra and Romalis, 2014). Investigations of the responses to low-wage competition by firms and workers attempt to reveal where comparative advantage is exerted (e.g. Bernard et al., 2006; Bloom et al., 2011; Amiti and Khandelwal, 2013; Martin and Méjean, 2014; Utar, 2014). As a general pattern, it

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<sup>4</sup>An account of the theory and evidence on firms’ international operations and offshore production is provided in Feenstra (2010).

suggests that product upgrading and switching towards higher skill-, knowledge-, and capital-intensity are prevalent. Low-skilled workers in routine tasks are hurt the most in their employment and income prospects (Autor et al., 2013a,b; Utar, 2015).

This thesis contributes to the different strands of the literature outlined above. It makes an attempt to investigate alternative aspects that describe the relationship between economic development, trade, and structural change. In particular, the thesis shall contribute to a better understanding of the causes and effects of the increased participation of low-wage countries in international trade. The dissertation comprises three essays which are presented in a conceptual order, but may be read separately. While their conclusions are derived from empirical investigations, they also contain theoretical sections where existing models are either formally extended or applied to a new question. Their methodology is integrative in that it considers panel data and estimates “Gravity Equations” in line with the theory. Yet, the articles differ in scope and in terms of their empirical identification strategies. While the first article (Chapter 2) considers the multilateral exports of several countries, Chapters 3 and 4 analyze the bilateral exports of a single country. The first essay uses both standard panel data methods and dynamic panel estimators with internally generated instruments (system GMM). Chapter 3 exploits a natural experiment and uses a difference-in-difference (DID) strategy, whereas Chapter 4 uses alternative dependent variables to interpret its results.

The first article, presented in Chapter 2, has the title ‘*Export Diversification and Stages of Economic Development*’. It addresses a debate on the relationship between a country’s stage of development, measured by its real GDP per capita, and characteristics of its exports in terms of product coverage. Its aim is to provide theoretical arguments and empirical evidence for the shape of this relationship. Empirical research has revealed alternative patterns: (i) initial diversification and subsequent re-specialization at higher stages of economic development; and (ii) a continuous diversification process. The paper discusses the possibility of either pattern from a theoretical viewpoint, and addresses the question formally with the model of Eaton and Kortum (2002). This has not been done before, as the literature has focused on the choice of diversification measures and estimation techniques. A review is presented at the beginning of the essay. Although the EK-model does not mention income per capita explicitly, its “absolute-advantage” parameter establishes an indirect relationship. Given this link, the model yields a Gravity Equation that predicts diversification in terms of the range of products

a country exports. Cross-sectional analyses reveal a positive and continuous relationship between diversification and income levels. However, adopting a dynamic specification (system GMM), it cannot be confirmed that GDP per capita levels affect export diversification. This may suggest that technology is the true driver. A reverse relationship is found, which is in line with theories where “economic self-discovery” triggers structural change (Acemoglu and Zilibotti, 1997; Hausmann and Rodrik, 2003).

The second article (Chapter 3) has the title ‘*US Policy Spillover(?): China’s Accession to the WTO and Rising Exports to the EU*’. It focuses on a different source of trade creation than the first chapter, and considers variation at the product level. As mentioned in the first paragraph of this introduction, China’s economic reforms encompassed agreements with industrialized countries. In the European Community and in the United States it has been granted preferential tariffs at or below the most-favored-nations (MFN) rate, since the 1980s. Hence, China’s WTO accession did not affect the applied tariffs on its exports. Nevertheless, since 2001, a boom of Chinese exports to both economic regions can be observed. The article raises questions about the causes of this pattern, and builds on related studies that explain China’s export boom to the US by a removal of trade policy uncertainty (TPU). Because a comparable policy shift did not occur in the EU, the paper hypothesizes that US policies spilled over to China’s general export performance. The channel is illustrated theoretically by an extension of the Melitz (2003) model. It is then applied to the data using a product-specific measure of the US tariff threat for a DID analysis. The results confirm the theoretical hypotheses and show that the effect phases out after a few years. Considering parametrizations of the Melitz model from other studies, the estimated coefficients appear to be in a plausible order of magnitude. The findings reveal a subtle, yet important, explanation of disaggregated trade patterns.

The last chapter, entitled ‘*Foreign Competition and Quality Sorting?: Overlaps in US and Chinese Exports*’, focuses on the consequences of Chinese market entry. It builds on a considerable body of literature that investigates the effects of low-wage competition. While most studies concentrate on import competition, the presented essay focuses on the penetration of export markets. This provides insights from a different margin at which exporters face low-wage competition. In particular, the essay assesses patterns of price and quality competition through an inference of US export unit values. In contrast to assertions that average product quality increases under stiffer competition, it is found that price competition prevails when China enters a US export

market. Moreover, the analysis reveals heterogeneous effects across products, similar to prior studies. The results may be explained by the particular set of US export goods where China exerts competition. The affected product range accounted for 16 percent of US total manufacturing exports in the years 1994-2006, on average. Most of them contribute individually a relatively large fraction to total exports; and 50 percent of the effects are found in the machinery and electronics industry. While these findings are based on revealed correlations between US export unit values and Chinese market presence, it is also shown that US exports in the exposed product categories decrease relative to similar but not exposed products. This suggests that Chinese competition triggers structural adjustments in the US export basket, which is comparable to patterns found in the literature on import competition.

Overall, the dissertation highlights the interdependence of today's integrated world economy, where China's reforms triggered its catch-up towards advanced countries. Altered institutional frameworks, and adaptation of new technologies through trade and foreign investment enabled China to increase its global trade participation. The accession to the WTO represented another key event in its economic transition, as it fostered relations with important trading partners and encouraged further investment. However, China still ranks relatively far below the most advanced economies; at 20 percent of the US real GDP per capita. This might explain why the competitive effects indicate mostly cost-based adjustments, in a relatively small range of products. It also suggests that China benefits primarily from its labor-cost advantage.

The essays presented in this dissertation naturally leave room for further investigations. The first article suggested that export diversification is driven primarily, if not exclusively, by technological progress. However, the characterization of these technologies and a potentially distinct role of trade flows remained unexplored. Yet, the EK model seems to provide a good starting point for further analyses. Likewise, the article in Chapter 3, which suggests a specific channel for the US policy spillover. It is possible that other mechanisms are at work, too, so that further research may shed light on the validity of alternative theoretical modeling strategies. Finally, the last paper describes US export unit value patterns, conditional on Chinese exports. It would be particularly interesting to explore these patterns more thoroughly, in a way that fosters the causal interpretation and encompasses alternative adjustment strategies, similarly to what has been done in the literature on import competition.



# Chapter 2

## EXPORT DIVERSIFICATION AND STAGES OF ECONOMIC DEVELOPMENT<sup>1</sup>

**Abstract:** The paper revisits the relationship between GDP per capita and diversification. It argues that trade models provide useful guidance for the analysis: general predictions can be derived only for the extensive product margin. This has implications for the appropriateness of alternative measures of diversification and allows application of parametric methods to estimate a gravity equation. Using detailed data on countries' exports, the empirical analysis rejects the case of re-specialization — a major controversy in the literature. According to the theoretical considerations, GDP per capita operates only as a proxy for the state of a country's technology. Application of standard and dynamic panel data methods suggests that GDP per capita has no distinct effect on export diversification. Reversely, a positive effect of exporting more goods on GDP per capita can be detected. This conforms to theories where the adoption of new activities facilitates economic development.

### 2.1 Introduction

Economic theories suggest a positive relationship between a country's stage of economic development and the range of activities it engages in. Developing countries discover new

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<sup>1</sup>A revised version of this Chapter will be published in the *Review of World Economics* under the title "Export Diversification and Income Differences Reconsidered: The Extensive Product Margin in Theory and Application".

activities through risky investments and they maintain them when they are profitable (Acemoglu and Zilibotti, 1997; Hausmann and Rodrik, 2003). Advanced economies diversify through innovation and the creation of new products (Grossman and Helpman, 1991, 1993). While not all research efforts lead to profitable inventions, the average arrival rate of breakthroughs is assumed to be constant (e.g. Eaton and Kortum, 1999). Surprisingly, empirical studies have revealed a different pattern. For both domestic production and employment, as well as for exports, they claim to identify a non-monotone relationship (Imbs and Wacziarg, 2003; Cadot et al., 2011, henceforth: CCSK). This relationship is characterized by initial diversification and subsequent re-specialization at high levels of real GDP per capita. Except for some special cases, conventional theories provide no rationalization for such a pattern. Also, the policy implications of a “hump-shaped” diversification path appear to be against the typical free-trade arguments set out by economists (Rodrik, 2007). Indeed, some authors question the robustness of this pattern and argue that countries continue to diversify (De Benedictis et al., 2009; Parteka, 2010). Abstaining from theoretical guidance, however, the debate focuses mostly on empirical methodology and relies on non-parametric analytic tools. Utilization of a wide range of measures, estimation techniques, and levels of disaggregation in the data makes the individual contributions difficult to compare.

The present paper revisits the case of re-specialization starting out from theoretical considerations. In doing so, it contributes to answering a number of open questions. The first question asks whether it is possible to predict alternative diversification patterns. Some studies investigate diversification among 30 sectors or less. Others look at several thousands of different product categories. It is possible that they document different processes of economic development. The second question addresses the derivation of general predictions that feed into a parametric specification. While most studies focus solely on the two variables diversification and GDP per capita, recent evidence suggests that country size and geography are important co-variates (Agosin et al., 2012; Parteka and Tamberi, 2013). Finally, the paper addresses the question of causality between export diversification and economic development. This question has remained untouched in previous contributions where GDP per capita is used to explain diversification. However, per capita income is the dependent variable in standard growth and development theories. One could argue that diversification facilitates economic development.

In addressing the first question the paper considers the distinction between the “in-

tensive” and the “extensive” product margin. This turns out to be crucial, since either margin leads to a different prediction. The paper shows that a hump-shaped diversification path is a natural outcome in the standard Heckscher-Ohlin (HO) framework. However, it holds only for the intensive margin, where the range and type of goods is unchanged and relative output and factor allocations vary. Moreover, it requires that all countries reside in the same cone of diversification. At the extensive margin, where the range and types of goods are variable, the paper argues that countries should continue to diversify as they reside in different cones of diversification.<sup>2</sup> These results carry over to the consideration of a more realistic model which relaxes the symmetry assumptions of classical trade models. The paper uses the framework Eaton and Kortum (2002, henceforth: EK) and shows that it yields a gravity equation for export diversification at the extensive margin. Moreover, it implies that diversification should be measured as the fraction of tradable goods a country actually exports. The EK model predicts that after controlling for factor costs and geography, a country with a higher state of technology exports a wider range of goods.

The theoretical predictions are tested empirically using disaggregated data on countries’ exports. The baseline dataset is based on CEPII BACI96, and distinguishes 4,254 manufacturing products across all industries in the years 1998-2009 (Gaulier and Zignago, 2010). Because many countries export almost all of these goods in every year, the analysis considers censored samples and additional data sources with higher disaggregation. Alternative thresholds for counting the goods exported are applied to prevent trade flows of negligible size from overstating the degree of diversification. The baseline estimates confirm the predictions of the model that countries continue to diversify their exports. There is a strong and positive correlation between diversification and the level of GDP per capita in cross-sectional observations. However, inference of causality suggests only a minor impact of income levels on diversification. Dynamic panel estimation (system-GMM) reveals that causality generally runs from diversification to GDP per capita. Only for a set of transition economies can any impact of GDP per capita on diversification be detected. Overall, it seems that the single driving factor of diversification is a country’s state of technology. This is in line with the EK model where countries diversify by exploiting their “absolute advantage”. The effect

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<sup>2</sup>This definition of intensive and extensive margin is widely used and also referred to by Cadot et al. (2011). Other definitions are discussed in Cadot et al. (2013) but they will not find application in this paper.

of diversification on GDP per capita conforms to theories of “economic self-discovery” emphasized by Hausmann and Rodrik (2003).

The paper is structured as follows: Section 2.2 reviews the existing empirical research and illustrates the conceptual problems of approaching the relationship between diversification and economic development. Section 2.3 discusses the possibilities of alternative diversification paths within classical trade theory. Section 2.4 presents a modern framework and derives the empirical specifications. Section 2.5 presents measures, data, and the empirical results. Section 2.6 concludes.

## 2.2 Literature Review and Conceptual Questions

Table 2.1: Contributions to the Diversification Literature since 2003; Data, Measures, and Methods

Authors/Activities	Data	Measures	Aggregation	Controls	U
Imbs and Wacziarg (2003) - Employment - Value added	ILO* UNIDO OECD*	Gini-, Herfindahl-Index Coeff. of Variation, Max-Min Ratio, Log Variance	9 Sectors 28 Sectors 20 Sectors	Fixed effects, Population**	✓
Klinger and Lederman (2004) - Exports	Comtrade	Herfindahl-Index	5,000 HS6 1,200 HS4 175 Sectors	None None Fixed effects	?
Klinger and Lederman (2006) - Exports	Comtrade	Herfindahl-Index	5,000 HS6	Fixed effects	?
Koren and Teneyro (2007) - Employment - Value added	UNIDO OECD*	Herfindahl-Index (logged)	19 Sectors 18 Sectors	Fixed effects	✓
De Benedictis et al. (2009) - Exports	ECLAC-UN	<u>Relative</u> : Balassa Index of Revealed Comparative Advantage, Gini, Theil	30 Sectors 539 Sectors	Fixed effects	✗
Parteka (2010) - Exports - Employment	UNIDO Comtrade	<u>Absolute</u> : Herfindahl, Gini, Theil, Coeff. of Variation <u>Relative</u> : Gini, Theil, Dissimilarity Index	17 Sectors	Fixed effects	✗
Cadot et al. (2011) - Exports	Comtrade	Theil-, Gini-, Herfindahl-Index, #Active HS6 lines	4,991 HS6	Fixed effects, excl. oil- and micro-states	✓
Agosin et al. (2012) - Exports	World Trade Flows	Herfindahl-, Gini-, Theil-Index		Yes	
Parteka and Tamberi (2013) - Exports	Comtrade	<u>Relative</u> Theil-, Gini-, Herfindahl-Index	149 Sectors	Yes	✗

*Note:* Author’s compilation. \*: Samples include services sectors; \*\*: Populations only included in robustness checks. The last column “U” indicates whether papers find evidence for re-specialization.

Table 2.1 summarizes the main contributions to the empirical literature on diversification and economic development. The first studies focused on diversification in

production and employment. They suggest that countries first diversify and then re-specialize. The pattern they revealed shows a hump-shaped diversification path along a horizontal axis which measures real GDP per capita. Imbs and Wacziarg (2003) prefer the Gini index and find that countries re-specialize around income levels comparable to Ireland in 1992.<sup>3</sup> Koren and Tenreyro (2007) confirm this pattern analyzing the log Herfindahl-Hirschmann-Index (HHI) and log GDP per capita. However, their pattern becomes fragile when they aggregate their data. The hump-shaped pattern is also found for exports. CCSK use highly disaggregated data and exploit a decomposition of the Theil (1972) index. They show that the extensive product margin drives the general picture. It suggests that countries add products to their export basket during early stages of economic development. High-income countries remove goods for which they have lost their comparative advantage. These studies suggest that a hump-shaped pattern can be found at different levels of disaggregation across different kinds of economic activities.

More room for interpretation can be found in the studies of Klinger and Lederman (2004, 2006). They find that the frequency of adding products to the export basket decreases as countries reach higher levels of GDP per capita. This does not necessarily imply that diversification stops, but it could also be that countries reach the maximum number of distinguishable product categories in the data. This seems to be supported by the observations of Klinger and Lederman (2006), where high-income countries register increasing numbers of patents. Studies that reject the case of re-specialization use a different approach. De Benedictis et al. (2009) apply a semi-parametric method to investigate the diversification path of a single hypothetical country. Their procedure averages-out the country-specific intercepts of the diversification variable. In a second step they apply non-parametric techniques to analyze the diversification path across different levels of GDP per capita. In contrast to former studies, they prefer relative diversification measures. Those measures account for the specific characteristics of alternative statistical indices and absorb annual aggregate variation.<sup>4</sup> Using a similar procedure, and analyzing an extensive set of diversification measures, also Parteka

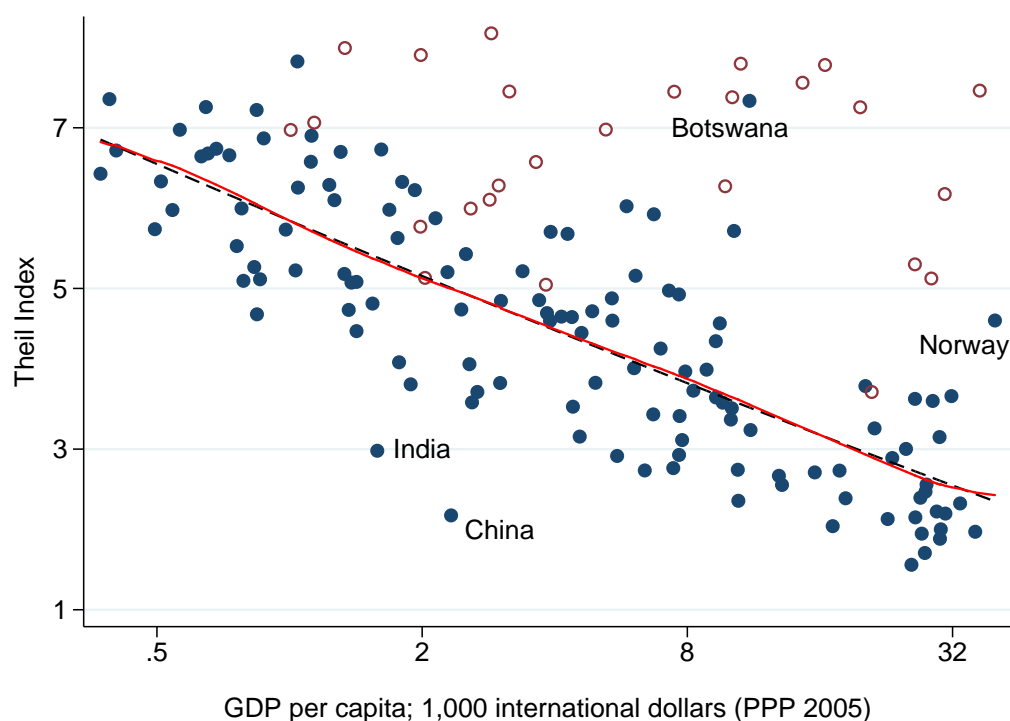
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<sup>3</sup>Note that statistical measures of concentration are inversely related to diversification. The terms specialization and diversification are used as antonyms in this paper, and in the literature.

<sup>4</sup>Agosin et al. (2012) show that sectoral concentration of exports remarkably increased since the 1990s after it had gradually declined during earlier decades. Since most studies cover these years and up to the early 2000s, it is possible that patterns of re-specialization originate from those general trends.

(2010) argues that countries continue to diversify in exports and employment. Only two recent studies explore further determinants of diversification (Agosin et al., 2012; Parteka and Tamberi, 2013). Finding that trade barriers and country size contribute to observed diversification patterns suggests that prior results might be driven also by omitted variable bias.

Figure 2.1: Product Concentration in Exports and GDP per Capita; Country Averages, 1988-2006



*Note:* Author's calculations. Figure shows average Theil index of export concentration and real GDP per capita from Cadot et al. (2011). The horizontal axis is scaled in logs.

It is difficult to conclude from this literature which approach should be preferred over another. To illustrate this, consider Figure 2.1. It plots CCSK's preferred measure of export concentration – the Theil (1972) index – against real GDP per capita. Each point reflects a country's average values during the period 1988-2006. The hollow points in the figure reflect oil-exporting countries and micro-states which are excluded from the analysis.<sup>5</sup> The dashed line shows the specialization path, which is inverse to

<sup>5</sup>Oil exporters are defined as countries exporting more than 50 percent in product categories within HS Chapters 26 and 27. Micro-states are defined as countries with populations below 1 million.

diversification, as predicted from a regression of the Theil index on log GDP per capita *and* squared log GDP per capita. The latter is statistically insignificant. The solid line confirms the linearity using locally weighted scatterplot smoothing (i.e. LOWESS). The two lines are hardly distinguishable from each other.

The main difference between the representation in Figure 2.1 and the one considered by CCSK is that the horizontal axis is scaled in logs. However, Koren and Tenreyro (2007) identify re-specialization using a log-scale and more aggregated data than CCSK (see Table 2.1). It seems that results are sensitive to the choice of measures, variable scales, and data properties. To obtain a sharper picture, each issue shall be considered step by step. The following section analyzes how alternative patterns of diversification are revealed from a theoretical framework. In doing so, it attempts to obtain guidance regarding the measurement of diversification.

## 2.3 Diversification and Classical Trade Theory

The analysis in this section focuses on the distinction of the extensive and the intensive product margin. Alternative predictions at either margin are discussed within the HO framework. The Lerner (1952) diagrams, as drawn in Figure 2.2, are close to the representation of Schott (2003) who emphasizes the existence of multiple cones of diversification. The vertical position of each endowment point depicts a given amount of capital per person,  $K/L$ . Assuming that the capital-output ratio,  $\beta \equiv K/Y$ , is constant in equilibrium, it implies that a country's capital abundance is proportional to its level of GDP per capita,  $K/L = \beta Y/L$ .

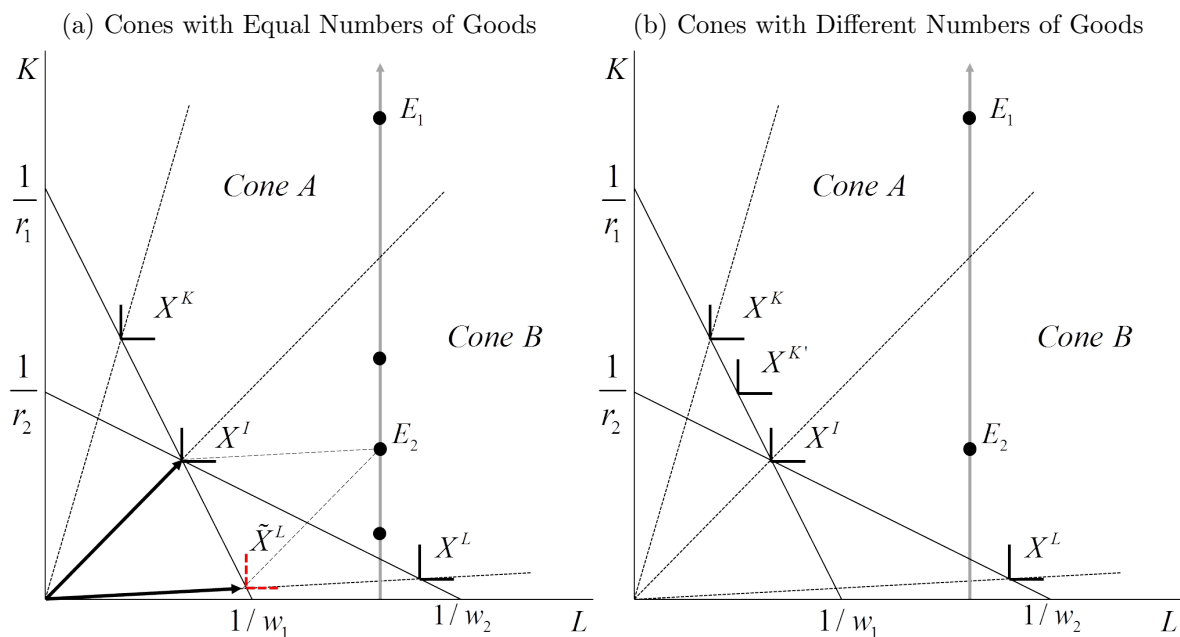
### 2.3.1 Intensive vs. Extensive Margin

Panel (a) of Figure 2.2 shows, in the lower cone  $B$ , a parallelogram connecting the endowment point  $E_2$ , the origin, and the rays that confine the cone of diversification. Vectors drawn from the origin up to the corners of the parallelogram depict the relative production structure. Compared to the other two countries residing in cone  $B$ , country  $E_2$  is both the middle-income country and the most diversified economy. The poorer country specializes in the labor intensive good  $X^L$  whereas the richer country produces

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These cutoffs were applied to the country averages in order to obtain unambiguous country-specific classifications.

Figure 2.2: Diversification and Per Capita Output in the Lerner Diagram



Note: Author's compilation based on similar representations by Schott (2003, 2004).

more of good  $X_I$ . Thus, within a cone, different levels of income per capita draw a hump-shaped diversification pattern. In terms of measurement, it suggests that any statistical concentration measure that captures relative output and factor allocations is suitable. Depending on the number of goods one observes, and on the overall degree of specialization in individual activities, the Gini, HHI, or Theil index might be applicable.

This seems to support the pattern promoted by one strand of the literature but it entails an important limitation. Schott (2003) provides convincing arguments that countries reside in different cones of diversification. Hence, the hump-shaped diversification pattern cannot be generalized to all countries. It is limited to those countries that have sufficiently similar factor endowments so that factor price equalization (FPE) is ensured. To illustrate this, consider to the higher-income cone A, in Panel (a). The endowment point of country  $E_1$  suggests that it resides relatively close to the lower border of its diversification cone. It is less diversified than country  $E_2$  but diversification relative to the other two countries in cone B is unclear. Moreover, comparing cones A and B implies that variation is driven also by the extensive margin. Countries in the lower-income cone B never produce the good  $X^K$  and high-income countries never

produce  $X^L$ . A cross-country analysis cannot distinguish these two dimensions, which are necessary for the interpretation of the results.

CCSK is the only study that focuses on these two margins of diversification. They argue that the hump-shaped pattern is driven by the extensive margin. This implies that rich countries produce different goods than poor countries. Panel (a) of Figure 2.2 indicates this for countries  $E_1$  and  $E_2$ , respectively. However, as drawn here, both countries produce and export equal amounts of goods so they are equally diversified. CCSK reconcile the hump-shaped pattern they identify suggesting that  $E_1$  and  $E_2$  could be the same country at different stages of economic development. As it moves from cone  $B$  to cone  $A$ , it expands its production range by adding the new good  $X^K$ . The “old” good  $X^L$  is maintained in the export basket through the introduction of trade barriers. This protects the good from international competition, as is indicated by the unit value isoquant  $\tilde{X}^L$ . The moment the protectionist barriers are removed, the labor intensive good is dropped from the product portfolio and the economy re-specializes.

Such a mechanism is problematic for two reasons. First, it implies that middle-income countries apply protectionist policies more extensively than other countries. This could lead to conclusions that are against typical free trade arguments (Rodrik, 2007). Second, and more importantly, this argument does not imply that a middle-income country exports more products. The reason is that such protectionist measures increase the domestic price of a good. But this does not make it competitive on the world market.<sup>6</sup> Hence, Panel (a) of Figure 2.2 cannot explain export diversification at the extensive margin; all countries produce and export equal numbers of goods.

### 2.3.2 Extensions and Implications

One solution to generating variation at the extensive margin is drawing an additional good into cone  $A$ . This is shown in Panel (b) of Figure 2.2 and is in line with innovation-based theories of Acemoglu and Zilibotti (1997, within the technology frontier) and Grossman and Helpman (1991, at the technology frontier). Imbs and Wacziarg (2003) follow this idea of diversification during early stages of economic development. They then consider non-traded goods to rationalize re-specialization. Goods become tradable through improvements of the infrastructure at later stages of development. When goods

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<sup>6</sup>A very similar representation of Panel (a) was also used by Bernard et al. (2006). However, they analyzed import competition that arises after the removal of trade barriers for product  $X^L$ .

become tradable at a higher rate than that at which new products are invented, the economy re-specializes and will produce fewer goods. Also this argument is problematic. First, it requires that high-income countries have a comparative disadvantage in producing non-tradable goods. Otherwise production would stay in the country. Second, the rate of trade-facilitating infrastructure must permanently exceed the rate of product discovery. If this is not the case, re-specialization is only a temporary phenomenon of an adverse technology shock. But even if this were true, permanence implies that all goods are tradable at some point; which brings back the original scenario shown in Panel (b).

The analysis shows that diversification patterns are difficult to reconcile within classical theories. This applies to both a hump-shaped and a continuous pattern. The route this paper wants to take is indicated by the representation of a Lerner diagram as shown in Figure 2.3. It is closely related to a representation of Gundlach (2007) and emphasizes that Harrod-neutral technology differences generate multiple overlapping cones of diversification.<sup>7</sup> The diversification cone of the low-income country  $E_2$  is confined by the dashed rays from the origin denoting cone  $B$ . It encompasses production of the goods  $X^I$  and  $X^L$  at the respective unit values. Country  $E_1$  has a higher income per capita and a different technology so that it produces three goods:  $X^I$ ,  $X^L$ , and  $X^K$ . The capital-intensive good  $X^K$  can only be produced at the level of technology of country  $E_1$  or higher. Goods  $X^L$  and  $X^I$  are produced with higher capital intensity than in country  $E_2$ . The steep dotted line indicates that at even higher levels of technology and income, an additional good can be produced. The implication of this setup is that countries continue to diversify by acquiring the technology to produce new goods.

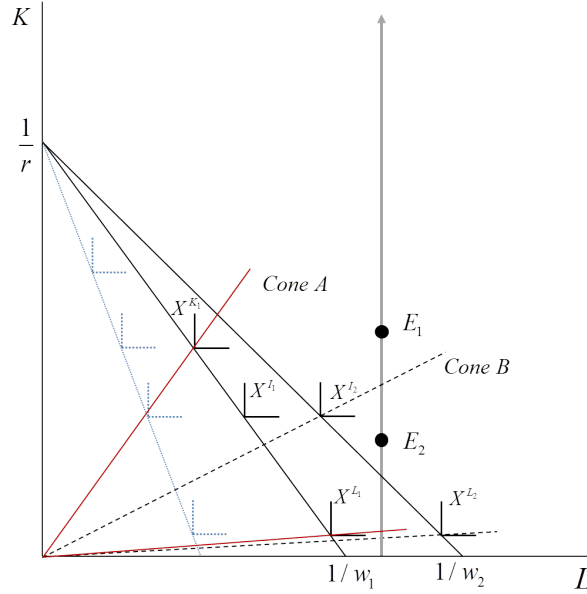
One caveat remains with this figure. It implies that country  $E_1$  would sell the goods  $X^L$  and  $X^I$  at a higher price than country  $E_2$ . Under perfect competition only one country exports a given good. However, empirical and theoretical work has shown that countries' trade patterns are explained by other factors than just unit output prices. Geographic barriers may allow countries to export their more expensive products to some destinations when potential competitors face high shipping costs.<sup>8</sup> Those factors

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<sup>7</sup>In contrast to the classical HO representation, Harrod-neutral technology suggests that capital accumulation and economic growth are driven by technological progress. As a result, the rate of return to capital is constant and equal for all countries while the assumption that  $K/L = \beta Y/L$  is maintained.

<sup>8</sup>Note that the differences in unit prices and factor intensities across source countries might also indicate differences in product quality (Schott, 2004).

Figure 2.3: The Lerner Diagram with Harrod-neutral Technology



*Note:* Author's compilation based on similar representations by Schott (2003, 2004) and Gundlach (2007).

are not modeled in the Lerner diagram but they appear in modern frameworks to which this paper refers in the next section. As a general conclusion, the presented analysis suggests that diversification should be measured by counting the number of goods a country exports. This results from the fact that patterns at the intensive margin cannot be predicted, whereas some intuition could be build for the extensive margin.

## 2.4 Diversification and Modern Trade Theory

This section expands on the idea that diversification is driven by technology differences. If technological progress is the fundamental source of economic growth, real GDP per capita enters as a proxy for the state of technology. The EK model provides a suitable framework for a formal analysis. A statement in their original article shows this: “A source with a higher state of technology, lower input cost, or lower barriers exploits its advantage by selling a wider range of goods.” (Eaton and Kortum, 2002, p. 1748)

### 2.4.1 Summary of the EK Model

The EK model encompasses an arbitrary number of countries  $i = 1, \dots, N$  and products  $j = 1, \dots, J$ . Its Ricardian nature suggests that international trade is driven by productivity differences.<sup>9</sup> The model features two technology parameters. They govern the location and shape of a Fréchet probability function from which firms randomly draw their productivity  $z(j)$ ;  $F_i = \exp^{-T_i z^{-\theta}}$ . The location of the function is country-specific and is denoted by the parameter  $T_i$ . It is positively related to the general probability of drawing a high  $z$  for any  $j$  and reflects the “absolute advantage” a country enjoys in international competition. The shape of the distribution is governed by  $\theta > 0$  and is equal for all countries. It denotes the strength of comparative advantage and thus determines the gains from trade.<sup>10</sup>

Perfect competition implies that consumers in country  $n$  purchase good  $j$  at the lowest price they can find;  $p_n(j) = \min\{p_{ni}(j), i = 1, \dots, N\}$ . The price is determined by factor costs over productivity ( $c/z$ ) and iceberg trade costs  $d$ :

$$p_{ni}(j) = \left( \frac{c_i}{z_i(j)} \right) d_{ni}; \quad d_{nk}d_{ki} > d_{ni} > d_{nk} > d_{nn} = 1 \quad (2.1)$$

The equation states that relative productivity, factor prices, and trade costs influence the probability that country  $i$  exports good  $j$  to destination  $n$ . EK derive a formal description of the trade relationship between two countries. It is expressed by the probability  $\pi_{ni}$  that country  $i$  provides a good at the lowest price in destination  $n$

$$\pi_{ni} = \frac{T_i(c_i d_{ni})^{-\theta}}{\sum_{k=1}^N T_k(c_k d_{nk})^{-\theta}}. \quad (2.2)$$

This probability is also equal to the fraction of goods  $n$  purchases from the exporting country  $i$ . Normalizing the total amount of traded products  $J = 1$  implies that  $\pi_{ni} \in [0, 1]$ . The variable on the left hand side of Eq. (2.2) is thus the measure of export diversification. Because perfect competition implies that the lowest price offer serves

<sup>9</sup>Levchenko and Zhang (2011) illustrate how the EK model can be extended to include also HO forces. An extension of the EK model to incorporate an AK-production technology was developed by Naito (2012). The specific assumptions made on the production technology do not affect the general outcomes presented in this section.

<sup>10</sup>Generally, it holds that a higher  $\theta$  corresponds to less variation of productivity across individual sectors (i.e. a more homogeneous distribution). See Lanati (2013) for alternative approaches to quantify  $\theta$  and the welfare effects.

the whole market, it captures the extensive product margin.

EK summarize the denominator under the common term  $\Phi_n \equiv \sum_{k=1}^N T_k (c_k d_{nk})^{-\theta} = (p_n/\gamma)^{-\theta}$ . It determines the price index  $p_n$  in destination  $n$ , which is governed by its geographic vicinity to other countries  $k$ , and their respective characteristics. In the gravity literature  $\Phi_n^{-1}$  denotes the “remoteness” of a country (Baldwin and Harrigan, 2011). Here it suggests that a destination  $n$  has a lower price index when it is closely located to countries with high technology and low factor prices. Thus, a remote destination has relatively high prices and a higher probability of purchasing goods from country  $i$ . For bilateral trade, export diversification can be expressed in log-linear form:

$$\ln \pi_{ni} = \ln T_i - \theta \ln c_i - \theta \ln d_{ni} - \ln \Phi_n \quad (2.3)$$

It suggests that a source with higher technology, lower factor costs, and lower distance from destination  $n$  exports a larger fraction of goods. The remoteness of the destination country enters as a constant because it is equal for all countries willing to export to  $n$ .

To obtain a prediction for multilateral exports Eq. (2.2) is aggregated so that  $\pi_i$  depends on the exporting country’s ability to serve any destination market  $n$

$$\pi_i = T_i c_i^{-\theta} \sum_{n \neq i}^N \frac{d_{ni}^{-\theta}}{\Phi_n}. \quad (2.4)$$

The fraction of goods country  $i$  exports, i.e. the level of export diversification, is governed by its state of technology, factor costs, and by its distance from remote destinations.<sup>11</sup> Using  $\Psi_i \equiv \sum_{n \neq i}^N (d_{ni}^{-\theta}/\Phi_n)$ , the fraction of goods country  $i$  exports takes the following log-linear form:

$$\ln \pi_i = \ln T_i - \theta \ln c_i - \ln \Psi_i. \quad (2.5)$$

Based on this equation the relationship between a country’s stage of economic development can be related to its level of export diversification at the extensive margin. As in the previous section, there is no mechanism that would generate re-specialization in exports. However, the model suggests that diversification patterns have to take into account more than just one variable.

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<sup>11</sup>This follows from the equality  $\pi_{ni} = X_{ni}/X_i$ , implied by the EK model.  $X_{ni}$  denotes the value of trade flowing from  $i$  to  $n$  and  $X_n$  denotes the importing country’s total expenditure. Aggregation yields  $\sum_n X_{ni}/X_n = X_i/X = \pi_i$ , which denotes the fraction of goods country  $i$  exports world wide.

## 2.4.2 Empirical Specifications

The state of technology,  $T_i$ , is the main variable of interest. It reflects the stage of a country's economic development and may encompass a wide range of fundamental variables.<sup>12</sup> In the first step of the empirical analysis it will be proxied by the level of real GDP per capita,  $y_i$ . Having controlled for the state of technology, the EK model suggests that a larger labor force  $L_i$  reduces the wage rate, and thus input costs  $c_i$ . This result is obtained because of  $\theta$ , which ensures that productivity differs across sectors. If the population is large, labor is employed in a larger set of activities, including those where productivity is low. This reduces the average wage rate.<sup>13</sup> The weighted distance term  $\Psi_i$ , in Eq. (2.5), is a combination of two variables that are subsequently aggregated. The first variable measures bilateral distance in order to capture  $d_{ni}$ . The second variable denotes the remoteness of each destination by which  $d_{ni}$  is discounted. Remoteness can be computed as suggested by Baldwin and Harrigan (2011);  $\Phi_n^{-1} \equiv R_n = (\sum_{k=1}^N Y_k / \text{dist}_{kn})^{-1}$ . Together and aggregated the two variables constitute the weighted distance measure  $\Psi_i = \sum_{n=1} (\text{dist}_{ni} / R_n)$ . It captures the negative effect of being distant from any country and discounts this by a positive impact of remote destinations.

### Baseline Specification

Using these variables, the baseline specification takes the following form for a cross-section of countries:

$$D_i = a_0 + a_1 \ln y_i + a_2 \ln L_i + a_3 \ln \Psi_i + \varepsilon_i \quad (2.6)$$

The dependent variable is the measure of diversification. It will be computed in different ways but generally reflects the fraction of goods country  $i$  exports. According to the EK model, the estimated coefficients should be positive for real GDP per capita and labor,  $a_1, a_2 > 0$ , and negative for weighted distance,  $a_3 < 0$ . The estimation equation

<sup>12</sup>For instance, a country's institutional and legal framework, infrastructure, and other factors that enhance aggregate productivity.

<sup>13</sup>The original EK model assumes that costs are also determined by the domestic price index for traded intermediate inputs; i.e.  $c_i = w_i^\beta p_i^{1-\beta}$ . This would imply that also the remoteness of the exporting country,  $\Phi_i^{-1}$ , enters the specification. This paper abstains from this in order to stay closer to the discussion of the previous section. In this context, EK refer to Baxter (1992) where production uses capital and labor, and countries face a common interest rate.

includes fewer but similar variables as those emphasized by Agosin et al. (2012) and Parteka and Tamberi (2013). In contrast to De Benedictis et al. (2009), diversification is measured directly and in absolute terms, because it is not related to diversification levels observed for other countries.

Eq. (2.6) cannot provide direct evidence against the case of re-specialization. However, any non-linear pattern should be absorbed by the error term  $\varepsilon_i$ . One way to test for a non-linear relationship would thus be to regress these residuals on squared log GDP per capita:  $\hat{\varepsilon}_i = \rho(\ln y_i)^2 + \nu_i$ . Whenever  $\rho = 0$  is rejected, it implies that the diversification path is not linear in income levels. Another way is to include squared log GDP per capita directly into the estimation equation:

$$D_i = a_0 + a_1 \ln y_i + a_2 \ln L_i + a_3 \ln \Psi_i + \psi(\ln y_i)^2 + \varepsilon_i. \quad (2.6a)$$

The empirical analysis will consider both of the two approaches.

### Fixed Effects and Dynamic Specification

The baseline specification considers cross-sectional patterns, but it uses GDP per capita only as a proxy for the state of technology. With panel data, the cross-sectional estimates should be compared to the fixed effects model (Gould, 2001). The estimation equation is extended to include time effects,  $\delta_t$ , and country fixed effects,  $\mu_i$ :

$$D_{it} = b_0 + b_1 \ln y_{it} + b_2 \ln L_{it} + b_3 \ln \tilde{\Psi}_{it} + \delta_t + \mu_i + \varepsilon_{it}. \quad (2.7)$$

Only if estimated coefficients are statistically the same in the respective specifications, can omitted variable bias be ruled out. Otherwise, a coefficient obtained from Eq. (2.6) would be driven by correlated but unobservable factors. These are absorbed by  $\mu_i$  in Eq. (2.7). The time effects have to be included to control for aggregate average variation in all variables. This implies that the fixed effect model, as stated here, considers relative diversification patterns and their correlation with the relative variation in the explanatory variables (Wooldridge, 2002).

Besides this standard test, the question remains whether causality runs from GDP per capita to diversification. The EK model suggests that technology is the actual driver. A separate impact of GDP per capita on diversification can be detected in a

dynamic panel specification.

$$D_{it} = c_0 + \gamma D_{it-1} + c_1 \ln y_{it} + c_2 \ln L_{it} + c_3 \ln \Psi_{it} + \delta_t + \varepsilon_{it} \quad (2.8)$$

The dependent variable is included with a one-period lag on the right hand side of the estimation equation. To estimate this equation, it is necessary to use appropriate instruments for  $D_{it-1}$ . If causality goes into the reverse direction, also  $\ln y_{it}$  has to be instrumented. Both Eq. (2.7) and (2.8) will consider also extended versions that include squared log GDP per capita, analogously to Eq. (2.6a).

## 2.5 Empirical Analysis and Results

To evaluate the predicted patterns and econometric specifications, the empirical analysis uses disaggregated information on the number of products countries export. The analysis focuses on manufacturing exports. Those trade flows are well documented, and patterns are less likely to be driven by country-specific endowments.<sup>14</sup> Manufacturing goods are defined by all products comprised in Chapters 28 through 96 of the *Harmonized System* nomenclature (HS). The analysis excludes countries exporting oil and related commodities, comprised in HS Chapters 26 and 27, if their fraction exceeds 50 percent of total non-agricultural exports on average (i.e. HS Chapters 26-96). Following other studies, also small countries with an average population below one million are excluded. The respective benchmarks are applied to the years 1998-2009.

### 2.5.1 Descriptive Analysis

#### Data and Measures

The baseline dataset distinguishes 6-digit HS codes (HS6 products) as reported in the CEPII BACI96 dataset (Gaulier and Zignago, 2010). It features 4,254 HS6 manufacturing products in each year between 1998 and 2009. Data on per capita real GDP, total real GDP, and population are drawn from the World Development Indicators (WDI) database. Total real GDP is combined with distances between countries' most populated cities to compute the remoteness variable. Distance information is available from

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<sup>14</sup>This refers primarily to agricultural products and raw materials which some countries can never export.

the CEPII GeoDist database (Mayer and Zignago, 2011). The final baseline dataset features a fully balanced panel for 111 countries in 12 years.

The analysis considers three approaches to quantify diversification. The first measure simply counts the number of HS6 products country  $i$  exports at time  $t$ ;  $D_{it}^A \equiv J_t(i)$ . This measure was also used by CCSK so the results can be compared to their data.<sup>15</sup> It is obvious that the precision of such a measure depends on the reporting practices of individual countries. Recurrent flows at small amounts might not appear in official trade statistics and therefore understate actual diversification (Kehoe and Ruhl, 2013). It is also possible that trade flows are reported but they are exported at small amounts relative to most other flows. Like unstable export lines that are active only occasionally (e.g. Besedeš and Prusa, 2006), they might overstate actual diversification. To account for those potential distortions, Evenett and Venables (2002) choose a threshold of at least \$50,000 for an export good to be counted. This shall constitute the second measure of diversification;  $D_{it}^B \equiv J_t(i) | X_j \geq \$50,000$ .<sup>16</sup> A drawback of this measure is that it does not account for the economic size of a country. Kehoe and Ruhl (2013) suggest that a good should be counted only if it lies above the bottom decile in the cumulative distribution of a country's total exports. This constitutes the third measure of diversification;  $D_{it}^C \equiv J_t(i) | j \notin p[10]$ . To ensure that diversification ranges between the values 0 and 1, each measure is normalized by dividing it with the total number of traded goods (e.g. 4,254 in the CEPII BACI96 dataset).

### Levels of Disaggregation

A first look at the data shows that HS6 product codes merely provide enough detail to observe any continuous pattern. The reason is that 40 out of 111 countries export at least 80 percent of the HS6 products reported in the CEPII dataset, on average between 1998 and 2009. This is illustrated in Panel (a) of Figure 3.3 where the lines represent fitted values of quadratic and LOWESS predictions of the diversification path, conditional on log real GDP per capita. The curvature seems to be driven by the upper limit of the HS nomenclature, rather than by a reversal of the diversification pattern. The artificial limit imposed by the HS classification suggests that diversification measured

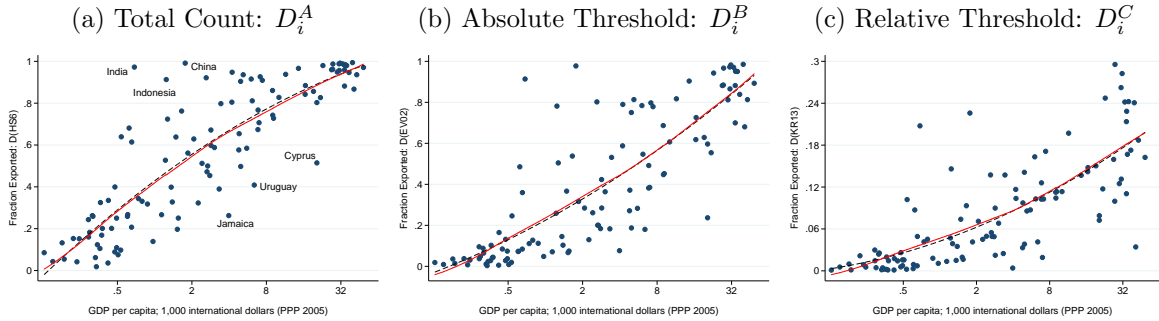
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<sup>15</sup>Their count measure  $D_{it}^A$  encompasses also agricultural and food products and is based on a constant sample of 4,991 HS6 products covering the years 1988-2006. In the fully balanced panel, excluding oil exporters and micro-states their data provides information for 89 countries.

<sup>16</sup>They apply this threshold to 3-digit bilateral exports data. While the data used here is more disaggregated it considers multilateral trade so it should be applicable also here.

by  $D_{it}^A$  should be analyzed for a sub-sample only (Tobin, 1958). This threshold will exclude observations where  $D_{it}^A > 0.8$ .

Figure 2.4: Number of Exported HS6 Products and GDP per Capita; Average 1998-2009



*Note:* Author's calculations based on data from CEPII BACI96. Figures show average diversification patterns for a cross-section of countries, and for alternative definitions of an exported product. The horizontal axis denotes log GDP per capita.

Panels (b) and (c) of Figure 3.3 depict the other two measures. They seem to be less confronted with the upper limit. Panel (b) counts 23 countries having  $\bar{D}_i^B > 0.8$ . The last measure,  $\bar{D}_i^C$ , reveals how exports are generally concentrated at the intensive margin. According to this definition, Italy has the most diversified exports at the extensive margin. But still, about 70 percent of the product lines reside in the bottom decile of its cumulative export distribution.<sup>17</sup> Overall, the graphical inspection suggests that the diversification measures do not have to be transformed into a logarithmic scale for cross-sectional analyses. The HS6 nomenclature is sufficiently aggregated to prevent the distribution of the dependent variable being extremely skewed.

An alternative dataset is considered for comparison. It reports more disaggregated information on US imports for the years 1992-2009. Earlier versions of this data were used by Schott (2008). After harmonizing its product codes over time it features a constant range of 10,640 product lines.<sup>18</sup> Because this information captures only bilateral

<sup>17</sup>Hausmann and Rodrik (2003); Hausmann et al. (2007) and Easterly et al. (2009) document and analyze this high degree of overall specialization at the intensive margin in greater detail.

<sup>18</sup>The US data reports 10-digit product codes according to the *Harmonized Tariff Schedule* nomenclature (HTS). The raw data comprises more than 15,000 distinguishable product lines, but many of them were split up or merged over the years. Application of the algorithm developed by Pierce and Schott (2009) results in 10,640 generic product categories for the years 1992-2009. 3,151 were summarized within synthetic categories. The data and the concordance files can be downloaded from [http://faculty.som.yale.edu/peterschott/sub\\_international.htm](http://faculty.som.yale.edu/peterschott/sub_international.htm).

trade, the empirical specifications stated in Eqs. (2.6)-(2.8) will use simple distances from the US,  $d_i^{US}$ , instead of weighted distances  $\Psi_i$ . This follows from Eq. (2.3) which describes diversification in bilateral trade. The US data encompasses 100 countries after excluding micro-states and oil exporters. In contrast to the multilateral CEPII BACI96, the US data will apply a threshold of \$10,000 to compute the diversification measure  $D_{it}^B$ . Because the cross-sectional distribution of export diversification is extremely skewed in the US data, all diversification measures are transformed into a logarithmic scale. The countries exporting the greatest fraction of goods to the US, on average, are Germany, China, and Italy for  $\bar{D}_i^A$ ,  $\bar{D}_i^B$ , and  $\bar{D}_i^C$ , respectively. The peak values in a single year between 1992 and 2009 are reported for Chinese exports to the US;  $D_{it}^A = 0.84$  and  $D_{it}^B = 0.78$  in 2007. The peak value for the third measure  $D_{it}^C = 0.11$  is reported for Germany in 1994. Because the US data does not confront the diversification measures with the upper limit of its product classification, the econometric analysis abstains from censoring.

## 2.5.2 Econometric Analysis

### Baseline Results

The baseline results characterize the general relationship between observed levels of diversification and economic development in a cross-section of countries. To avoid year-selection bias, estimations exploit the panel structure of the data using the Between Effects (BE) estimator. This estimator carries out an OLS regression on countries' average variable values observed over the sample period. In the applications presented here, the full period length was considered. However, to inspect the sensitivity of results with respect to certain time periods, also sub-periods were taken into consideration. The results were equivalent to those presented here.

Table 2.2 presents the results of the BE estimation, following Eqs. (2.6) and (2.6a). In this table, the dependent variable is the diversification measure  $\bar{D}_i^A$ . One observation is that the inclusion of squared log GDP per capita inflates the magnitude and standard errors of the coefficients  $\hat{a}_1$ . Only in column (6), which considers the US import data, squared log GDP per capita reveals a marginal negative impact.<sup>19</sup> Squared GDP per capita is statistically insignificant in both the (censored) CEPII BACI96 data and in

<sup>19</sup>Note that the US sample excludes Canada and Mexico in order to avoid the border problem appearing from trade with neighboring countries (Anderson and van Wincoop, 2003).

Table 2.2: Average Number of Exported Products and Country Characteristics; BE-Estimator, Alternative Datasets

Dataset	CEPII BACI96		CCSK		US Imports	
	(1)	(2)	(3)	(4)	(5)	(6)
GDPpc	0.180** (0.010)	0.293** (0.106)	0.156** (0.006)	0.171* (0.070)	0.830** (0.045)	1.704** (0.490)
Population	0.108** (0.011)	0.105** (0.012)	0.105** (0.007)	0.105** (0.007)	0.707** (0.052)	0.709** (0.052)
Distance	-0.131** (0.042)	-0.125** (0.042)	-0.017 (0.032)	-0.019 (0.034)	-0.403* (0.172)	-0.365* (0.171)
GDPpc2		-0.008 (0.007)		-0.001 (0.004)		-0.055 <sup>a</sup> (0.031)
Observations	853	853	1,688	1,688	1,764	1,764
Countries	75	75	89	89	98	98
R-squared	0.83	0.83	0.92	0.92	0.85	0.86
Period	1998-2009	1998-2009	1988-2006	1988-2006	1992-2009	1992-2009

*Note:* Table shows estimates based on Eqs. (2.6) and (2.6a), and data as stated in column headers. Columns (1) and (2) use a censored sample. Columns (5) and (6) exclude Canada and Mexico. Standard errors in parentheses; significance:  $a = 0.1$ ,  $*$  = 0.05,  $**$  = 0.01.

the full CCSK dataset. The inclusion of squared log GDP per capita does not improve the overall fit of the model, as indicated by the  $R$ -squared. It seems that continuous diversification cannot be rejected when diversification is measured by the total number of exported goods in a given country-year observation.

Table 2.3 considers all three measures. It shows the results obtained from CEPII BACI96 in Panel A and those obtained from the US data in Panel B. The first two columns show the same results as Table 2.2. They serve to compare the findings across the alternative diversification measures. In Panel A it stands out that the coefficients  $\hat{a}_1$  are statistically insignificant in the non-linear specifications for the more restrictive diversification measures  $D^B$  and  $D^C$ . Also squared log GDP per capita is not distinguishable from zero. This points at a serious problem of multicollinearity in the non-linear specification and prevents any ultimate conclusions about re-specialization. Column (6) in Panel B seems to reject re-specialization for exports to the US. Also here the coefficient  $\hat{a}_1$  is inflated but to a lesser extent than for the other measures.

Columns (2) and (4) of Panel B suggest that countries might re-specialize when

Table 2.3: Average Number of Exported Products and Country Characteristics; BE-Estimator, Alternative Count Thresholds

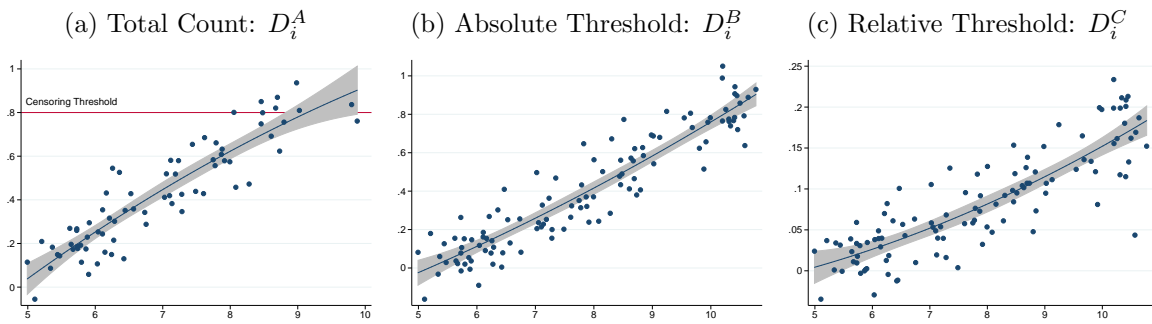
Dependent Variable	Counted Goods: $D_{it}^A$		Abs. Thresh: $D_{it}^B$		Rel. Thresh: $D_{it}^C$	
	(1)	(2)	(3)	(4)	(5)	(6)
<b>Panel A:</b> CEPII BACI96, 1998-2009						
GDPpc	0.180** (0.010)	0.293** (0.106)	0.161** (0.006)	0.073 (0.070)	0.031** (0.002)	-0.001 (0.021)
Population	0.108** (0.011)	0.105** (0.012)	0.116** (0.008)	0.115** (0.008)	0.025** (0.002)	0.025** (0.002)
Distance	-0.131** (0.042)	-0.125** (0.042)	-0.080* (0.035)	-0.073* (0.036)	-0.062** (0.011)	-0.060** (0.011)
GDPpc2		-0.008 (0.007)		0.006 (0.004)		0.002 (0.001)
Observations	853	853	1,329	1,329	1,329	1,329
Countries	75	75	111	111	111	111
R-squared	0.83	0.83	0.90	0.90	0.81	0.81
<b>Panel B:</b> US Import Data, 1992-2009						
GDPpc	0.830** (0.045)	1.704** (0.490)	0.917** (0.053)	2.049** (0.581)	0.695** (0.046)	1.049* (0.505)
Population	0.707** (0.052)	0.709** (0.052)	0.774** (0.062)	0.777** (0.061)	0.646** (0.053)	0.647** (0.053)
Distance	-0.403* (0.172)	-0.365* (0.171)	-0.380 <sup>a</sup> (0.204)	-0.330 (0.203)	-0.418* (0.174)	-0.402* (0.176)
GDPpc2		-0.055 <sup>a</sup> (0.031)		-0.071 <sup>a</sup> (0.036)		-0.022 (0.031)
Observations	1,764	1,764	1,764	1,764	1,764	1,764
Countries	98	98	98	98	98	98
R-squared	0.85	0.86	0.83	0.84	0.81	0.81

*Note:* Table shows estimates based on Eqs. (2.6) and (2.6a), and data as stated in Panel titles. Columns (1) and (2) of Panel A use a censored sample. Panel B excludes Canada and Mexico. Standard errors in parentheses; significance:  $a = 0.1$ ,  $*$  = 0.05,  $**$  = 0.01.

they pass a certain level of GDP per capita. Imbs and Wacziarg (2003) and CCSK compute these turning points. They range between \$20,000 and \$30,000 (PPP 2005). The turning points implied by the results presented here is much higher. Considering column (2), it suggests that the elasticity of the fraction of goods exported to the US with respect to real GDP per capita is given by:  $\partial \ln \bar{D}^A / \partial \ln y = 1.704 - 2 \times 0.055 \ln y$ . The turning point where the elasticity equals zero is  $\ln \tilde{y} = 15.49$ . This implies that countries would begin to re-specialize when they reach a level of real GDP per capita of  $\tilde{y} \approx \$534,092$  (PPP 2005). Obviously, no country has reached this point yet and it will take many years for the first country to pass it. It seems implausible that the non-linear specification correctly describes the relationship between GDP per capita and export diversification.

To obtain a sharper picture of the case of re-specialization, the alternative approach was to inspect the residuals of each linear specification obtained from Eq. (2.6). For any dataset and measure considered in Tables 2.2 and 2.3, regressing  $\hat{\varepsilon}_i$  on  $(\ln y_t)^2$  produces statistically insignificant results. Also the residual plots suggest that the error term shows no systematic pattern with regard to income levels. Instead of showing these directly, Figure 2.5 plots the residual variation of the data after controlling for population and weighted distances in the CEPII BACI96 data. That is, they are analogous to the figures presented in the descriptive analysis but assume that countries are symmetric in terms of population size and geography.

Figure 2.5: Predicted Number of Exported Goods and GDP per Capita; Equalized Population and Geography; Average 1998-2009



*Note:* Author's calculations based on data from CEPII BACI96 and results from estimating Eq. (2.6). Figures show predicted export diversification, after subtracting the effects of population and weighted distances. The horizontal axis denotes log GDP per capita.

The figure suggests that much of the variation is explained by the two control

variables so that there remains a relatively tight positive correlation between log GDP per capita and export diversification. The lines and 95 percent confidence intervals indicate slight but statistically insignificant non-linearities. In Figure 2.5(a) it appears to be driven by two observations in the upper right of the graph (Israel and Cyprus) but censoring prevents consideration of the full sample of countries. Figure 2.5(b) and (c) show all 111 countries. In the latter figure, Ireland appears to be a negative high-income country outlier. Overall, the analyses of the baseline specification suggest that there is no evidence of re-specialization. The inclusion of theory-based control variables appears to capture important parts of the variation observed in cross-sectional data. Squared log GDP per capita may pick up the effects of some of those variables, but mostly leads to multicollinearity problems without improving the fit of the data.

### Country Fixed Effects

The BE estimator, like all cross-sectional estimators, cannot rule out omitted variables, even if the included variables capture most of the variation. This implies that the observed correlation between export diversification and levels of GDP per capita might be driven by unobserved but correlated variables. Panel data offers tools to analyze this potential source of omitted variable bias. A standard step is to compare the BE estimator to a fixed-effects estimation. The empirical specification is stated in Eq. (2.7). Comparing coefficients  $\hat{a}_v$  with  $\hat{b}_v$  for each independent variable  $v$ , shall reveal whether the cross-sectional pattern is the same as the within-country pattern over time.<sup>20</sup> Whenever the two coefficients differ from each other, the observed cross-country pattern must be driven by a correlated but unobserved variable, and is thus inconsistent.

Table 2.4 shows the coefficients and test statistics obtained for log GDP per capita, estimating Eq. (2.7). The underlying datasets are identical to those that produced Tables 2.2 and 2.3. The results look quite different, however. In three of the seven cases, log GDP per capita is statistically insignificant, and in the remaining cases they are considerably smaller than the BE coefficients. Similar findings apply to the other independent variables. Distance to the US, in Columns (3), (5), and (7), is absorbed by the country fixed effects.

The results in this table suggest that the FE and the BE model statistically differ

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<sup>20</sup>Gould (2001) discusses the advantage of comparing the BE to the FE estimator. His suggested coefficient test has also been applied here and supports the results presented here.

Table 2.4: Number of Exported Products Within Countries over Time; FE-Estimator, Alternative Datasets

Dep. Variable	Total Count: $D_{it}^A$			Abs. Thresh. $D_{it}^B$		Rel. Thresh. $D_{it}^C$	
Dataset	BACI96	CCSK	US Imp.	BACI96	US Imp.	BACI96	US Imp.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDPpc	0.022 (0.021)	0.077** (0.017)	0.141 (0.112)	0.037** (0.011)	0.156 (0.120)	0.007* (0.003)	0.024 (0.150)
Population	0.063 (0.086)	0.150 (0.111)	-0.509 (0.432)	-0.028 (0.054)	-0.444 (0.463)	0.043** (0.015)	-0.023 (0.599)
Distance	-1.109 (0.965)	-1.887 <sup>a</sup> (1.135)		-0.716 (0.592)		-0.301 <sup>a</sup> (0.166)	
Observations	853	1,688	1,764	1,329	1,764	1,329	1,764
Countries	75	89	98	111	98	111	98
R-squared	0.37	0.70	0.39	0.35	0.32	0.10	0.06

*Note:* Table shows estimates based on Eqs. (2.7) and data as stated in column headers. Column (1) uses a censored sample (see text). All regressions include time dummies. Robust standard errors in parentheses; significance:  $a = 0.1$ ,  $*$  = 0.05,  $**$  = 0.01.

from each other. This indicates that the cross-sectional results of the previous subsection is spurious. It might be partly or sometimes fully driven by time-invariant country characteristics, or by aggregate annual variation, which is absorbed by  $\delta_t$  in the FE estimation. Another reason could be panel-unit heterogeneity; i.e. that  $b_1$  is not the same for every country. These explanations have different implications.

In the former case, the lower  $\hat{b}_1$  would imply that GDP per capita is differently related to export diversification in the short- and in the long-run. A similar argument is made by Kehoe and Ruhl (2013). They find that export growth at the extensive product margin, as measured by  $D^C$ , is insensitive to business cycle fluctuations. Their explanation is that trade relationships are established over the long-run so that temporary economic disruptions do not alter their status. Related to the EK model, this explanation results from the fact that diversification patterns are driven by relative prices. Those prices are not determined by the level of the annual output of a country but rather by its technology and by the co-variates stated in the equations above. A country's technology can be assumed to evolve smoothly, as it reflects its institutional and regulatory framework, infrastructure, and the diffusion of knowledge (e.g. Lucas, 2009).

The other case, panel heterogeneity, suggests that countries at different stages of economic development diversify their exports in different ways. Relating to the theories of Acemoglu and Zilibotti (1997) and Hausmann and Rodrik (2003), developing countries diversify their exports within the technology frontier. Hence, they carry out activities that have already been conducted before. They experiment with various of these activities and maintain them when they prove to be profitable. Besides their technological ability, capital indivisibilities and size may contribute to their diversification process. In contrast, advanced countries operate at the technology frontier and explore activities that have never been carried out before. As in Eaton and Kortum (1999) and their following work, the arrival rate of profitable inventions is constant and exogenous. Thus, capital accumulation and the size of the research sector have a negligible impact on export diversification among high-income countries in the short-run.

### Long-run Effects and Causal Relationships

To provide further evidence, the dynamic specification stated in Eq. (2.8) is estimated. All variables are expressed in logs and censoring continues to apply to  $D_{it}^A$  in the CEPII BACI96 sample. Results are obtained from the System-GMM estimator. This estimator is chosen because it is designed for causal inference of persistent dependent variables in short panels (Roodman, 2009). The System-GMM estimator generates internal instruments by using past changes in variable values to predict their current levels. This approach of instrumentation is used for the lagged endogenous variable as well as for GDP per capita, which is assumed to be predetermined. The other variables, log population and log weighted distance, are assumed to be exogenous and thus treated like external instruments. The results are shown in Table 2.5, where the stated number of instruments is constituted by the two exogenous variables, a time-dummy for each year, and by the internal instruments generated for per capita income and lagged diversification levels.

The results suggest that there exists no general causal impact of GDP per capita on export diversification. This conforms to the results obtained from the FE estimator in the previous subsection. Inclusion of squared income does not change this picture. The dynamic specification confirms that past levels of diversification predict current levels of diversification. The results in the first row of columns (1), (3), and (5), where  $0 < \hat{\gamma} < 1$ , suggest that the diversification process is stationary. In contrast, column (4)

Table 2.5: Number of Exported Goods and Country Characteristics; System-GMM Estimation

Dep. Variable:	Goods Count: $\ln D^A$		Abs. Thresh: $\ln D^B$		Rel. Thresh: $\ln D^C$	
	(1)	(2)	(3)	(4)	(5)	(6)
Lag Dep. Var.	0.847** (0.104)	0.908** (0.299)	0.816** (0.113)	1.070** (0.071)	0.842** (0.211)	0.808** (0.194)
GDPpc	0.061 (0.055)	0.126 (0.542)	0.010 (0.068)	0.035 (0.284)	0.146 (0.140)	0.322 (0.426)
Population	0.049 (0.035)	0.040 (0.113)	0.071 (0.043)	-0.026 (0.028)	0.049 (0.078)	0.066 (0.070)
Distance	-0.036 (0.041)	-0.007 (0.088)	-0.034 (0.043)	-0.015 (0.025)	-0.026 (0.246)	-0.133 (0.116)
GDPpc2		-0.005 (0.025)		-0.001 (0.015)		-0.013 (0.025)
Instruments	21	19	19	22	16	17
AR2 ( $p$ -value)	0.088	0.119	0.477	0.438	0.471	0.478
Hansen ( $p$ -value)	0.443	0.469	0.312	0.035	0.515	0.537
<b>Reverse Causality:</b> $\ln y_{it} = \xi_0 + \xi_1 \ln y_{it-1} + \xi_2 \ln D_{it-1} + \delta_t + \eta_{it}$						
GDPpc (lagged)		0.851** (0.108)		0.844** (0.052)		0.801** (0.095)
Diversification (lagged)		0.527* (0.259)		0.257** (0.082)		0.358* (0.137)
Instruments		17		14		16
AR2 ( $p$ -value)		0.151		0.095		0.329
Hansen ( $p$ -value)		0.335		0.242		0.271
Observations	783	783	1,221	1,221	1,221	1,221
Countries	75	75	111	111	111	111

*Note:* Table shows estimates based on Eq. (2.8), and data from CEPII BACI96. The dependent variable is stated in the column header. Columns (1) and (2) use a censored sample. Standard errors in parentheses with small-sample Windmeijer correction. Significance:  $a = 0.1$ ,  $*$  = 0.05,  $**$  = 0.01.

provides an unreasonable result. It shows that  $\hat{\gamma} > 1$  and suggests that diversification does not converge to a long-run equilibrium. The Hansen- $J$  Statistic rejects exogeneity of the instruments.<sup>21</sup>

A second result is presented in the lower panel of Table 2.5. It shows the outcome of estimating a reverse specification where the log of GDP per capita is regressed on its (instrumented) first lag and on the (instrumented) lagged level of export diversification. All three specifications satisfy the critical test statistics of instruments exogeneity and second order autocorrelation. As expected, also GDP per capita evolves along a stationary path. However, export diversification has a distinct impact on GDP per capita. This effect can be found for any measure of diversification and is statistically significant at the five percent level or better.

To investigate further the principal relationship of interest, the effect of GDP per capita on export diversification, Eq. (2.8) is re-estimated for a sub-sample of countries. The question is whether developing countries expand their exports in a different way than high-income countries. To analyze this, the estimations concentrate on transition economies that are characterized by high average annual growth rates of GDP per capita. Considering the top quartile of this distribution results in a sample of 28 countries. Their growth rates in the period 1998-2009 range from 8.9 to 14.5 percent per annum. Table 2.6 shows the results for this set of countries.

The estimated impact of the lagged endogenous variable differs only slightly from that obtained for the full sample of countries. The coefficient  $\hat{c}_1$ , which quantifies the separate effect of GDP per capita, is positive and statistically significant for two of the three diversification measures. The quadratic specifications eliminate this effect. A causal impact cannot be confirmed for the simple count measure  $D_{it}^A$ , which might also be a consequence of censoring the data. It excludes countries like China, India, or Indonesia, which already export almost all products. The second measure,  $D_{it}^B$ , finds the strongest results, including an impact of country size on diversification. However, the absolute threshold of this measure might drive this result, as it tends to understate diversification of small economies. The final measure,  $D_{it}^C$ , provides at least indicative evidence that a causal effect exists. If this is taken to be true, it implies that the process of export diversification differs across stages of economic development.

Altogether, the dynamic panel analyses reveal that there is no general causal effect

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<sup>21</sup>This result was obtained for alternative calibrations of the lag-structure from which the system-GMM estimator generates its instruments.

Table 2.6: Number of Exported Goods in Transition Economies; System-GMM Estimation

Dep. Variable:	Goods Count: $\ln D^A$		Abs. Thresh: $\ln D^B$		Rel. Thresh: $\ln D^C$	
	(1)	(2)	(3)	(4)	(5)	(6)
Lag Dep. Var.	0.809** (0.229)	0.870** (0.070)	0.757** (0.072)	0.876** (0.080)	0.887** (0.063)	0.879** (0.142)
GDPpc	0.042 (0.096)	0.128 (0.306)	0.212** (0.073)	0.143 (1.043)	0.174* (0.083)	0.583 (1.689)
Population	0.059 (0.071)	0.058 (0.040)	0.107* (0.041)	0.064 (0.044)	0.058 <sup>a</sup> (0.032)	0.064 (0.061)
Distance	-0.221 (0.344)	-0.025 (0.126)	-0.034 (0.166)	-0.033 (0.109)	0.177 (0.182)	-0.125 (0.106)
GDPpc2		-0.003 (0.020)		-0.003 (0.065)		-0.032 (0.106)
Instruments	17	17	21	18	22	17
AR2 ( <i>p</i> -value)	0.440	0.416	0.195	0.202	0.750	0.709
Hansen ( <i>p</i> -value)	0.362	0.176	0.551	0.476	0.359	0.375
Observations	198	198	308	308	308	308
Countries	18	18	28	28	28	28

*Note:* Table shows estimates based on Eq. (2.8), and data from CEPII BACI96. Dependent variables are stated in the column headers. Columns (1) and (2) use a censored sample. Standard errors in parentheses with small-sample Windmeijer correction. Significance:  $\alpha = 0.1$ ,  $*$  = 0.05,  $**$  = 0.01.

running from GDP per capita to diversification. This is in line with the EK model (and also with the Lerner diagram shown in Figure 2.3) where export diversification is driven by technology and relative prices. The reverse impact of diversification on GDP per capita fits with theories of “economic self-discovery” (Hausmann and Rodrik, 2003). They describe the process of sectoral transitions which facilitate economic development through additional gains from trade and higher wage incomes.<sup>22</sup> A separate effect of GDP per capita on diversification in transition economies could be rationalized with theories of economic development where capital indivisibilities impede the process of pioneering new activities (Acemoglu and Zilibotti, 1997). In this case, large economies

<sup>22</sup>In line with this, Eaton et al. (2007) find that the export volume of goods increases considerably when they survived the first three years after they were exported for the first time. Similar findings are presented by Kehoe and Ruhl (2013) who find that products moving from the bottom decile to any higher percentile contribute substantially to aggregate export growth.

and those with a higher stock of physical or human capital per person might be able to diversify faster than other transition countries. Since such a pattern could be detected only for some measures of diversification, it remains to be seen whether this effect can be verified in future research.

## 2.6 Conclusion

The paper presented theoretical arguments for why predictions on the relationship between diversification and economic development can be made only for the extensive margin. This has implications for the measurement of diversification and might provide an explanation for why so many empirical studies produced conflicting results. Staying close to economic theories of international trade, a gravity equation for export diversification was derived from the Eaton and Kortum (2002) model. Applied to detailed export data, three variables are enough to explain about 90 percent of the cross-country variation. Using alternative measures and datasets, convincing patterns of re-specialization — a major controversy in the literature — could not be detected.

The paper ultimately focused on the detection of causal effects between export diversification and real GDP per capita. The empirical analysis found that causality runs from export diversification to GDP per capita, rather than the other way around. While this is not a surprising result from the viewpoint of reduced-form growth and development theories, it suggests that the process of diversification cannot (or only slightly) be influenced. Related to the theoretical EK-framework, it implies that diversification evolves alongside the overall state of technology. At the country level, this parameter typically captures relatively stable characteristics, such as infrastructure, institutional framework, or the accumulation of knowledge at a broad level. A reverse impact running from diversification to GDP per capita could be detected. It supports theories of economic growth and development where economies evolve by adopting new activities for which they have acquired the knowledge to perform.

Besides the investigation of causality, a contribution of the paper is the illustration of the link between the diversification literature and modern trade theories. The model analyzed in this paper proved to be useful for the analysis of export diversification. Expanding on those models might provide further insights on the drivers and benefits of economic diversification.



## Chapter 3

### US POLICY SPILLOVER(?): CHINA'S ACCESSION TO THE WTO AND RISING EXPORTS TO THE EU

**Abstract:** The paper explores the causes of China's rising manufacturing exports to the EU after WTO accession. While the European trade policy environment remained largely unchanged in most sectors, a spillover from a change in US trade policies towards China is emphasized. In the proposed model the transmission occurs through a global component of the fixed costs firms must pay in order to export. If a large fraction of this component can be covered from exporting to one destination, exporters will serve also other markets to maximize their profits. The empirical analysis makes use of the removal of US tariff uncertainty in conjunction with China's WTO accession. It shows that: (i) the structure of China's export boom to the EU conforms to the pattern of US tariff uncertainty; (ii) the adjustment takes place at the extensive margin, (i.e. a good is exported to more destinations); and (iii) the effect phases out after a few years. The results have implications for the scope of international policy negotiations and provide suggestive evidence on the nature of the fixed costs that manufacturing firms in low-wage countries must overcome.

### 3.1 Introduction

When China entered the World Trade Organization (WTO) in December 2001, industrialized countries saw an increasing amount of Chinese goods flowing into their

domestic markets. Since then, numerous studies have been engaged in assessing the consequences of the increased competition on domestic firms and workers. However, little is known about the fundamental causes of China's export boom. Import duties levied on Chinese products mostly corresponded to preferential rates even before WTO entry. This rules out tariff reductions as the most obvious explanation in standard trade models.<sup>1</sup> In search of alternative causes, recent studies appealed to the idea of trade policy uncertainty (TPU). Several papers show that a US policy change explains well the timing and structure of China's export boom to the US (Handley and Limão, 2013; Feng et al., 2014). It also conforms to sectoral patterns observed in the decline of US manufacturing employment since 2001 (Pierce and Schott, 2013).

While the US policy change towards China reconciles the evolution of their bilateral trade relationship, it does not explain the surge of Chinese exports to other high-income countries. In particular, the EU experienced a similar increase of Chinese goods flowing into its markets. This is surprising, because EU trade policies towards China were less uncertain and did not change in the way they did in the US. China's tariff status in the EU was governed under the Generalized Scheme of Preferences (GSP). Since the 1980s, it grants preferential tariffs below most-favored-nations (MFN) rates, and incorporates a transparent, performance-based graduation mechanism. Inspecting the applicable EU tariffs on Chinese products since the mid-1990s suggests that they decreased slower than those for most other trade partners. Shortly after China's WTO entry they actually increased due to graduation from the preferential GSP rates.<sup>2</sup> Nevertheless, Figure 3.1 shows that, after WTO entry, China's exports to the EU departed from its long- and medium-run trend.<sup>3</sup>

This paper explores the possibility that the US policy change towards China encouraged Chinese exports to the EU. In doing so it extends existing work where the mechanism through which bilateral TPU operates provides no explanation of a spillover to multilateral trade. Feng et al. (2014) suggest that the removal of US tariff uncertainty faced by Chinese exporters facilitated market entry through a reduction of the

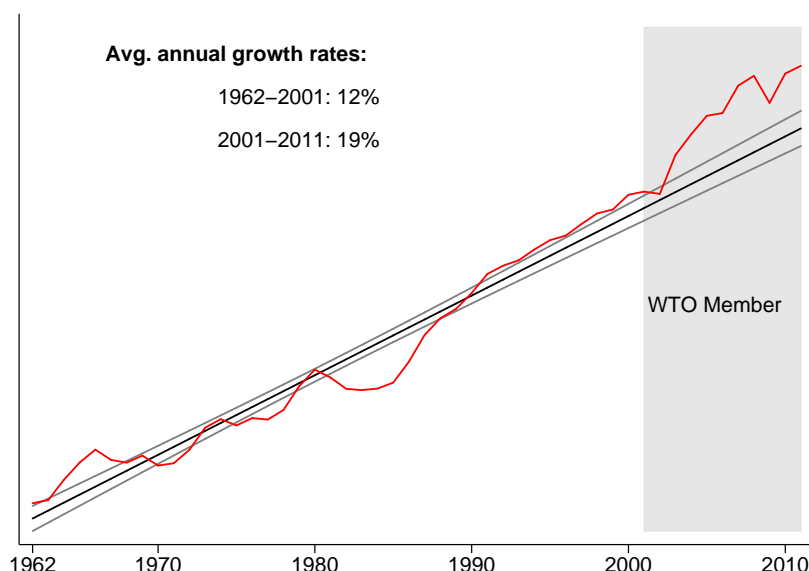
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<sup>1</sup>Frequently used procedures were, thus, using China's export structure observed in other destinations as an instrument for domestic market penetration (e.g. Autor et al., 2013a; Dauth et al., 2014). Some studies exploit the removal of quotas in the textile and clothing industry (e.g. Brambilla et al., 2010; Utar, 2014).

<sup>2</sup>This pattern is revealed by EU tariff schedules available at the World Integrated Trade Solutions (WITS) databases and from the several European Council regulations of the GSP in this period.

<sup>3</sup>Throughout this paper, the European Union will be referred to as the EU-15; i.e. the countries constituting the EU between 1995 and 2004.

Figure 3.1: Real Commodity Exports from China to EU-15 Countries; Log-scale; 1962-2011



*Note:* Author's calculations based on NBER-UN World Trade Flows, UN Comtrade, and Penn World Tables 8.0. Exports expressed in international dollars (PPP 2005). Fitted line shows trend for 1962-2001 and 95% confidence intervals.

expected tariff rate. This is also suggested by Handley and Limão (2013) who, as an additional mechanism, consider technology upgrades by firms that exported to the US before the policy change. However, since such technology upgrades are modeled to reduce distribution costs in the destination, the effect is limited to their bilateral setting. To generate a spillover, this paper considers an alternative channel. Similar to the exposition of Hanson and Xiang (2011), it assumes that Chinese firms willing to export must incur both a country-specific and a global fixed cost. Empirical evidence from Iacovone and Javorcik (2012) justifies the assumption of a global fixed cost for low-wage countries. They observe that Mexican firms upgrade their products prior to becoming exporters.

The proposed model suggests that a change in US policies towards China lowers the productivity threshold at which its firms can profitably export to third countries, given that they serve the US, too. Generally, the effect is larger when the policy-making economy is able to cover a major fraction of the global fixed cost. Bilateral fixed costs ensure that more productive firms export to a larger number of destinations, a stylized

pattern in manufacturing trade data (e.g. Eaton et al., 2004). A reduction of TPU in the US implies that China increases its exports to the EU. This occurs at the extensive margin through entry of firms into new destination markets. To test the predictions empirically, the paper uses disaggregated data on Chinese exports in the period 1995-2005. The impact of the US policy change is evaluated via a difference-in-difference (DID) strategy. It exploits cross-product differences of the US “tariff threat” under TPU, and compares the periods before and after China’s WTO entry. The results reveal a robust and positive impact of the US policy change on Chinese exports to the EU. The estimated coefficients appear to be in reasonable orders of magnitude, considering model parameter values used in the literature. It is also confirmed that trade increases at the extensive margin, i.e. through the creation of new trade relationships at the product-destination level. Further analyses provide suggestive evidence in support of a redistribution of global fixed costs. An extended sample period up to the year 2012 reveals that the effect of the US policy change phases out after a few years.

The paper makes several contributions to the literature. It shows that bilateral trade policies are not without consequences for third countries, especially when large economies are involved. This extends the scope of the trade creating effects observed in bilateral studies (Handley, 2012; Handley and Limão, 2012, 2013). The proposed transmission channel, a global fixed cost component, generalizes the findings of Hanson and Xiang (2011), who focused in their analysis on services exports. Although global fixed costs seem to contradict stylized patterns where firms enter markets one by one, a reason for why this could apply in the presented case is the large amount of processing trade in China (Amiti and Freund, 2010). It suggests that firms do not sell their goods directly to consumers but rather produce for firms in high-income countries which then place the good on the market. Chinese firms pay fixed costs to meet general standards required by those firms, irrespective of their provenance. Country-specific fixed costs remain an important feature of manufacturing trade, as they influence the costs of moving goods between source and destination countries. Finally, as product-specific trade policies and uncertainty contribute to the formation of trade patterns and investment, they might affect the development of seemingly random patterns of specialization observed across similar countries (Hausmann and Rodrik, 2003).

The paper proceeds as follows. Section 3.2 describes the trade policy environments faced by Chinese exporters, and argues that TPU was higher in the US than in the EU. Section 3.3 introduces the theoretical model, which links bilateral policies to a

multilateral dimension and derives the testable predictions. Section 3.4 explains the empirical strategy and the data used to carry out the analysis. Section 3.5 presents and discusses the results. Section 3.6 concludes.

## **3.2 US and EU Trade Policies towards China**

### **3.2.1 China-US Trade Relations**

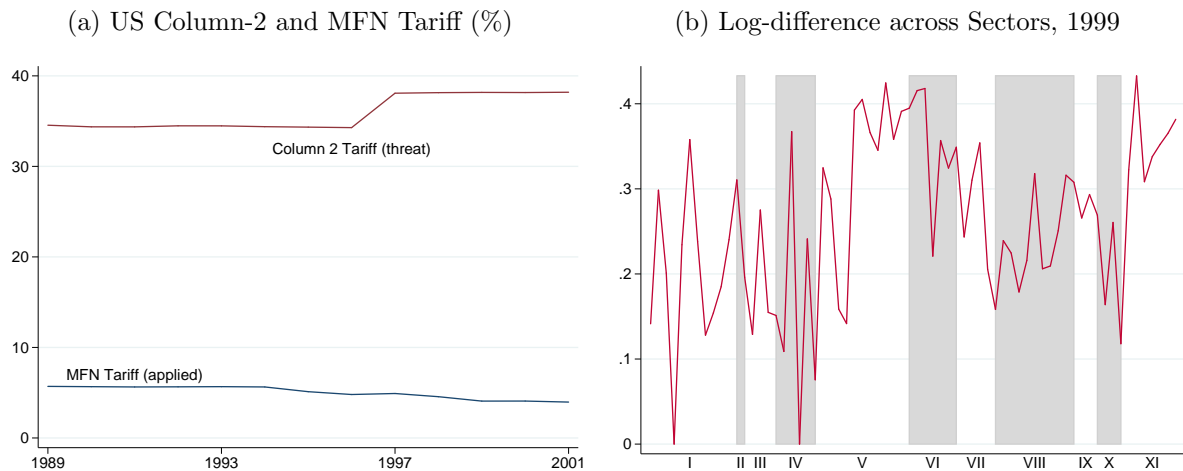
In the late 1970s the US and China established their diplomatic relations. In 1980 the US granted China preliminary MFN status for its exports. Prior tariffs corresponded to the “Column 2” schedule the US typically applies to non-market economies. These were originally defined under the Smoot-Hawley Tariff Act of 1930. In many cases Column 2 rates are much higher than the MFN rates, which were gradually dismantled during GATT/WTO negotiations. The preliminary nature of China’s MFN status in the US entailed the risk that it would return to apply Column 2 rates.

Approval of MFN rates for China required a majority of votes in the US Congress, and guaranteed the status for one additional year. Accordingly, Chinese exporters could be certain about applied tariffs in the present year but not for those that would follow. Handley and Limão (2013) quote a number of business practitioners and politicians suggesting that this form of TPU deterred investments into Chinese exports to the US. Moreover, in the 1990s it was witnessed that China’s MFN status was close to being overturned. In the aftermath of the Tiananmen Square incident, in 1989, political opposition to China’s MFN status arose, pointing out the violation of human rights standards. Pierce and Schott (2013) emphasize that, in the early 1990s, votes sufficed for a return to Column 2 tariffs, but the US Senate failed to act on this. Shortly before China’s WTO entry, in the years 1997-2001, the votes against its MFN status amounted to 38 percent, on average. During these years, political tensions between the two countries remained. In 1999, NATO accidentally bombed the Chinese embassy in Serbia, and in 2001 China refused to return a US surveillance plane after its collision with a Chinese fighter jet over the South China Sea. It was deployed and returned to the US after several diplomatic interventions.

The entry of China into the WTO was decided in December 2001 and has been effective since January 2002. Upon this event the US granted China “permanent normal trade relations” (PNTR). This removed the inhibiting effect of TPU for Chinese

exporters and encouraged their entry into the US market. In particular, the fact that the preliminary MFN status was never actually overturned makes this policy change appropriate for consideration as a natural experiment. Its evaluation requires information about the US Column 2 and MFN tariff schedules for the years prior to China's WTO accession. Figure 3.2 shows how these rates differ according to the US tariff data that is going to be used in this paper. It shows that MFN rates gradually decline to below 5% for an average manufacturing product, while Column 2 rates increased from 34 to 38 percent. The log difference between the two rates, calculated for 1999, suggests that the threat of tariff increases was present across all industries.<sup>4</sup>

Figure 3.2: Average US MFN and Column-2 Tariffs 1989-2001, and the Tariff Threat towards China



*Note:* Author's calculations based on US Tariff Data (Feenstra et al., 2002). Horizontal axis of Panel (b) denotes manufacturing sectors and their sub-chapters: I Chemicals, II Plastic/Rubber, III Hides/Leather, IV Wood Products, V Textiles, VI Apparel/Footwear, VII Stone/Glass, VIII Metals, IX Machinery/Electronics, X Transport, XI Other Manufactures.

### 3.2.2 China-EU Trade Relations

China and the former European Community (EC) agreed on an equivalent to PNTR in 1979, which established China's MFN status in Europe. In addition, China became a beneficiary country under the Generalized Scheme of Preferences (GSP) in 1980. The

<sup>4</sup>In Panel (b) of Figure 3.2 the threat is calculated as  $\ln \tau^{Col} - \ln \tau^{MFN}$ ; a tariff of 5% implies  $\tau = 1.05$ .

GSP grants preferential market access to developing countries through discounts on applied MFN rates. In contrast to the China-US relations, the European GSP entails a lower degree of TPU, as it sets out tariff preferences for several years. The GSP also includes a graduation mechanism which implies that a country may return to MFN rates. This happens when it reaches a certain level of economic development, or when it becomes a dominant exporter of a good in comparison to other GSP beneficiaries. These criteria are transparent so that Chinese exporters should have faced less uncertainty regarding future tariffs. When China entered the WTO, nothing changed in these formal procedures.

Figure 3.3: Average European Union Applied Tariffs (%); Ad-valorem Equivalents, 1995-2012



*Note:* Author's calculations based on World Integrated Trade Solution (WITS) and European Council Regulations (EC) No 3281/94, 2820/98, 2501/2001, 2331/2003, 980/2005, 732/2008, and 512/2011.

Figure 3.3 depicts European MFN and GSP tariffs, as well as those applicable to China for an average manufacturing good. The former gradually decline and evolve proportionally.<sup>5</sup> Tariffs on Chinese goods declined at a lower rate until 2004. Since 2005 they increased due to graduation from GSP preferences and have fully returned to

<sup>5</sup>The local MFN peak in 2002 is driven by a number of steel products where the EU temporarily raised the tariff rate. This occurred in response to the rise of US steel tariffs in March 2002 under president George W. Bush.

MFN rates since 2006. Altogether, the European trade environment, in terms of applied tariffs, appears to have worsened for China, and so it can barely explain China's rising exports to the EU since 2002.

### 3.3 Policy Spillover

This section attempts to rationalize the rise of Chinese exports to the EU. It presents first the bilateral framework similar to Handley and Limão (2013) and then expands on it to establish a channel through which bilateral policies affect the multilateral export performance.

#### 3.3.1 Baseline Model

##### Setup

**Demand.** Following the Melitz (2003) framework monopolistic firms  $j$  consider demand of utility-maximizing consumers. Consumers allocate a fraction  $0 < \mu < 1$  of their expenditures on product  $J$  across foreign varieties  $X_J$ . The rest is spent on a domestic numéraire,  $0_J$ .  $X_J$  is defined as a CES aggregator over available varieties  $j \in \Omega_J$  so that demand is given by

$$X_J = \left( \int_{j \in \Omega_J} x_j^\epsilon dj \right)^{1/\epsilon}. \quad (3.1)$$

The elasticity of substitution is stated in the exponents,  $\sigma \equiv 1/(1 - \epsilon) > 1$ . Total expenditure on differentiated goods,  $E_J$ , the price for a variety,  $p_j$ , and the aggregate price index,  $P_J \equiv \left[ \int_{j \in \Omega_J} p_j^{1-\sigma} dj \right]^{1/(1-\sigma)}$ , determine the demand for variety  $j$ :

$$x_j = \frac{E_J}{P_J} \left( \frac{p_j}{P_J} \right)^{-\sigma} \quad (3.2)$$

**Supply.** Monopolistic firms charge a mark-up over their marginal costs in order to maximize profits. The price consumers in destination  $n$  have to pay for variety  $j$  is determined by the firm's productivity parameter,  $\varphi(j)$ , wages in the exporting country,  $w$ , the costs of shipping the good to country  $n$ ,  $d_{Jn} \geq 1$ , and by the tariff rate,  $\tau_{Jn} \geq 1$ ,

$$p_{jn} = \left( \frac{\sigma}{\sigma - 1} \right) \frac{w}{\varphi_j} d_{Jn} \tau_{Jn}. \quad (3.3)$$

The only variety-specific component is the productivity of firm  $j$ .

**Firm Entry.** The profit function of the firm is  $\pi = (\tilde{p} - c)x - f$ . The unit cost parameter is given by  $c_{jn} \equiv d_{Jn} \tau_{Jn} (w/\varphi_j)$  whereas the unit price  $\tilde{p}_j \equiv p_j/\tau_J$  received by the firm is discounted by the tariff collected at the border. Substituting (3.2) and (3.3) into the profit function states the problem of the firm that considers exporting to  $n$

$$\pi_{jn} = \tau_{Jn}^{-\sigma} \left( \frac{d_{Jn}}{\varphi_j} \right)^{1-\sigma} E_{Jn} (1 - \epsilon) \left( \frac{w}{P_{Jn} \epsilon} \right)^{1-\sigma} - f_{Jn}. \quad (3.4)$$

A positive fixed cost  $f_{Jn} > 0$  prevents firms from exporting to  $n$  when operating profits are too low. Using  $\pi_{jn} = 0$  identifies the marginal firm which is indifferent between exporting and not-exporting. It has productivity

$$\varphi_{Jn}^* = \tau_{Jn}^{\frac{\sigma}{\sigma-1}} \left[ \frac{f_{Jn}}{E_{Jn}(1 - \epsilon)} \right]^{\frac{1}{\sigma-1}} \left( \frac{d_{Jn} w}{P_{Jn} \epsilon} \right). \quad (3.5)$$

Higher applied tariffs,  $\tau$ , shipping costs,  $d$ , or fixed costs,  $f$ , require a higher firm productivity to pass the zero-profit cutoff (ZPC). Higher demand  $E$  or prices  $P$  in the destination market allow less productive firms to export profitably.

### Tariff Uncertainty

The analysis of tariff uncertainty considers the possibility that  $\tau^s$  takes different values depending on the policy regime faced in destination  $n$ :  $s = \{p, np\}$ . If the importing country grants preferential market access ( $s = p$ ), the tariff is lower than with non-preferential access ( $s = np$ ), i.e.  $\tau^p \leq \tau^{np}$ .

In the context of this paper, interest focuses on the removal of uncertainty regarding the application of preferential tariffs. As long as this uncertainty exists, firms do not know how future tariffs will be. They assume that a shift from preferential to non-preferential tariffs occurs with probability  $0 \leq \delta \leq 1$ . The expected tariff can be written as a weighted geometric average of the two scenarios,  $\tau^E = (\tau^{np})^\delta (\tau^p)^{(1-\delta)}$ . It

implies that  $\tau^p \leq \tau^E \leq \tau^{np}$ .<sup>6</sup> Equation (3.5) can be rewritten as

$$\varphi_{Jn}^* = (\tau_{Jn}^E)^{\frac{\sigma}{\sigma-1}} \left[ \frac{f_{Jn}}{E_{Jn}(1-\epsilon)} \right]^{\frac{1}{\sigma-1}} \left( \frac{d_{Jn}w}{P_{Jn}\epsilon} \right) \quad (3.6)$$

and gives the key result of the bilateral model with tariff uncertainty.

**Lemma 1** *If  $\tau_J^p < \tau_J^{np}$ , a removal of tariff uncertainty implies a reduction of the threshold productivity level,  $\varphi^*$ , firms must achieve to export profitably.*

This follows from the positive relationship between (expected) tariffs and the productivity threshold,  $(\partial\varphi^*/\partial\tau^E) > 0$ , and from the fact that expected tariffs equal the preferential rate when uncertainty vanishes ( $\delta = 0$ ). If preferential and non-preferential tariffs are the same, uncertainty has no effect on the productivity threshold, and nothing happens when it is removed.

### Product-level Predictions for Bilateral Trade

Firm-level export revenues  $r_{jn} \equiv \tilde{p}_{jn}(\varphi)x_{jn}$  can be aggregated to obtain product-level predictions

$$R_{Jn} = a_{Jn}\sigma \left( \int_{j \in \Omega_{Jn}} \varphi^{\sigma-1} dj \right), \quad (3.7)$$

where  $a_{Jn} \equiv \tau_{Jn}^{-\sigma} d_{Jn}^{1-\sigma} A_{Jn}$  and  $A_{Jn} \equiv \left[ \left( \frac{\sigma}{\sigma-1} \right) \frac{w}{P_{Jn}} \right]^{1-\sigma} \frac{E_{Jn}}{\sigma}$ . The expression in parentheses is equivalent to multiplying the total number of firms,  $M_J$ , with the fraction of firms residing at or above the ZPC

$$R_{Jn} = a_{Jn}\sigma M_J \left( \int_{\varphi_{Jn}^*} \varphi^{\sigma-1} dG_J(\varphi) \right). \quad (3.8)$$

If productivity levels across firms are Pareto distributed,<sup>7</sup> the probability that a random productivity draw from this distribution exceeds its lower bound  $\varphi_L$  equals  $G(\varphi) =$

<sup>6</sup>The characterization of uncertainty is simplified since the analysis will focus on the policy spillover. Handley and Limão (2013) analyze alternative policy regimes and their probabilities within a Markov transition matrix. Several transitional trajectories are ruled out by assumption. Uncertainty can also be modelled as a Poisson-process with an arrival rate  $\lambda$  (Feng et al., 2014). Both papers end up comparing the scenarios  $\delta > 0$  and  $\delta = 0$ .

<sup>7</sup>This is a standard assumption in the context of generating aggregate predictions from the Melitz (2003) model, and it is valid at least for the right tail of the distribution, where exporting firms typically reside.

$\left(\frac{\varphi_L}{\varphi}\right)^k$ .<sup>8</sup> Integrating (3.8) with  $G(\varphi)$  gives

$$R_{Jn} = a_{Jn} \left(\frac{1}{\varphi^*}\right)^{k-\sigma+1} \alpha_J, \quad (3.9)$$

where  $\alpha_J \equiv \sigma M_J \varphi_L^k \frac{k}{k-\sigma+1}$  represents a product-specific intercept. A gravity equation is obtained by plugging (3.6) into (3.9) and taking logs

$$\ln R_{Jn} = -\frac{\sigma k}{\sigma-1} \ln \tau_{Jn}^E - k \ln d_{Jn} + \frac{k}{\sigma-1} \ln A_{Jn} + \ln \alpha_J - \frac{k-\sigma+1}{\sigma-1} \ln f_{Jn}. \quad (3.10)$$

The removal of tariff uncertainty in  $n$  increases exports to this country through a reduction of expected tariffs. As the model suggests that additional firms enter the market, the adjustment takes place at the extensive margin. These predictions have been confirmed for China's exports to the US in previous studies (Handley and Limão, 2013; Feng et al., 2014).

### 3.3.2 Separable Fixed Costs and Multilateral Trade

The baseline model provides no explanation for increased exports to a country where policies did not change. To establish this link, additional structure is imposed on the fixed market-entry costs  $f_{Jn}$ . It is assumed that  $f_{Jn}$  can be separated into a local and a global component,  $f_{Jn} \equiv f_n + f_J$ .<sup>9</sup> With this assumption the export decision of a firm becomes interdependent. The global fixed cost component has to be paid irrespective of the number of destinations a firm serves. It implies that the burden of the global fixed cost can be distributed across sources of revenue. Considering firm  $j$ 's profits in all destinations  $n = \{1, \dots, N\}$  total export profits result as the sum of bilateral "partial"

<sup>8</sup>This feature suggests that the probability of a firm to have a certain productivity level  $\varphi_j > \varphi_L$  decreases with the size of  $\varphi_j/\varphi_L$ . The shape parameter  $k$  raises this ratio to a power  $k > (\sigma-1)$  so that a larger  $k$  implies a higher concentration of low-productivity firms and a smaller number of very productive firms.

<sup>9</sup>This is similar to Hanson and Xiang (2011) who analyze the relative importance of global and local fixed costs. Focusing on US movie exports, they find that global fixed costs dominate. However, for manufacturing trade, they acknowledge that bilateral fixed costs must play a larger role, since trade patterns vary substantially across countries.

profits,  $\tilde{\pi}$ , minus the global fixed cost:

$$\begin{aligned}
\tilde{\pi}_{j1} - f_J &= \tau_{J1}^{-\sigma} \left( \frac{d_{J1}}{\varphi_j} \right)^{1-\sigma} E_{J1} (1 - \epsilon) \left( \frac{w}{P_{J1}\epsilon} \right)^{1-\sigma} - f_1 - f_J \\
+ \tilde{\pi}_{j2} &= \tau_{J2}^{-\sigma} \left( \frac{d_{J2}}{\varphi_j} \right)^{1-\sigma} E_{J2} (1 - \epsilon) \left( \frac{w}{P_{J2}\epsilon} \right)^{1-\sigma} - f_2 \\
&\vdots \\
+ \tilde{\pi}_{jN} &= \tau_{JN}^{-\sigma} \left( \frac{d_{JN}}{\varphi_j} \right)^{1-\sigma} E_{JN} (1 - \epsilon) \left( \frac{w}{P_{JN}\epsilon} \right)^{1-\sigma} - f_N \\
\Pi_j(N) \equiv \sum_{n=1}^N \tilde{\pi}_{jn} - f_J &= (1 - \epsilon) \left( \frac{w}{\varphi_j \epsilon} \right)^{1-\sigma} \sum_{n=1}^N \left[ \left( \frac{d_{Jn}}{P_{Jn}} \right)^{1-\sigma} \frac{E_{Jn}}{\tau_{JN}^\sigma} \right] - \sum_{n=1}^N f_n - f_J.
\end{aligned} \tag{3.11}$$

The respective ZPC productivity  $\Phi^*$  for exporting to all  $N$  destinations follows as

$$\Phi_N^* = \sigma^{\frac{1}{\sigma-1}} \left( \frac{w}{\epsilon} \right) \left[ \sum_{n=1}^N \tau_{Jn}^{\frac{\sigma}{\sigma-1}} \left( \frac{f_n + f_J}{E_{Jn}} \right)^{\frac{1}{\sigma-1}} \frac{d_{Jn}}{P_{Jn}} \right]. \tag{3.12}$$

### General Implications of the Multilateral Productivity Threshold

Equation (3.12) states the productivity threshold required for a firm that exports to all destinations. Whether serving all destinations is optimal depends on the partial bilateral profits.

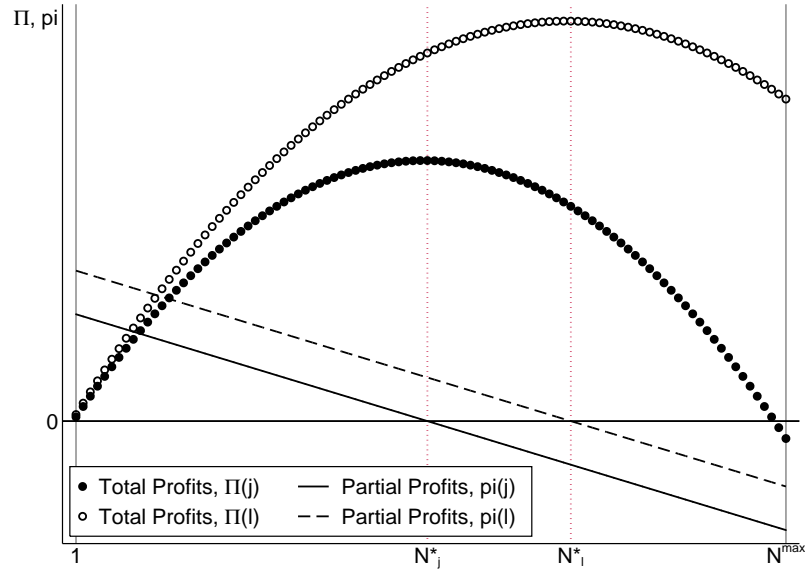
**Lemma 2** *Irrespective of global fixed costs  $f_J$ , a firm  $j$  exports to a destination  $n$  only if bilateral partial profits are positive,  $\tilde{\pi}_{jn} \geq 0$ .*

This follows from Equation (3.11). A row with a negative partial profit lowers total exporting profits. It implies that the number of destinations an exporting firm serves results from an assessment of each market. To determine this number, destinations can be ranked in decreasing order of the bilateral partial profits. The ranking is independent of the firm's individual productivity level. It then follows that

**Lemma 3** *If  $\tilde{\pi}_{j1} \geq \tilde{\pi}_{j2} \geq \dots \geq \tilde{\pi}_{jN}$ , and if global fixed costs can be covered, a firm exports to all destinations for which  $\tilde{\pi}_{jn} \geq 0$  holds.*

Figure 3.4 summarizes Lemmas 2 and 3 considering two firms with different productivity levels. The horizontal axis denotes the range of potential export destinations

Figure 3.4: Partial and Total Export Profits of Two Firms



Note: Author's calculations based on Eq. (3.11) with 100 destinations.

$n$ . They are ranked in decreasing order of the partial profits. The solid line with negative slope denotes these profits for firm  $\varphi(j)$ . The lower dotted curve denotes its total export profits earned by exporting to a respective number of destinations. Total profits rise, up to the point where partial profits become negative. The firm's optimal number of destinations is indicated at point  $N_j^*$ . The other firm  $l$  has productivity  $\varphi_l > \varphi_j$  and serves a larger number of countries. This prediction conforms to evidence from firm-level data (e.g. Eaton et al., 2004). It leads to a statement on the multilateral productivity threshold in Equation (3.12):

**Lemma 4** *If  $N = N^*$  denotes the optimal number of destinations to which a firm exports, then the productivity threshold  $\Phi_N^*$  is increasing in  $N$ .*

Lemmas 2-4 hold also for the case where fixed costs are purely country-specific. The distinct feature with a global fixed cost component arises when  $f_J$  is large enough to prevent a firm from earning positive profits in the first destination  $\tilde{\pi}_{j1} - f_J < 0$ . If that is the case, a firm might need the revenues from several markets in order to export profitably. This prediction seems to be at odds with observations where firms export first to one destination and enter additional markets when they grow. However, it is

possible that Chinese manufacturers are different. Amiti and Freund (2010) note that a large fraction of China's recent export growth is driven by processing trade. The firms carry out certain production processes but contribute less to the development of a product or to distributing it to final customers. This allows them to save destination specific costs by focusing on standardized processes. The global fixed cost  $f_J$  is paid to attract orders from foreign firms that are willing to save labor costs through outsourcing.<sup>10</sup> The bilateral fixed cost  $f_n$  governs the eligibility of Chinese firms to be integrated in the production chain of certain countries.

### Bilateral Tariff Uncertainty and Multilateral Trade

The effect of a reduction in tariff uncertainty on multilateral trade is illustrated with two examples. The first assumes that countries are symmetric. The second example considers the market size of the policy making country.

**Two Symmetric Countries.** Supposing that firms consider exporting to two foreign destinations,  $n = \{1, 2\}$ , the baseline scenario describes the outcome where the tariffs are uncertain in country 1. The applied tariff in country 1 corresponds to the preferential rate  $\tau_1^p = 1$  but the non-preferential rate  $\tau_1^{np} = 2$  might be applied with a probability  $\delta_1 = 0.5$ . The expected tariff in country 1 is then  $\tau_1^E = 1^{0.5}2^{0.5} \approx 1.4$ . There is no uncertainty in country 2 so that the expected tariff corresponds to the applied preferential rate  $\tau_2^E = \tau_2^p = 1$ . Equation (3.12) is used to compute the ZPC productivity for any possible scenario. To obtain numerical results it is assumed that the elasticity of substitution is  $\sigma = 3$  and that all other non-tariff variables equal 1.<sup>11</sup>

Columns (1)-(3) of Table 3.1 show ZPCs when firms export to both or only to one of the two countries, respectively. The first row shows the baseline scenario with tariff uncertainty in country 1. It suggests that most firms would export only to country 2 because column (3) states the lowest threshold. The second row displays the ZPCs when uncertainty is removed. It indicates that most firms will export to both destinations, as shown in column (1). The regime shift from uncertainty to certainty in country 1

<sup>10</sup>Empirical evidence along these lines is provided for Mexican firms that make investments to improve the quality of their products before they start to export (Iacovone and Javorcik, 2012). Feng et al. (2012) find that Chinese exporters benefited from importing larger amount of intermediate inputs after they entered the WTO.

<sup>11</sup>  $\sigma = 3$  follows Handley and Limão (2013) who refer to estimates of Broda and Weinstein (2006). Other authors use  $\sigma = 4$  (e.g. Head et al., 2014).

Table 3.1: Alternative Productivity Thresholds with Bilateral Tariff Uncertainty and Symmetric Countries

	(1) $\Phi_N^*$	(2) $\Phi_1^*$	(3) $\Phi_2^*$
Baseline: $\tau_1^E = 1.4$	3.53	5.35	3.18
Treatment: $\tau_1^E = 1$	2.90	3.18	3.18
<i>Note:</i> Author's calculations based on Eq. (3.12) with two destinations, $\sigma = 3$ , and all variables equal 1, except $\tau_1^E$ .			

induces firm entry into both markets. This follows because the ZPC without uncertainty is below any other ZPC of the baseline. The firms that become exporters after the policy change have productivity  $\varphi \in (2.90; 3.18)$ .

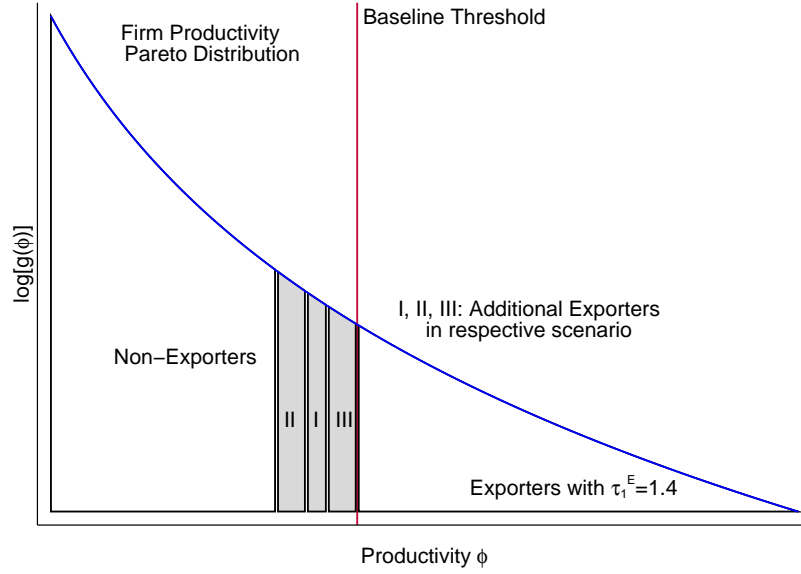
**Three Asymmetric Countries.** With three asymmetric countries  $n = \{1, 2, 3\}$ , it is possible to analyze how the size of the policy-making destination affects the multilateral threshold. Country 1 is again the one where tariffs are uncertain ( $\tau_1^E = 1.4$ ). Three scenarios are considered where the size of country 1 is I.  $E_1 = 1$ ; II.  $E_1 = 2$ ; and III.  $E_1 = 0.5$  in the respective cases. Country 2 is always large  $E_2 = 2$  and country 3 is always small  $E_3 = 0.5$ . Besides this parametrization, and  $\sigma = 3$ , all other non-tariff variables equal one.

Figure 3.5 illustrates how the removal of tariff uncertainty translates to multilateral exports. It depicts the (log of the) Pareto-density function  $g(\varphi)$ . Typically, most firms have a relatively low level of productivity and very few firms are very productive. The baseline scenario is normalized and shows the ZPC applicable for exporting to countries 1 and 2.<sup>12</sup> Only firms residing to the right of the baseline ZPC export under tariff uncertainty. The shaded areas indicate the amount of firms that become exporters when tariff uncertainty vanishes. It shows the smallest amount for case III where country 1 is small. The largest amount of new exporters is found for case II in which country 1 is big.

The figure suggests that the size of a market is correlated with the fraction of global fixed costs it absorbs. If the policy-making country is very small, the effect of removing TPU might be negligible. Scenario III suggests that uncertainty in country 1 induces

<sup>12</sup>The baseline ZPC for exporting to all three destinations is always higher but the mechanics remain the same.

Figure 3.5: Multilateral Productivity Thresholds with Bilateral Tariff Uncertainty and Asymmetric Countries



*Note:* Author's calculations based on Eq. (3.12) with three asymmetric destinations (see text). Figure shows Pareto density function  $g(\varphi) = \frac{k}{\varphi_L} \left( \frac{\varphi_L}{\varphi} \right)^{k+1}$  with lower bound  $\varphi_L = 1$  and shape-parameter  $k = 2$ . The vertical axis is scaled in logs.

the least productive exporter to serve countries 2 and 3. When tariff uncertainty is removed the threshold for exporting to 1 and 2 equals the ZPC of exporting to 2 and 3. As a result, exports do not adjust at the multilateral level, because there is no additional entry of firms that were non-exporters in the first place.

The results for asymmetric countries in terms of market size carry over to heterogeneity in terms of other country characteristics (e.g. bilateral trade costs). To evaluate the predictions of the model, two hypotheses shall be spelled out:

**Proposition 1** *If  $\tau_{Jn}^p < \tau_{Jn}^{np}$ , a removal of tariff uncertainty in a large country  $n$  induces an increase in the value of exports to any other destination  $m \neq n$  with positive partial profits.*

**Proposition 2** *If  $\tau_{Jn}^p < \tau_{Jn}^{np}$ , a removal of tariff uncertainty in a large country  $n$  induces an increase in the number of destinations  $N$  to which product  $J$  is exported.*

Both propositions follow from a new ranking of a firm's bilateral partial profits and the possibility of re-distributing global fixed costs. As tariff uncertainty vanishes,

non-exporters are able to take into account additional revenues, enabling them to earn positive total exporting profits. The policy spillover works through a reduction of the multilateral export threshold. This implies that the adjustment takes place at the extensive margin. An investigation of the removal of US tariff uncertainty towards China will provide evidence on the existence of countries that are large enough to generate the predicted effects.

## 3.4 Empirical Framework

### 3.4.1 Empirical Model

The empirical specification is derived from the previous section. It extends the gravity equation stated in Equation (3.10) by the global fixed cost.

$$\ln R_{Jn} = -\frac{\sigma k}{\sigma - 1} \ln \tau_{Jn}^E - k \ln d_{Jn} + \frac{k}{\sigma - 1} \ln A_n + \ln \alpha_J - \frac{k - \sigma + 1}{\sigma - 1} \ln (f_n + \theta_{Jn} f_J) \quad (3.13)$$

The parameter  $\theta_{Jn}$  indicates that a fraction of  $f_J$  is allocated to each destination  $n$ . It implies  $0 < \theta < 1$  for any existing trade relationship and  $\theta_{Jn} = 0$  whenever  $\tilde{\pi}_{Jn} \leq 0$ .

An allocation rule could take the following form:

$$\theta_{Jn} \equiv \frac{\tilde{\pi}_{Jn}}{\Pi_J - f_J},$$

which ensures that the rankings of bilateral partial profits  $\tilde{\pi}_{Jn}$  and of the same profits net of global costs,  $\tilde{\pi}_{Jn} - \theta_{Jn} f_J$ , are proportional. The interpretation is that a reallocation of the fixed cost burden away from destination  $n$  increases exports to this country  $\partial R_{Jn} / \partial \theta_{Jn} < 0$ . To incorporate the effect of  $\theta$  into the estimation equation, it is assumed that  $\theta_{Jn}$  is correlated with the tariff threat faced in a country  $m \neq n$ . In the context of this paper:  $\partial \theta_{Jn} / \partial GAP_J^{US} > 0$ . The tariff uncertainty Chinese exporters faced in the US forced them to increase  $\theta$  for any other export destination.

The econometric analysis focuses on the removal of uncertainty. Hence, the variable  $GAP_J^{US}$  is interacted with a period dummy  $D_t^T$  which equals zero before China's WTO entry and one afterwards. This is shown by the first term of the following equation:

$$\ln R_{Jnt} = b_1 (GAP_J^{US} \times D_t^T) + b_2 \ln \tau_{Jnt} + b_{Jn} + b_{nt} + b_{St} + \varepsilon_{Jnt} \quad (3.14)$$

The sign of  $b_1$  is expected to be positive, since the removal of US tariff uncertainty reduces  $\theta_{Jn}$  and increases  $R_{Jn}$ . The second term measures the tariff rate in destination  $n$  and should reveal a negative effect. The analysis focuses on China's exports to EU countries, so it is assumed that there is no tariff uncertainty, and  $\ln \tau_{Jn}^E = \ln \tau_{Jn}^p$ . The product-destination fixed effect captures the country specific trade costs of shipping good  $J$  to its destination;  $b_{Jn} \equiv -k \ln d_{Jn}$ . Destination-specific time effects  $b_{nt} \equiv \frac{k}{\sigma-1} \ln A_{nt}$  control for changing aggregate conditions in each destination, such as higher demand or prices.  $b_{Jn}$  and  $b_{nt}$  absorb also the local fixed cost component,  $f_n$ . Finally, sector-time effects  $b_{St}$  capture variation in  $\alpha_J$  over time at a more aggregated level.

### 3.4.2 Data and Measures

Estimating Equation (3.14) requires information on US MFN and Column 2 tariffs before China's WTO entry, to construct  $GAP_J^{US}$ , on applied EU tariffs for China, and on the value of Chinese exports to the EU.

US tariff data is drawn from the National Bureau of Economic Research's (NBER) website (Feenstra et al., 2002). The same data was used by Pierce and Schott (2013) to study the effect of removing US tariff uncertainty on domestic manufacturing employment. The data reports ad-valorem equivalents of applied tariffs at the 8-digit level of the Harmonized Tariff Schedule (HTS). This allows matching the data up to the 6th digit with product codes of the Harmonized System nomenclature (HS6). The US tariff threat is calculated at the disaggregated level and then averaged over the respective HS6 category  $J$ :

$$GAP_{J,99}^{US} \equiv \frac{1}{H(J)} \sum_{hts=1}^{H(J)} \ln \tau_{hts,99}^{Col2} - \ln \tau_{hts,99}^{MFN}.$$

The definition  $GAP_J^{US} \equiv \ln \tau_J^{Col2} - \ln \tau_J^{MFN}$  follows from the definition of the expected tariff rate,  $\ln \tau^E = \ln \tau^p + \delta(\ln \tau^{np} - \tau^p)$ , where the expression in parentheses equals  $GAP$ . Following other studies, the year 1999 is chosen to compute US tariff uncertainty. It varies only across product categories  $J$  but will be interacted with the period dummy for China's WTO membership. In a final step the HS6 codes are harmonized over time to reflect the classification of goods according to the HS 1988/1992 revision.<sup>13</sup>

European tariff data is obtained from the tariff schedules at the World Integrated

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<sup>13</sup>Correspondence tables for the HS nomenclature are available at the United Nations Statistics Division (UNSD).

Trade Solution (WITS). It reports ad-valorem equivalents at the 8-digit level of the Combined Nomenclature (CN8). Also this classification can be matched with HS6 products at the first six digits. A problem with this data is that information is missing for some years and products, and that this is difficult to trace, because the raw data does not take into account the revisions of product codes over time. Using the correspondence tables provided by Bernard et al. (2012) helps to trace most products.<sup>14</sup> A few remaining empty cells could be filled using information from similar products where observable tariffs evolved identically. The complete set of MFN rates is needed to compute GSP rates and those applicable to China in each product year. The GSP discount factors and the exceptions for China were drawn from the respective European Council Regulations. After aggregating and harmonizing product codes according to the HS6 1988/1992 revision, tariffs were expressed as  $\tau = 1 + (\% \text{-rate}/100)$ .

The data on Chinese exports was obtained from the UN Comtrade Online Database. Exports to the 15 EU members were selected and product codes were converted into the HS6 1988/1992 revision. Belgium and Luxembourg are treated as one country because they are not reported separately in all years. To distinguish the extensive margin, missing information on Chinese exports for a given HS6-country pair is assumed to reflect that no trade had taken place. In a fully balanced panel, covering the years 1995-2005, observations with zero trade amounts to 56 percent. Most export zeros are observed for Ireland (75%) and Austria (71%) and the fewest are reported for exports to Germany (34%) and Italy (40%). These numbers generally decrease over time.

## 3.5 Results

### 3.5.1 Main Findings

#### Level of Chinese Exports to the EU

Table 3.2 presents results from estimating Equation (3.14) for the period 1995-2005. The baseline sample considers the full range of manufacturing products of which there are 3,985, comprised in the HS Chapters 28-96. About six percent of the products were not exposed to US tariff uncertainty. The tariff threat for an average exposed product

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<sup>14</sup>The CN8 correspondence tables for the most recent years are available at the EUROSTAT Reference and Management of Nomenclatures (RAMON) archive.

was 0.289 in 1999. The reported results represent a sample with 14 destinations  $n$  and 11 sectors  $S$ .

Column (1) reports a positive and statistically significant coefficient for the removal of US tariff uncertainty. It suggests that Chinese exports of threatened products increased by 18.7 percent relative to a non-threatened product. Potentially differential patterns may arise in the textile and clothing sector (T&C) where the EU removed quotas for Chinese goods in 2002, 2005, and 2009 (Utar, 2014). These goods are comprised in HS Chapters 50-67 and were excluded in the estimation reported in column (2). The estimated effect is lower but still statistically significant and positive. Column (3) controls explicitly for the removal of quotas.<sup>15</sup> It suggests that China's exports increased due to both the removal of quotas and the removal of US tariff uncertainty. The implied average increase is 11.7 percent relative to non-threatened products.

The estimated coefficient can be interpreted in the context of the theoretical model. According to Equation (3.13) it reflects the elasticity of exports with respect to a reduction of the fixed-costs burden;  $(k - \sigma + 1)/(\sigma - 1)$ . Column (3) suggests that a one percent reduction increases exports by 0.405 percent. Head et al. (2014) estimate the Pareto parameter of China's firm productivity distribution to be  $k = 4.854$ . The implied elasticity of substitution is  $\hat{\sigma} = 4.455$ ; not too far from to their parametrization ( $\sigma = 4$ ).

Columns (4) through (6) adopt a discrete measure of the US tariff threat. Similar to Handley and Limão (2013) *GAP* is divided into groups. The first group (not shown) considers the goods where  $GAP = 0$ , i.e. where Column 2 rates equaled the MFN tariff rate. The second group considers the bottom quartile and the last group includes the top quartile of the tariff threat. Half of the products fall into the third group, where *GAP* ranges between 0.19 and 0.35. All specifications confirm the qualitative results of the baseline specification. Quantitatively, they suggest that US tariff uncertainty prevented market entry especially when  $GAP \geq p[25]$ . This corresponds to a difference of 0.187 log points or more between Column 2 and MFN tariffs. For an average good in the top quartile, column (6) suggests that exports increased by 17.3 percent relative to the non-threatened products. Table 3.2 also suggest that applied tariffs in the EU had no effect on China's exports to the EU. This is not surprising given that they changed only marginally during this period.

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<sup>15</sup>Information on the affected products is available online at the *Système Intégré de Gestion des Licences à l'Exportation et à l'Importation (SIGL)*.

Table 3.2: Chinese Exports to the EU-15 after the Removal of US Tariff Uncertainty; Linear Panel Regression, 1995-2005

Product Range:	Baseline			Discrete Measure		
	(1) Full	(2) No T&C	(3) Full	(4) Full	(5) No T&C	(6) Full
US Tariff Threat	0.647** (0.076)	0.237** (0.091)	0.405** (0.077)			
$p[+]-p[25]$				0.192** (0.074)	0.158* (0.076)	0.212** (0.073)
$p[25]-p[75]$				0.400** (0.071)	0.371** (0.073)	0.387** (0.071)
$p[75]-p[100]$				0.463** (0.072)	0.311** (0.076)	0.393** (0.072)
EU Tariff	-0.386 (0.420)	0.283 (0.433)	-0.052 (0.419)	-0.524 (0.421)	0.088 (0.435)	-0.181 (0.420)
EU Quota '02			0.576** (0.034)			0.576** (0.034)
EU Quota '05			0.449** (0.050)			0.446** (0.049)
Observations	270,767	207,476	270,767	268,499	205,966	268,499
R-squared	0.170	0.176	0.172	0.171	0.177	0.173
Fixed effects	All	All	All	All	All	All

*Note:* Table shows estimates based on Eq. (3.14), and data from various sources (see text). Fixed effects:  $Jn$ =product-destination,  $nt$ =destination-year,  $St$ =sector-year. Robust standard errors in parentheses; significance: <sup>a</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ .

### Extensive vs. Intensive Margin

To analyze the trade creation effect of the US policy change, patterns at the extensive margin are investigated. Table 3.3 presents results of different specifications that capture this adjustment.

The first two columns present the odds-ratio and the coefficient of a logistic regression. The dependent variable takes a value equal to one when China exports to a given product destination at time  $t$ , and zero otherwise. Column (1) suggests that the removal of non-tariff trade barriers, e.g. US tariff uncertainty and EU import quotas, increase the probability of observing Chinese exports to a given European product-country pair. Higher tariffs make trade less likely to occur. The signs of the coefficients stated in column (2) show the marginal effects of a change in the independent variable

Table 3.3: Chinese Market Entry in the EU-15 after the Removal of US Tariff Uncertainty; Alternative Estimators, 1995-2005

	Logistic Regressions		Linear Regressions		
	Odd Ratio	Coeff.	# Destinations	Norm. Growth	Log Growth
	(1)	(2)	(3)	(4)	(5)
US Tariff Threat	2.511** (0.201)	0.921** (0.080)	1.770** (0.275)	0.159** (0.034)	0.094 <sup>a</sup> (0.048)
EU Tariff	0.406* (0.169)	-0.902* (0.417)	0.300 (1.071)	-0.010 (0.327)	-0.327 (0.405)
EU Quota '02	1.157* (0.040)	0.146** (0.034)	0.920** (0.144)	0.090** (0.017)	0.082** (0.023)
EU Quota '05	2.115** (0.148)	0.749** (0.070)	1.234** (0.210)	0.691** (0.039)	0.683** (0.060)
Observations	341,814		44,038	284,134	204,837
R-squared	0.177		0.364	0.056	0.010
Fixed effects	$Jn, t$		$J, St$	$Jn, nt, St$	$Jn, nt, St$

*Note:* Table shows estimates based on alternative specifications. Columns (1) and (2) show results of a logistic regression. Column (3) considers the number of EU-15 destinations served by China. The last two columns compare the normalized (4) and the log-growth rate (5) of Chinese to the EU-15 over time. Fixed effects:  $Jn$ =product-destination,  $nt$ =destination-year,  $St$ =sector-year. Standard errors in parentheses; significance: <sup>a</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ .

on the odds ratio. As expected, tariffs reduce the probability of exporting to the EU, whereas the removal of other trade barriers reveals positive and statistically significant effects. Because the logistic regressions were not able to include a complex fixed effects structure, column (3) considers an alternative specification. The dependent variable corresponds to the number of EU destinations to which China exports good  $J$ . This reduces the dimension of the panel to have variation across products over time. The result confirms that products with a high US tariff threat before China's WTO entry were exported to more destinations after the removal of the threat. The same is found for the removal of import quotas on T&C products. Columns (4) and (5) consider a third test against adjustments at the extensive margin. They report the estimated effect on the annual growth rate of Chinese exports in a particular product destination pair. Column (5) uses the log-difference as a measure of the growth rate. By construction, it is confined to report patterns at the intensive margin, because it cannot be computed when trade was zero at the beginning or at the end of the period under consideration. The effect of the US policy change is only marginally significant in statistical terms.

In contrast, column (4) uses the normalized growth rate (Davis et al., 1998; Pierce and Schott, 2013). It takes into account entry and exit in export markets by taking its bound values  $g^N \in [-2, 2]$ . The rate is defined as

$$g^N \equiv \frac{R_t - R_{t-1}}{0.5(R_t + R_{t-1})}$$

If this growth rate is considered, the removal of US tariff uncertainty reveals a positive and statistically significant effect. This result confirms that the US policy change encouraged Chinese exporters to establish new trade relationships with EU countries.

### 3.5.2 Further Results

The main findings could not reject either proposition made at the end of Section 3.3. This subsection attempts to provide further results that support the mechanism emphasized throughout this paper.

#### US Share in Chinese Exports

A main concern could be that the US policy change operates through a different mechanism than the redistribution of a global fixed costs burden. The problem is that such costs cannot be observed. To provide further (suggestive) evidence, the proposed allocation rule for  $\theta_{Jn}$  will be addressed. The interpretation was that the US policy change invoked the allocation of a larger fraction of  $f_J$  to the US so that EU markets become easier to penetrate. This fraction is assumed to be proportional to the share of the partial bilateral profit in total export profits. To analyze this, the explanatory variable  $GAP_J^{US}$  is replaced by the fraction of China's total exports of product  $J$  that is shipped to the US before and after WTO entry.

The variable is constructed by calculating the average  $s_{J,US} = R_{J,US}/R_J \approx \theta_{J,US}$ , respectively for two periods 1992-2000 and 2002-2009. For the first period it yields  $\bar{s}_{J,US}^{pre}$ , the fraction of exports of  $J$  shipped to the US before China's WTO entry. For the second period  $\bar{s}_{J,US}^{post}$  denotes the fraction of exports of  $J$  shipped to the US after China's WTO entry. In order to capture the change of this fraction the difference  $\Delta \bar{s}_J^{US} = \bar{s}_{J,US}^{post} - \bar{s}_{J,US}^{pre}$  is used to replace  $GAP_J$  in Equation (3.14). A positive  $\Delta \bar{s}_J^{US}$  suggests that China exports more of good  $J$  to the US compared to the years before its WTO membership. This implies that a larger fraction of the global fixed cost burden

is covered through this trade relationship.

Table 3.4: Chinese Exports to the EU-15 and the Role of Trade with the US; Alternative Estimators, 1995-2005

	Baseline	Logit		Linear Regressions		
	Levels	Odd Ratio	Coeff.	# Dest.	Norm. vs.	Log Growth
	(1)	(2)	(3)	(4)	(5)	(6)
US Share	0.789** (0.090)	3.371** (0.293)	1.215** (0.087)	2.073** (0.348)	0.030 (0.037)	0.039 (0.058)
EU Tariff	-0.073 (0.420)	0.429* (0.180)	-0.847* (0.419)	0.403 (1.068)	-0.000 (0.327)	-0.328 (0.406)
EU Quota '02	0.595** (0.034)	1.222** (0.040)	0.201** (0.033)	1.029** (0.142)	0.106** (0.016)	0.091** (0.023)
EU Quota '05	0.448** (0.050)	2.102** (0.147)	0.743** (0.070)	1.228** (0.213)	0.694** (0.039)	0.685** (0.060)
Observations	267,870	337,711		43,307	281,203	202,702
R-squared	0.173	0.183		0.374	0.056	0.010
Fixed effects	$Jn, nt, St$	$Jn, t$		$J, St$	$Jn, nt, St$	$Jn, nt, St$

*Note:* Table shows estimates based on Eq. (3.14), but with a different treatment variable instead of  $GAP$ . Fixed effects:  $Jn$ =product-destination,  $nt$ =destination-year,  $St$ =sector-year. Robust standard errors in parentheses; significance: <sup>a</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ .

The results are presented in Table 3.4. Column (1) is analogous to the third column of Table 3.2. The estimated coefficients for EU tariffs and the quota removals are qualitatively and quantitatively unchanged. The coefficient obtained for the US share in Chinese exports is positive and statistically significant. Moreover, it exceeds that obtained from the original specification. An explanation could be that  $\Delta \bar{s}_J^{US}$  can take negative values allowing it to better describe the conditions of Chinese exporters willing to export to the EU. Related to this, the removal of US tariff uncertainty does not explain the entire pattern of Chinese exports to the US, so that  $\Delta \bar{s}_J^{US}$  provides a more complete assessment of the theoretical model. The remaining columns are analogous to Table 3.3. Except for columns (5) and (6) the previous results are confirmed. Together this analysis suggests that Chinese exporters benefit from selling much of their exports in the US. This supports the hypothesis of an existing global fixed cost burden and the associated economies of scale.

### Dynamic Adjustments and Transitional Growth

So far, the analysis has concentrated on the years immediately after China's WTO accession. Available trade and tariff data allows an extension of the analysis up to the year 2012 so that the effect can be studied over a longer period. Re-estimating Equation (3.14) for the years 1995 up to 2012, using  $GAP_J^{US}$  and taking into account the removal of import quotas, produces a coefficient  $\hat{b}_1 = 0.691$  (see Table 3.5). This is larger and statistically different from that obtained for the baseline period shown in Column (3) of Table 3.2. One explanation could be that the US policy change interacts with a dynamic component. While Section 3.3 considers comparative statics, it is possible that firms gradually increase their production capacities and exploit their full cost advantage with a delay. A complementary explanation would be that some firms start to export only when they observe the success of other firms (e.g. Hausmann and Rodrik, 2003). Following these arguments, a dynamic specification should eliminate the positive correlation between  $b_1$  and the length of the post WTO-entry period.

Including a lagged endogenous variable  $\ln R_{Jnt-1}$  on the right-hand side of the estimation equation often creates problems due to correlated errors and biased coefficients. However, biased coefficients can be controlled by inferring the upper and lower bounds of the true coefficient of  $\ln R_{Jnt-1}$ . It should lie between the estimate obtained from a dynamic pooled OLS (POLS) and a dynamic fixed effects (FE) model (Roodman, 2009). In the latter case, the effect of the lagged endogenous variable is underestimated. This implies that it picks up some but not all of the dynamics that were induced by the US policy change.

The left panel of Table 3.5 shows the results for the full 1995-2012 period, for each of the three specifications considered: baseline in column (1), dynamic FE in column (2), and dynamic POLS in column (3). The POLS model generates a higher coefficient for the lagged endogenous variable than the FE model. In the two dynamic specifications, the removal of the US tariff threat reveals a lower coefficient for  $GAP$  than in the baseline. However, the POLS model produces unplausible results for the effect of EU tariffs, and also the effects of the removal of quotas in the EU become fragile. It seems that the FE model in column (2) produces more plausible results overall.<sup>16</sup>

<sup>16</sup> Assuming that the baseline specification in column (1) represents the long-run effect of the policy spillover, the estimate must be compared to  $b_1^{long} = b_1/(1 - \gamma)$ , where  $\gamma$  denotes the coefficient for the lagged endogenous variable. For columns (2) and (3), the implied long-run effect is 0.543 and 1.320, respectively.

Table 3.5: Chinese Exports to the EU-15 after the Removal of US Tariff Uncertainty; Static and Dynamic Effects, 1995-2012

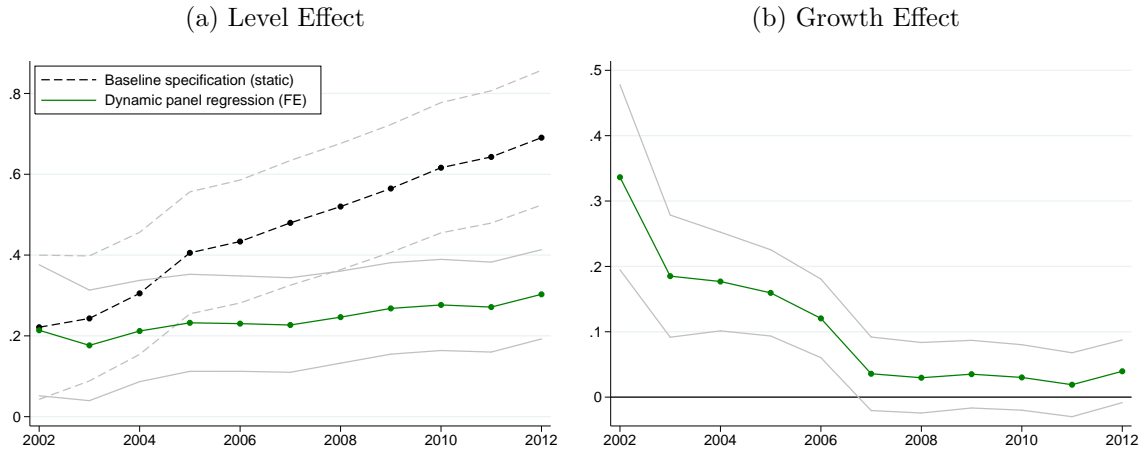
	Levels 1995–2012			Growth 1995–T		
	Baseline (1)	FE (2)	POLS (3)	$T = 2002$ (4)	$T = 2006$ (5)	$T = 2010$ (6)
US Tariff Threat	0.691** (0.085)	0.303** (0.056)	0.231** (0.023)	0.336** (0.072)	0.120** (0.031)	0.030 (0.026)
EU Tariff	-3.050** (0.420)	-2.024** (0.312)	0.867** (0.110)	-0.056 (0.397)	-0.205 (0.319)	-0.005 (0.270)
EU Quota '02	0.391** (0.038)	0.176** (0.026)	0.017 (0.013)	0.287** (0.035)	0.068** (0.016)	0.068** (0.014)
EU Quota '05	0.484** (0.046)	0.352** (0.032)	0.035* (0.017)		0.396** (0.026)	0.241** (0.016)
EU Quota '09	0.870** (0.071)	0.514** (0.041)	0.188** (0.028)			0.046 (0.029)
Lagged Exports		0.442** (0.003)	0.825** (0.001)			
Observations	508,433	414,950	414,154	182,946	321,436	472,600
R-squared	0.313	0.474	0.746	0.045	0.078	0.116
Fixed effects	$Jn, nt, St$	$Jn, nt, St$	$nt, St$	$Jn, nt, St$	$Jn, nt, St$	$Jn, nt, St$

*Note:* Table shows estimates from alternative specifications. Columns (1) through (3) compare the baseline specification to dynamic panel estimates providing lower and upper bounds of the coefficient for lagged exports (shown in the last row). Columns (4) through (6) analyze the transitional growth effect of  $GAP_{J,99}^{U,S}$  by comparing periods of different length after the policy change. Abbreviations represent fixed effects model (FE), pooled OLS (POLS), and the last year observed in the sample for which results are shown ( $T$ ). Fixed effects:  $Jn$ =product-destination,  $nt$ =destination-year,  $St$ =sector-year. Standard errors in parentheses; significance: <sup>a</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ .

Figure 3.6 presents the point estimates of the effect of  $GAP_J^{US}$  graphically. In Panel (a) it shows results analogous to columns (1) and (2) of Table 3.5 where the sample period was expanded stepwise ( $T = 2002, \dots, 2012$ ). The dashed line shows how the baseline specification produces higher coefficients  $\hat{b}_1$  as the period gets longer. The immediate effect for  $T = 2002$  is  $\hat{b}_1^{02} = 0.214$ . In the dynamic FE model the immediate effect is the same and remains within the confidence intervals of any other period length. This is indicated by the solid line in Panel (a) where  $\hat{b}_1$  still increases over time but remains statistically the same. Together with  $k = 4.854$   $\hat{b}_1^{02} = 0.214$  implies that  $\hat{\sigma} \approx 5$ . This estimate is still plausible given that estimates vary considerably across countries (Imbs and Méjean, 2010).

The right panels of Table 3.5 and Figure 3.6 analyze the evolution of the growth rate.

Figure 3.6: Evolution of the US Policy Effect on Chinese Exports to the EU; 2002-2012



*Note:* Figure shows estimated effects of  $GAP_j^{US}$  on the level (Panel a) and normalized growth rate (Panel b) of Chinese exports to the EU-15 as obtained from varying period length 1995- $T$  ( $T = 2002, \dots, 2012$ ). All regressions include product-country, sector-year, and country-year effects.

As was shown in column (4) of Table 3.3, the average annual growth rate of products exposed to high uncertainty increased after China's WTO entry. If this effect was due to the policy change, it should disappear as the year of the WTO accession moves further into the past. Columns (3) to (6) show econometric results for the normalized growth rate. In the first year of China's WTO membership, the estimated coefficient is between 2.5 and 3 times larger than that of the years up to 2006. The last column shows that growth rates do not differ when the period is extended up until 2010. Panel (b) of Figure 3.6 shows how the effect phases out and disappears after 2006. Together, the results presented in this subsection suggest that the analyzed effects reflect a spillover from a change in US policies towards China on the performance of Chinese exports to the EU. Moreover, the analysis of the fraction of China's exports shipped to the US supports the assumption of a global fixed cost component.

### 3.6 Conclusion

The paper analyzed a potential source of China's export boom to the EU. In contrast to the US, where China benefited from the establishment of permanent normal trade relations, EU trade policies remained largely unchanged upon China's accession to the

WTO. A transmission channel is proposed through which the change in the US trade policy affected China's trade performance at a more general level. It emphasizes the existence of a global fixed cost component which Chinese exporters must cover before they start exporting. This component can be distributed across sources of revenues, so that a firm entering the US market will find it easier to export also to the EU. The predictions of the model were confirmed empirically using product-level data at the disaggregated HS6 level. Chinese exports to the EU are about 12 percent higher for goods that were exposed to US tariff uncertainty before WTO entry. In line with the theoretical model, adjustments at the extensive margin could be verified. An analysis of how the effect of the US policy spillover evolves over time suggested that it levels out after a few years.

The findings of this paper bear important implications for the scope of international policy negotiations, as well as for their impact on third countries. To the extent that details about negotiations remain unobserved they may expose firms to unexpected competitive shocks. A closer analysis of the consequences is a possible direction of future research. The paper also presented supportive evidence that exporters face both destination specific and global fixed costs. This complements findings presented by Hanson and Xiang (2011) for services exports, but raises the question as to how this conforms to stylized patterns observed in manufacturing firm-level datasets. Characteristics of the production processes (i.e. standardized vs. differentiated goods) might be one explanation worth pursuing further. A final result revealed in this paper relates to the estimation of model parameters. The estimated effect of the US policy spillover appeared to be correlated with the length of the sample period. A dynamic specification was able to produce more robust quantitative results. With regard to estimating certain parameters of a model, neglect of underlying dynamic processes may lead to serious biases and misinterpretations of the importance of economic variables.



# Chapter 4

## FOREIGN COMPETITION AND QUALITY SORTING?: OVERLAPS IN US AND CHINESE EXPORTS

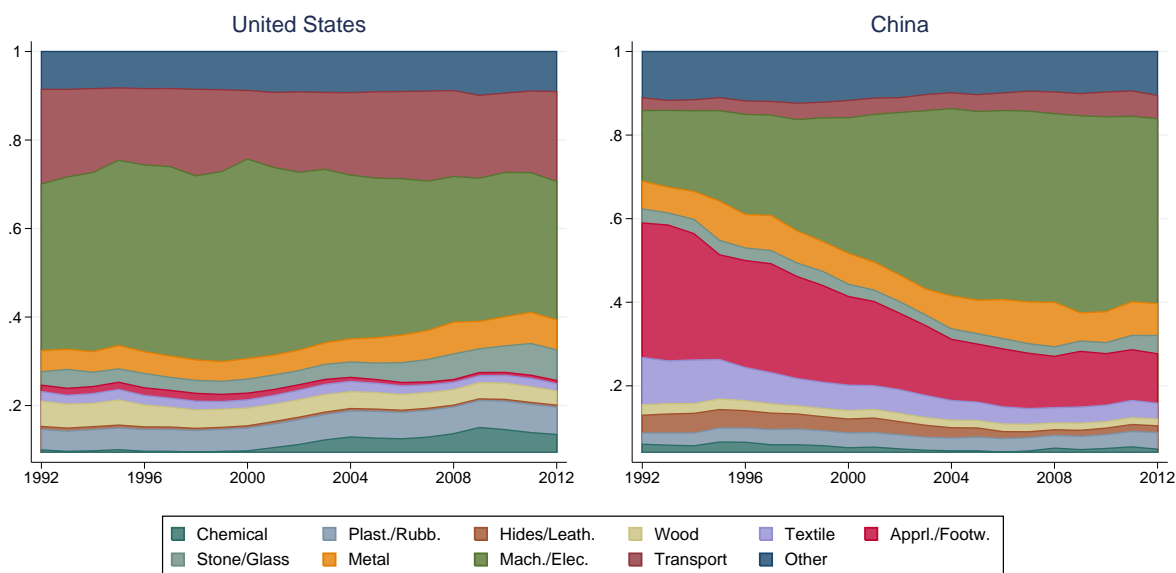
**Abstract:** The paper analyzes US export unit values conditional on Chinese presence in narrow product-destination markets. Particular focus lies on the distinction of price and quality competition. In contrast to popular conjectures that high-income countries generally improve the quality of their goods in response to low-wage competition, the paper finds that unit values are usually lower when China penetrates US export markets. Aggregate effects appear to be small but accounting for product heterogeneity reveals large effects among individual products. These constitute up to 16 percent of total US manufacturing exports. The duration of export overlaps and China's import market share affect the detection rate and the size of statistically significant coefficients. Most of the affected goods account for a relatively large share in US exports. Overlaps in EU import markets confirm the general patterns and suggest that US exports switch to non-exposed but similar products. In line with the literature on low-wage import competition, it appears that low-wage export competition triggers structural adjustments.

### 4.1 Introduction

Recent decades have witnessed the integration of China into the global economy. Through exploitation of its labor cost advantage it has been able to access new markets and con-

test the positions of incumbent firms. Numerous studies document firms' adjustments to low-wage import competition in high income regions (e.g. Bernard et al., 2006; Bloom et al., 2011; Utar, 2014). Others have focused on export competition between China and other low-wage countries (Greenaway et al., 2008; Mattoo et al., 2012; Utar and Torres Ruiz, 2013). Although the structure of China's exports is increasingly similar to that of advanced economies (Rodrik, 2006), the effects of its expansion into high-income countries' export markets are essentially unstudied. To highlight this similarity Figure 4.1 depicts the sectoral structure of US and Chinese exports to the rest of the world over the years 1992-2012. It shows that China's textiles and apparel exports contract relative to a growing machinery and electronics industry. It expands into the largest sector of US exports. Machinery and electronics products account for about 35 percent of total US manufacturing exports in 2012. The fraction for China doubled from 20 to 40 percent within two decades. More detailed data reveals an increasing number of overlapping trade relationships at the product-destination level. These developments raise questions as to how high-income countries respond to China's export performance.

Figure 4.1: Sectoral Structure of US and Chinese Manufacturing Exports to the Rest of the World; 1992-2012



*Note:* Author's calculations based on UN Comtrade and US export data (Schott, 2008). The US data accessed via [http://faculty.som.yale.edu/peterschott/sub\\_international.htm](http://faculty.som.yale.edu/peterschott/sub_international.htm).

The coexistence of low- and high-income country exports within product-destination markets has been noticed before. As a general pattern, Schott (2004) suggests that countries produce imperfect substitutes, allowing high-income countries to continue exporting despite higher prices. Although this rationale holds for cross-sectional observations, less is known about the patterns within a destination market that is suddenly exposed to low-wage competition. Related to this question, Martin and Méjean (2014) analyze the evolution of product quality. They find that increased low-wage and Chinese export competition contributed significantly to an overall observed increase of product quality among French exporters. A quality index, however, captures only one dimension of a firm's reaction to competition. It neglects the possibilities of cutting prices or switching to less exposed products. Such strategies were revealed in studies on import competition, and they should be relevant also for exports. Regarding their applicability, empirical evidence suggests that goods have intrinsically different scopes for quality differentiation (Khandelwal, 2010; Johnson, 2012). In particular, Khandelwal (2010) notes that low-wage competition prevails in industries where the potential for product upgrades is relatively low.

To explore this issue, the paper regresses the log of US export unit values on measures of Chinese presence within narrow product-destination pairs over a period of 13 years (1994-2006). The main focus is put on inferring the mode of competition; i.e. quality versus cost competition. It is identified through the sign of the coefficient regressions produce for the measure of Chinese market presence. The analysis also accounts for product heterogeneity. This is done by analyzing US export unit values separately for each of about 3,000 manufacturing products. The approach allows for comparison with unit value patterns obtained for other economic variables. Baldwin and Harrigan (2011) provide evidence that, on average, US exports have higher unit values in distant destinations. Similar patterns are described by Johnson (2012) and Baldwin and Ito (2011), who highlight substantial product heterogeneity, although quality competition dominates. Their approaches differ, in that the latter focus on the effect of bilateral distances, whereas Johnson (2012) infers variation in the productivity thresholds firms must surpass to earn positive profits. Empirical studies by Kamin et al. (2006) and Broda and Weinstein (2010) suggest that increasing Chinese market penetration is associated with a decline of its overall price level. In the context of the quality heterogeneous firms (QHF) model emphasized by Baldwin and Harrigan (2011) and Johnson (2012), it implies that firms are confronted with lower profits as consumers re-allocate parts of

their expenditures to Chinese products. This forces incumbent firms to exit the market. Other theories allow firms to adjust by cutting down their mark-ups, or by switching to other products (e.g. Mayer et al., 2014).

The results presented in this paper find that cost competition dominates both in pooled and in product-by-product estimations. The detection of statistically significant effects for individual goods is higher when China penetrates a market for at least three consecutive years, or when it captures a relatively high import market share. Inspecting the role that affected goods play in US exports suggests that larger coefficients are obtained for less important products. Nevertheless, the share of most of the affected goods in total US manufacturing exports is above that of the median product. The results contrast with unit-value patterns described in previous studies that found prevalence of quality competition. An explanation could be that Chinese market penetration affects only a fraction of the goods the US exports. Products revealing statistically significant coefficients for Chinese market presence represent about 16 percent of total US manufacturing exports. The number of goods revealing significant correlations with bilateral distances is more than twice as large. The analysis reveals further that it is mostly the machinery and electronics industry which is affected. The respective products cover about 8 percent of total US manufacturing exports. Focusing on overlaps within EU countries confirms the baseline results. It also reveals negative effects on the value of US exports relative to non-exposed products. This indicates that structural adjustments take place. Overall, the results suggest that Chinese market presence imposes price pressures on US exporters. Quality upgrading does not appear to be the dominant response strategy. The findings complement existing studies by revealing a new margin of the challenges firms face under low-wage competition.

The paper is structured as follows. Section 4.2 summarizes the theoretical background which motivates the inference of export unit values to distinguish quality from price competition. Section 4.3 presents the empirical framework and discusses the estimation strategies based on the data and on the possibility of product heterogeneity. Section 4.4 describes stylized patterns of the expansion of China's exports into the US market and presents the empirical results. Section 4.5 concludes.

## 4.2 Theoretical Background

### 4.2.1 Classical Theory, Unit Values, and Quality

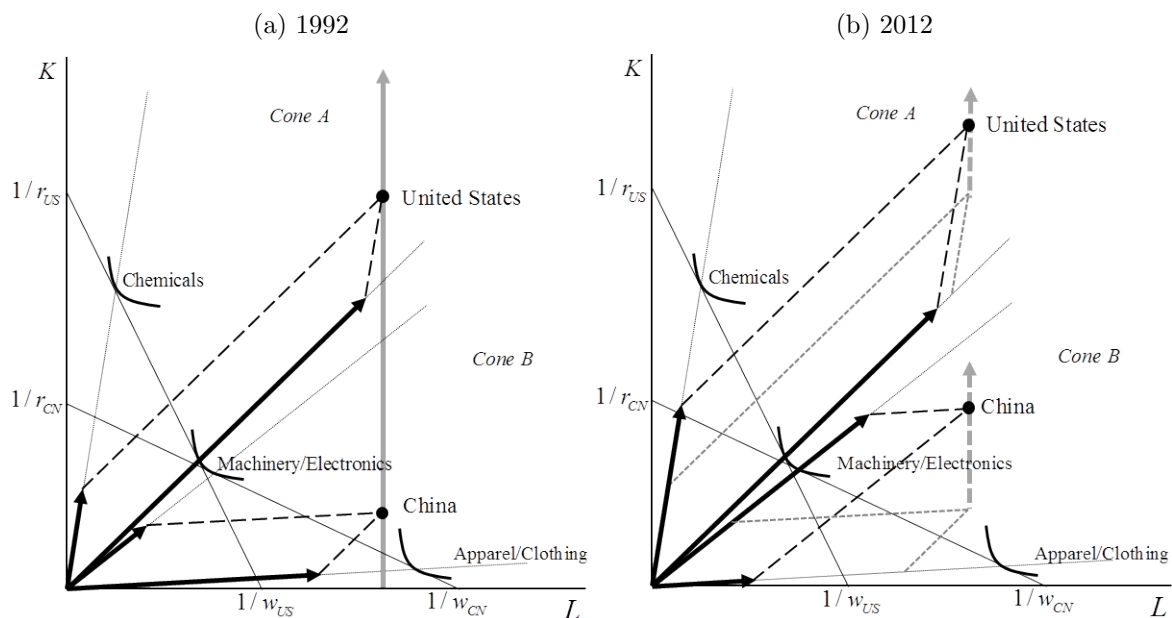
Following similar expositions of Bernard et al. (2006) and Schott (2008), the evolution of Chinese and US exports can be sketched in a classical Heckscher-Ohlin (HO) framework. The Lerner (1952) diagrams shown in Figure 4.2 denote the situations as observed in 1992 and 2012, respectively in Panels (a) and (b). The sectoral production structures in China and in the US are indicated by the lengths of their respective production vectors. They are obtained from the parallelograms confined by the endowment points and the origin. The Figures show how, holding labor ( $L$ ) constant, accumulation of capital ( $K$ ) induces China to decrease its share in “Apparel/Clothing” and to increase the share in more capital-intensive “Machinery/Electronics”. Meanwhile, the US increases production of goods in the “Chemicals” industry. Because recent economic growth rates in China were higher than in the US, their production structures have become more similar. Yet, the two countries reside in different cones of diversification so that they produce the overlapping goods with different capital intensity.<sup>1</sup>

The diagrams are not able to rationalize patterns of disaggregated data and for trade with multiple countries. If competition was perfect, China and the US could not sell the same good to the same destination. Schott (2004) rejected this hypothesis based on a similar representation and found that income per capita levels and export unit values are positively correlated within product categories. He concludes that, to produce any given good, rich countries use capital more intensively than poor countries so that the former offer a better quality of the good. This rationale should be applicable also to Figure 4.2, where China and the US partly export the same goods, but the latter offers a better quality.<sup>2</sup> While Schott (2008) shows that Chinese exports have typically lower unit values than exports of high-income OECD countries, the question this paper addresses

<sup>1</sup>As drawn here, the cones of diversification reflect technology differences between China and the US. Extensions of the Lerner diagrams, including more than two goods and countries, were investigated by (Deardorff, 1994).

<sup>2</sup>The consideration of unit values as a proxy for quality has been criticized and attempts were made to generate improved measures (e.g. Hallak, 2006; Khandelwal, 2010; Hallak and Schott, 2011). However, a recent study by Feenstra and Romalis (2014) finds that most of the variation of export unit values can be explained by quality differences. Generally, the present paper differs from other product-level studies as it focuses on unit values within markets over time rather than considering cross-country patterns where the potential of confounding factors is probably larger.

Figure 4.2: Sectoral Transition in a Lerner Diagram



Note: Author's compilation.

is whether export unit values change when China enters a US export market. To obtain guidance for the analysis of this question, a formal framework shall be considered.

## 4.2.2 Micro Foundations and Unit Value Patterns

The derivation of an empirical framework focuses on the analysis of export unit values. Unit value patterns have been analyzed in QHF models where firms are selected into exporting based on their individual productivity levels (e.g. Baldwin and Harrigan, 2011; Johnson, 2012). Although alternative frameworks allow for different mechanisms of adjustment at the firm level, predictions for product-level export unit values remain unaltered.<sup>3</sup> The quality differentials highlighted by Schott (2004) and subsequent work justify the consideration of monopolistic firms. In the standard QHF setup, they produce a single variety  $j$  and sell to consumers that care about both quantity,  $x_j$ , and quality,  $q_j$ .

The utility function suggests that consumers want to purchase some of each available

<sup>3</sup>See, for instance, Mayer et al. (2014) for an analysis with endogenous mark-ups and multi-product firms.

variety  $j$  of a good  $z$ ; i.e.  $j \in \Omega_z$

$$U_z = \left[ \int_{j \in \Omega_z} (\tilde{x}_j)^{(\sigma_z-1)/\sigma_z} dj \right]^{\sigma_z/(\sigma_z-1)}; \sigma_z > 1 \forall z. \quad (4.1)$$

The variable  $\tilde{x}_j \equiv x_j \cdot q_j$  denotes consumption of a quality-adjusted unit of variety  $j$ . It implies a quality-quantity trade-off. Consumers demand less, if the price is high or if quality is low. Their purchasing decision is based on the quality-adjusted price  $\tilde{p}_j \equiv p_j/q_j$ .

Only the nominal price is observable, but inference of average prices  $\bar{p}_z \equiv UV(z)$  in two scenarios is sufficient to identify the mode of competition. To do this, it is established that a higher product quality demands higher unit costs of production (Baldwin and Harrigan, 2011).<sup>4</sup> Unit costs  $c = (q/a)$  depend on the quality of the output and on the firm-specific ability parameter,  $a_j$ . Quality itself is governed by the ability a firm draws from a cumulative distribution function (CDF),  $G(a)$ , with support  $[a_L, a_H]$ :  $q_j = a_j^\theta$ . This implies that  $c = a_j^{\theta-1}$ . The monopolistic pricing rule implies a constant mark-up  $\bar{m} = [\sigma_z/(\sigma_z - 1)]$  over unit production costs. The price firm  $j$  offers is given by

$$p_j = \bar{m}c_j = \bar{m}a_j^{\theta-1}. \quad (4.2)$$

Equation (4.2) describes the mechanism at the core of QHF models. Without quality differentiation, i.e. if  $\theta = 0$ , the most capable firm charges the lowest price ( $\partial p/\partial a < 0$ ). This represents the standard view, where the lowest-cost producer has the strongest position in the market. As long as  $\theta < 1$  price-cost competition prevails because quality is inelastic to firm ability. As soon as  $\theta > 1$ , the relationship is reversed, and the most capable firm charges the highest price ( $\partial p/\partial a > 0$ ). In that case quality competition prevails.

The QHF framework belongs to a family of models where exporting requires firms to pay a fixed cost (Melitz, 2003). This implies that only the most profitable firms will export. The zero-profit cut-off (ZPC) ability  $a^*(z)$  identifies the firm that is indifferent between exporting and not-exporting. Among exporters, Johnson (2012) notes that

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<sup>4</sup>This can be justified by arguing that production becomes more skill-intensive or that more expensive input materials are used. Kugler and Verhoogen (2012) present evidence from Colombian firm-level data that suggests that prices (and hence quality) increase when more costly inputs are chosen. Manova and Zhang (2012) relate export unit values of Chinese firms to the number of foreign partners that these firms source their inputs from. A greater variety of sources implies variety in input costs and a broader quality portfolio of the firms; including also high-quality varieties.

firms can be ranked in increasing order of their ability,  $a^*(z) < \dots < a_H(z)$ . This holds as long as  $\theta_z$  is the same for all  $j \in \Omega_z$ . Assuming that  $\theta_z > 1$  yields an analogous ranking of prices,  $p(a_z^*) < \dots < p(a_z^H)$ . It implies that the marginal exporter offers the lowest price and the lowest quality. Moreover, it implies that an increase of the ZPC ability  $a^*(z)$  increases the average price observed for product  $z$ . The export unit value can be expressed as the weighted average of the prices individual exporters charge:

$$UV(z) = \int_{a^*}^{a_H} \alpha_a p_a da; \quad 0 < \alpha_a < 1 \quad (4.3)$$

The intuition behind Equation (4.3) is that the export unit value for good  $z$  changes with the ZPC ability. An increase of  $a^*$  suggests that fewer firms export, whereas a lower  $a^*$  allows additional firms to start exporting.

Given Equation (4.3), the question is how  $a^*$  is affected by the presence of Chinese exporters. This can be inferred through the solution of the ZPC:

$$a_{zd}^* = \left( \frac{\sigma_z}{\sigma_z - 1} \right) \frac{\tau_{zd}}{\tilde{P}_{zd}} \left( \frac{\sigma_z f_{zd}}{E_{zd}} \right)^{1/(\sigma_z - 1)} \Rightarrow UV_{zd} = F(a_{zd}^*). \quad (4.4)$$

It incorporates the full set of variables and parameters of the QHF model.  $a_{zd}^*$  depends on total expenditures on  $z$  in the destination market,  $E$ , the quality-adjusted price level,  $\tilde{P}$ , on fixed and variable trade costs,  $f$  and  $\tau$ , and on the elasticity of substitution,  $\sigma > 1$ . Assuming that Chinese market entry lowers the price level of  $z$  in destination  $d$  (Kamin et al., 2006; Broda and Weinstein, 2010) implies that  $a_{zd}^*$  rises. With  $\theta_z > 1$ , fewer US firms export higher quality products at a higher average price. Whenever  $\theta_z < 1$ , the prediction on US export unit values is reversed.

### 4.3 Empirical Framework

Previous studies suggest that  $\theta_z > 1$  for most products. They evaluated export unit values conditional on exporters' distance from their destination (Baldwin and Harrigan, 2011; Baldwin and Ito, 2011) or on variation in ZPC thresholds (Johnson, 2012). The analysis in this paper seeks to identify the dominant pattern for Chinese market presence. The empirical specification corresponds to the log of Equation (4.4) and replacing  $a^*$  by  $UV$ :

$$\ln uv_{zdt} = \phi_{zd} + \phi_{zt} + \gamma' \mathbf{X}_{dt} + \delta C N_{zdt} + \varepsilon_{zdt}. \quad (4.5)$$

It denotes an estimation equation for panel data analysis. The parameter  $\delta$  will indicate the correlation of US export unit values with Chinese presence,  $CN_{zdt}$ , within a product-destination market. In the baseline specification,  $CN_{zdt}$  is defined as a binary variable. It equals one when China is present and zero when absent. Alternative definitions will be used for robustness checks.<sup>5</sup> Also, concerns regarding the identification of an effect of Chinese presence on US export unit values will be addressed. The equation, as stated here, does not rule out the possibility that the specification estimates the entry conditions for Chinese exporters. The vector  $\mathbf{X}_{dt}$  describes time-varying country characteristics, i.e. price levels, market size, and trade costs. The paper follows Baldwin and Harrigan (2011) and includes the logs of real GDP per capita, total real GDP, and remoteness. The latter captures the multilateral trade resistance of a destination (Anderson and van Wincoop, 2003). It is computed as  $R_{dt} = [\sum_k GDP_{dt}/distance_{dk}]^{-1}$ , where  $k = 1, \dots, K$  denotes the respective partner countries.

Equation (4.5) includes two types of fixed effects.  $\phi_{zd}$  controls for time-invariant unobserved characteristics of the product-destination market. It includes the distance between the US and the destination country, but also fundamental production and preference structures that govern  $d$ 's import demand for good  $z$ . Moreover, it accounts for the average probability of observing Chinese exports to this destination. The other fixed-effect,  $\phi_{zt}$ , absorbs unobserved product-specific variation over time. This is important because the circumstances of the world market to which both countries are exposed are not explicitly controlled for. Hence,  $\phi_{zt}$  accounts for changes in product-specific input prices, its generic characteristics, or industrial policies in the US and China. It also controls for the extent to which the US economy faces import competition, or the propensity that production of this good is outsourced to other countries.

### 4.3.1 Data

The empirical analysis uses data from two major sources. The UN Comtrade database provides information on countries' bilateral imports of products at the 6-digit level of the Harmonized System nomenclature (HS6). The sample used in this paper starts in 1994 because the number of reporting countries is small in the early 1990s. HS6

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<sup>5</sup>The main reason why import market shares are not used in the baseline is that the data reveals mostly variation at the extensive margin. That is, there is a sizeable amount of observations with  $CN_{zdt} = 0$ , which corresponds to zero import market shares. A distinction of market shares in cases where  $CN_{zdt} = 1$  results in a much lower variation than for the binary measure (see below).

codes are converted to the 1988/1992 HS revision in order to track products over time.<sup>6</sup> The second source uses US export data from Feenstra et al. (2002). Later versions of this data cover the years up to 2006. It is used to calculate US export unit values. The advantage of this data is that it reports f.a.s. (free alongside ship) values. These are closer to firms' production values than the c.i.f. (cost, insurance, freight) values reported by importing countries in the Comtrade data. Moreover, it distinguishes goods at the 10-digit level, and provides information on measurement units of the quantities exported. This allows more precise calculations of export unit values. To minimize measurement error, products with differential unit measures across years or destinations were removed from the sample, unless they were convertible.<sup>7</sup> The US and the Comtrade datasets are merged at the 6-digit level after aggregating US export unit values.

The final sample encompasses manufacturing products comprised in HS Chapters 28 through 96. To focus on stable US trade relationships, only observations where US product-destination flows were not interrupted are considered. That is, every product-destination pair in the dataset has exactly 13 observations. The final dataset has 511,654 observations. It covers 2,923 HS6 manufacturing products shipped to up to 63 destinations. The sample represents about 41 percent of total US manufacturing exports in each year.<sup>8</sup> Data for the control variables stems from the World Development Indicators (WDI) database and from the CEPII Gravity dataset.

### 4.3.2 Estimating a Pooled Sample

The estimation in a pooled sample allows comparison of the results to those of Baldwin and Harrigan (2011). It assumes that all products have the same mode of competition, i.e.  $\delta_z = \delta \forall z$ . If this is not true, the resulting coefficient will indicate the average impact of each variable on the level of US export unit values. Estimating Equation (4.5) entails a technical caveat when it is applied to disaggregated trade data and many destinations. The reason is that the fixed effects require  $Z \times D$  product-destination and  $Z \times T$  product-

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<sup>6</sup>Correspondence files are available at the United Nations Statistics Division (UNSD).

<sup>7</sup>For example, quantity information where units changed from gram to kilogram or from meter to centimeters were converted and remained in the sample. Products with measurement units switching from, for instance, square meters to pieces were removed.

<sup>8</sup>This number is low mainly because the HS6 codes often had mixed unit measures according to the US data. Including product-destination flows with interruption would increase the share slightly to 44 percent and double the number of observations to 1,075,325.

time dummies. This takes standard statistical packages to their computational limits. The hierarchical structure of  $\phi_{zd}$  and  $\phi_{zt}$  does not allow a demeaning of the variables.<sup>9</sup> Labor economists have dealt with similar problems and suggest an algorithm to obtain these fixed effects through iteration (Guimarães and Portugal, 2009). This paper makes use of the iterated fixed effects,  $\bar{D}_{zd}$  and  $\bar{D}_{zt}$ , and includes them into the estimation equation:

$$\ln uv_{zdt} = \gamma' X_{dt} + \delta CN_{zdt} + \rho_1 \bar{D}_{zt} + \rho_2 \bar{D}_{zd} + \varepsilon_{zdt}. \quad (4.6)$$

They replace  $\phi_{zd}$  and  $\phi_{zt}$  and their coefficients must be exactly  $\hat{\rho} = 1$ .

### 4.3.3 Estimating Single Equations

While the pooled sample informs about the average effect of Chinese market presence on US export unit values, estimating the model product-by-product reveals potential panel heterogeneity. It relaxes the assumption that  $\delta_z = \delta \forall z$ . The results can be compared to those of Johnson (2012) and Baldwin and Ito (2011). Single equations take the following form:

$$\ln uv_{dt}^z = \phi_t^z + \phi_d^z + \gamma^z X_{dt}^z + \delta^z CN_{dt}^z + \varepsilon_{dt}^z, \quad (4.7)$$

where the superscripts  $z$  indicate that  $\delta^z \neq \delta^{z'}$  is possible. The problem of high-dimensional fixed effects vanishes because the regression requires only time and destination fixed effects.

## 4.4 Results

### 4.4.1 General Patterns

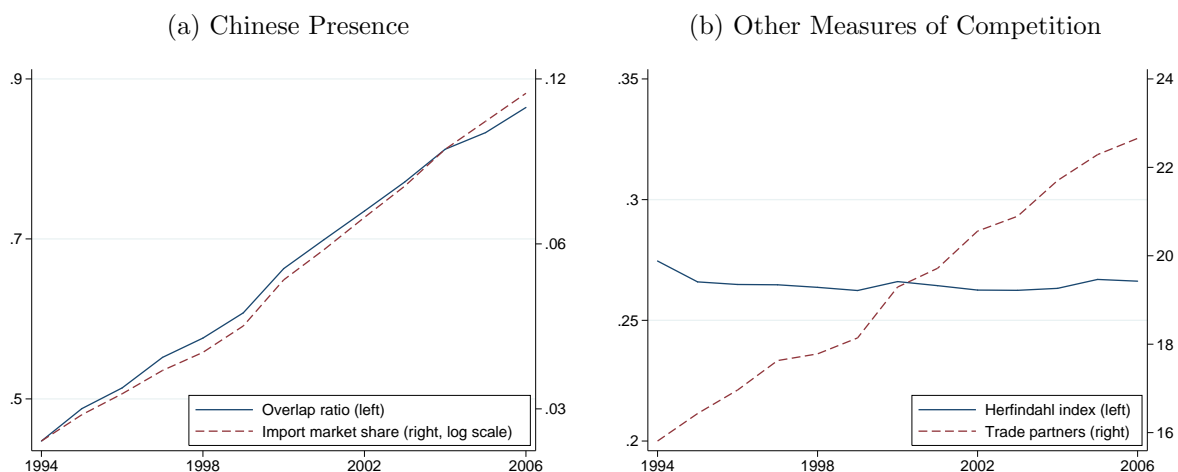
Figure 4.3 shows how the dataset documents China's expansion into US product-destination markets and compares it to other measures characterizing the market environment for US exporters. The solid line in the left panel indicates an increase in the “overlap ratio” (OR). It reflects the aggregate equivalent of the explanatory variable  $CN_{zdt}$  and is computed as the fraction of US product-destination pairs to which

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<sup>9</sup>A hierarchical structure implies that the data is organized in two levels. Observations at the first (individual) level — product-destination pairs — are tied to the second (group) level — the product-time combinations (Abowd et al., 2002).

also China exports, i.e.  $OR_t^{cn,us} = N_t^{cn,us}/N_t^{us}$ . The OR increases from less than 50 percent to almost 90 percent within little more than a decade. The dashed line denotes China's average import market share for the overlapping trade relationships. It increases from 2.6 percent in 1994 to 11.3 in 2006. It suggests that China gradually spread out its exports to almost all markets that are regularly served by the US. The dashed line in the right panel indicates the average number of countries from which a US product-destination sources its goods. The number increased from 16 to about 23 trade partners, while the Herfindahl index within product-destination markets is relatively stable. These and other control variables shall be included to ensure that Chinese presence does not measure other characteristics of the destination market.

Figure 4.3: Characteristics of US Product-Destination Markets; 1994-2006



*Note:* Author's calculations based on data from UN Comtrade and Feenstra et al. (2002).

A more detailed picture of Chinese market penetration is shown in Table 4.1. It documents, for broad manufacturing sectors, average annual changes in the overlap ratio,  $\Delta OR$ , in China's import market share,  $\Delta IMS$ , and the average share of US manufacturing exports exposed to these overlaps,  $Share_{ind}^{US}$ . Only in three sectors the  $OR$  increases by less than three percentage points per year. The changes in market shares are also positive throughout and highlight the expansion of China at both the intensive and extensive margin. The two final columns report average annual changes of US export unit values and their standard deviation. Machinery and electronics is the only industry where unit values decreased. This is where US manufacturing exporters

are most exposed to Chinese market presence. The largest increase of unit values is found in the chemical industry.

Table 4.1: Chinese Presence and US Export Unit Values by Industry, 1994-2006

HS2	Industry	Chinese penetration			US Export UV	
		$\Delta$ OR	$\Delta$ IMS	Share $_{ind}^{US}$	$\Delta$	SD
28-38	Chemicals	0.035	0.005	0.042	0.186	1.020
39-40	Plastics/Rubbers	0.041	0.004	0.024	0.078	0.600
41-43	Hides/Leather	0.008	0.016	0.001	0.034	0.647
44-49	Wood Products	0.037	0.005	0.015	0.040	0.172
50-60	Textiles	0.037	0.008	0.007	0.037	0.153
61-67	Apparel/Footwear	0.014	0.015	0.007	0.051	0.241
68-71	Stone/Glass	0.037	0.008	0.005	0.079	0.319
72-83	Metals	0.041	0.007	0.021	0.023	0.148
84-85	Machinery/Electrical	0.037	0.008	0.125	-0.121	0.729
86-89	Transportation	0.038	0.004	0.022	0.042	0.206
90-96	Other Manufactures	0.024	0.010	0.015	0.052	0.300

*Note:* Author's calculations based on data from UN Comtrade and Feenstra et al. (2002). OR = overlap ratio; IMS = import market share; Share = average penetrated share of total US exports.  $\Delta$  indicates average annual changes of the variable, SD indicates the standard deviation of unit values within products of respective industry and over time. Unit values were normalized to base year 2000 in order to account for different measurement units.

The table suggests that China expands its exports across all sectors. Nevertheless, it seems to produce differential patterns that fit the sectoral transitions described at the beginning of this paper. The next subsections present the results of the econometric analysis to see whether these patterns reflect statistically significant relationships.

#### 4.4.2 Pooled Sample Estimation

The baseline results for the pooled sample are presented in Table 4.2. It shows the estimated coefficients obtained from Equation (4.6). The first two columns illustrate the effect of including product-time effects into the regression. Replacing aggregate time effect by product-time effects raises the explained variation in the data from one percent to almost 13 percent. Surprisingly, the estimated coefficients remain stable, which suggests that product-specific trends are not correlated with the explanatory variables. In columns (1) and (2) Chinese presence is defined as the binary variable described in the previous section. It suggests that US export unit values are about one

percent lower whenever Chinese and US exports coexist in a given product-destination market. The same result is found when Chinese presence is defined more broadly. This is shown in column (3) where Hong Kong re-exports complement the scope of Chinese exports.<sup>10</sup> The identification of re-exports follows through inspection of Hong Kong's imports from China of product  $z$  and re-exports of the same good and in the same year to any destination  $d$ . In column (4) Chinese presence is measured by its import market share in the respective product-destination. The coefficient is statistically insignificant. A potential explanation, relating to the descriptive analysis, is that the variation in import market shares is very low. In early years, about 50 percent of US exports did not face any overlap with China. Import market shares were below 6 percent until 2001, on average.

Table 4.2: US Export Unit Values and Chinese Market Presence; Pooled Sample

	(1)	(2)	(3)	(4)
Measure of Chinese presence	Binary	Binary	Binary HK	Market Share
Chinese presence	-0.014** (0.004)	-0.013** (0.004)	-0.012** (0.004)	-0.033 (0.021)
(log) real GDP per capita	0.504** (0.077)	0.443** (0.067)	0.444** (0.067)	0.456** (0.067)
(log) real GDP	-0.712** (0.091)	-0.684** (0.077)	-0.685** (0.077)	-0.698** (0.077)
(log) Remoteness	-0.285** (0.110)	-0.317** (0.045)	-0.315** (0.045)	-0.316** (0.045)
Time effects	Y	N	N	N
Product-time effects	N	Y	Y	Y
Product-destination effects	Y	Y	Y	Y
# Observations	508,021	508,021	508,021	508,021
# Product-destination	39,358	39,358	39,358	39,358
R-squared (within)	0.009	0.129	0.129	0.129

*Note:* Table shows estimates based on Eq. (4.6), and data from various sources (see text).

Robust standard errors in parentheses are clustered at the product-destination level; significance:

<sup>a</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ .

To see whether the coefficient for Chinese presence is influenced through the presence of other countries, Table 4.3 shows results after including alternative potentially omitted variables. Here, the measure of Chinese presence considers the baseline binary indicator

<sup>10</sup>Feenstra and Hanson (2004) note that large amounts of Chinese exports are shipped via Hong Kong so that trade statistics potentially understate the amount of Chinese goods flowing into their markets.

variable. Columns (1) and (2) include the control variables that were presented in the descriptive analysis: the number of countries exporting to the product-destination at time  $t$  and the Herfindahl index of import market concentration. Both control variables produce the expected signs and are statistically significant. However, the correlation with Chinese presence remains. In columns (3) to (6), the presence and market shares of other low-wage countries (LWCs) and of a set of Asian LWCs and emerging markets is included. The identification of these countries follows Bernard et al. (2006), calculating countries' GDP per worker relative to the United States and defining LWCs as those ranging below a threshold of 5 percent.<sup>11</sup> None of these variables suggest that the negative coefficient for China is driven by an omitted variable. If this were the case, the absolute size of the coefficient would have become smaller and possibly statistically insignificant.

Table 4.3: US Export Unit Values and Chinese Market Presence; Control Variables

	(1)	(2)	(3) Presence		(5) Market Share	
Control variable	#Partners	Herfindahl	LWC	Asia	LWC	Asia
Chinese presence	-0.010*	-0.012**	-0.012**	-0.012**	-0.013**	-0.013**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Market environm.	-0.002**	0.087**	-0.016**	-0.012**	-0.071	-0.047
	(0.000)	(0.013)	(0.004)	(0.004)	(0.045)	(0.043)
(log) real GDPpc	0.451**	0.430**	0.448**	0.445**	0.444**	0.442**
	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)
(log) real GDP	-0.682**	-0.661**	-0.690**	-0.686**	-0.686**	-0.684**
	(0.077)	(0.077)	(0.077)	(0.077)	(0.077)	(0.077)
(log) Remoteness	-0.342**	-0.303**	-0.330**	-0.325**	-0.320**	-0.319**
	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)
# Observations	508,021	508,021	508,021	508,021	508,021	508,021
# Product-dest.	39,358	39,358	39,358	39,358	39,358	39,358
R-squared (within)	0.129	0.129	0.129	0.129	0.129	0.129

*Note:* Table shows estimates based on Eq. (4.6), including additional control variables, and data from various sources (see text). Robust standard errors in parentheses are clustered at the product-destination level; significance: <sup>a</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ . All estimates use product-destination and product-time effects, as described in the text.

Altogether, the results suggest that US export unit values are lower when China

<sup>11</sup>This procedure identifies 44 LWCs. The Asian LWCs are: Bangladesh, Bhutan, Cambodia, India, Indonesia, Laos, Nepal, Philippines, Sri Lanka, and Vietnam.

serves the same market at the same time. This contrasts with the findings of Baldwin and Harrigan (2011) and other studies, which claim that high-income countries generally compete at a quality margin. A possible explanation could be that China does not enter all markets that were encompassed by previous studies. Noting the findings of Khandelwal (2010), entry prevails where the scope for quality upgrading is limited. This point will be inspected in the following subsection. In terms of economic significance, Tables 4.2 and 4.3 suggest that the effects are small, which supports the possibility of product heterogeneity and different modes of competition across products.

### 4.4.3 Product-by-Product Estimates

#### Alternative Definitions of Chinese Presence

The inspection of US export unit values for individual products requires that Equation (4.7) is estimated separately for each HS6 product category. It allows that  $\delta^z \neq \delta^{z'}$  for any  $z \neq z'$ .<sup>12</sup> The analysis continues to measure Chinese presence with a binary variable, but alternative definitions of Chinese market penetration are considered. Table 4.4 shows the percentages of statistically significant correlations among the individual regressions of unit values on Chinese presence. The number of analyzed products varies, depending on which definition is used. This is because panel regressions require observations for several countries where China enters or exits the market.

Except for the panel in the top, each row of Table 4.4 considers an alternative definition of Chinese presence. In the baseline specification, as in the previous section, it is defined as the binary variable that takes a value equal to one whenever an overlap between Chinese and US exports to the given market is observed. The second row uses the same definition but includes the market-specific controls that were also used in the previous subsection.<sup>13</sup> It shows that only about 12 percent of the products reveal a statistically significant coefficient at the 10 percent level. Little more than half of these coefficients are negative. This explains why the pooled estimates produce quantitatively and economically small results: the individual effects cancel out. Their absolute size,

<sup>12</sup>Panel unit heterogeneity has been studied by Pesaran and Smith (1995), who introduced the mean-group estimator. Their procedure, however, is more suitable for application in panel data spanning a longer time period, and encompassing fewer cross-sectional units than the data used here.

<sup>13</sup>That is, within product-destinations, the number of total exporters, the Herfindahl index, and presence of other low-wage countries and Asian low-wage and emerging economies are jointly included into the regression equation.

Table 4.4: US Export Unit Values and Chinese Market Presence; Single Equations

	# HS6	% Detected	%Neg.	$ \hat{\delta} _{p25}$	$ \hat{\delta} _{p50}$	$ \hat{\delta} _{p75}$	$R^2_{p50}$
Baseline Model	2,713	11.7	6.3	0.25	0.38	0.62	0.22
Market controls	2,712	12.5	6.5	0.26	0.42	0.72	0.27
Duration $\geq 3$ years	2,581	15.8	8.8	0.30	0.48	0.72	0.23
$IMS > \bar{IMS}$	2,312	15.6	8.2	0.33	0.52	0.84	0.20
$IMS > 20\%$	1,952	14.8	7.1	0.45	0.67	1.08	0.21

*Note:* Table summarizes estimates based on Eq. (4.7), and data from various sources (see text). The first column informs about the number of products. The two following columns state the percentages with statistically significant and negative coefficients at the ten percent level, respectively.  $|\delta|$ s indicate the absolute size of the point estimates. The last column shows the median within  $R$ -squared.

however, can be quite large. The baseline estimate suggests that the interquartile range of the absolute coefficients spans values from 0.25 to 0.62. In 50 percent of the cases where a statistically significant effect was found, the absolute coefficient was  $|\hat{\delta}| \geq 0.38$  and its  $R$ -squared was 0.22 or larger.

In the lower panel in Table 4.4 the first row accounts for the duration of Chinese market presence. This may be important because trade relationships are often interrupted or unstable (Besedeš and Prusa, 2006). Moreover, developing countries tend to experiment with new business practices, so that the probability that a relationship becomes permanent increases if it survives the first couple of years (e.g. Eaton et al., 2007). As shown in the table, the detection rate increases to almost 16 percent when the indicator of Chinese presence considers only cases where an overlap persists for at least three consecutive years. The negative correlations still slightly exceed the positive ones, and the absolute size of the coefficients is larger than in the baseline. The remaining rows consider China's import market share in the respective product-destination market. They seek to identify the role of China being a major supplier to a US export market. The second row in the lower panel considers presence only if China has a market share that exceeds that of an average country exporting to destination  $d$ . That is,  $CN_{dt}^z = 1$  if  $IMS_{dt}^z > 1/N_{dt}^z$ , where  $N$  is the number of countries exporting to  $d$ . In the last row,  $CN_{dt}^z$  is equal to one whenever China's import market share is larger than 20 percent. In both cases the detection rate is similar but somewhat smaller than for the persistent export relationships. However, the estimated coefficients are larger and

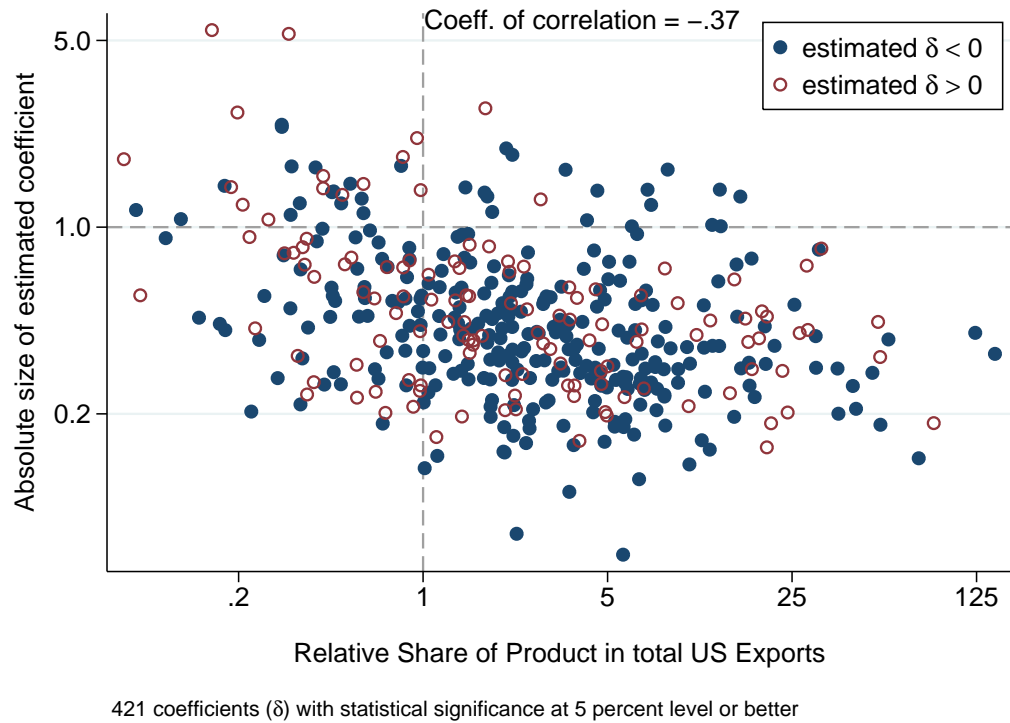
exceed unity in some cases.

Table 4.4 supports the view that US export unit value patterns respond to characteristics of Chinese exports in the same market. Larger market shares and persistent trade relations with China are reflected by a different set of US exporters. Product heterogeneity prevents detection in a pooled sample where coefficients are assumed to be equal by construction. This conforms to the findings of Johnson (2012) who focused on variation in ZPC values. The neglect of product heterogeneity can lead to misinterpretations. The present case suggests that aggregate effects are small but structural adjustments are taking place.

### Chinese Presence vs US Export Products

To obtain a clearer picture of the size of the estimated coefficients, the importance of a good in US manufacturing exports is considered. Figure 4.4 plots  $|\hat{\delta}^z|$  with statistical significance of 5 percent or better against a measure of  $z$ 's relative export share in the US. It is calculated as  $RES_z = (s_z^{US}/s_{p50}^{US})$  and relates  $z$ 's average share in total US exports to the average share of the median product. The figure considers the estimated coefficients for the baseline definition of  $CN_{zdt}$  and where all market controls are included. The correlation is negative, which suggests that China's presence produces larger absolute coefficients in product categories that are relatively less important for US exports. Nevertheless, most observations are to the right of the vertical median line. It indicates that most of the affected goods contribute a relatively large fraction to total US export revenues. Conversely, it implies that the less or unaffected products are relatively unimportant sources of US export revenues.

A systematic pattern for cost and quality competition cannot be obtained from the figure. To see how the coefficients reveal across different industries, estimation results are shown for each of the manufacturing sectors considered at the beginning of the paper. They can be compared to the results of Johnson (2012), who uses the same classification of industries and infers unit value correlations conditional on ZPC thresholds, and to Baldwin and Ito (2011), who analyzed heterogeneous effects of distance on export unit values. Table 4.5 shows the original results from Johnson (2012, Table 1, Panel B), in the first column pair (ZPC), and for unit value correlations with distance in the second column pair (Distance). The latter were generated by estimating Equation (4.7) and replacing the country fixed effect with a bilateral distance measure. The

Figure 4.4: Absolute  $\hat{\delta}^z$  and Relative Importance of  $z$  in US Exports; Average 1994-2006

*Note:* Author's calculations based on estimates from Eq. (4.7), and data from various sources (see text). Both axes are scaled in logs.

obtained coefficients for Chinese presence are shown in the third column pair. Chinese presence was set equal to one for observation where a trade relationship persisted for at least three consecutive years.

The prevalence of quality competition identified by Johnson (2012), and also by Baldwin and Ito (2011), for distances, cannot be confirmed for Chinese presence. It rather suggests that price-cost competition dominates. No industry with a reasonable number of observations has more positive than negative coefficients. The number of statistically significant coefficients is smaller than in columns (ZPC) and (Distance). Effects for Chinese presence are found for 613 HS6 products, whereas distance is significant in 1,424 cases. It suggests that the dominance of negative effects for China is driven by the type of goods it exports. In most cases, Chinese and US exports are sufficiently different to prevent competitive pressures through substitution by consumers.

Table 4.5: Prevalence of Quality Competition Across Market Characteristics

Dep. Var.: $\ln uv_{dt}^z$		ZPC		Distance		China		$s_z^{US}$
HS2	Industry	Positive	Negative	Positive	Negative	Positive	Negative	
28-38	Chemicals	402	51	281	38	46	109	2.47%
39-40	Plastic/Rubb.	145	5	100	6	6	49	1.73%
41-43	Hides/Leather	17	14	13	6	2	0	0.03%
44-49	Wood Products	129	3	64	16	7	26	0.53%
50-60	Textiles	153	52	104	13	22	36	0.51%
61-67	Apparel/Footw.	41	127	59	37	20	20	0.24%
68-71	Stone/Glass	78	30	33	5	7	9	0.30%
72-83	Metals	349	36	213	15	21	65	1.18%
84-85	Machin./Elect.	261	141	229	72	48	65	8.35%
86-89	Transportation	29	56	18	7	6	5	0.50%
90-96	Other Manuf.	59	145	88	7	6	28	0.46%
Total		1,663	660	1,202	222	191	412	16.20%

*Note:* Table reports frequencies of statistically significant coefficients at the 10 percent level. “ZPC” shows results from Johnson (2012, Panel B of Table 1) on the correlation between export unit values and ZPC capabilities. Columns “Distance” report frequencies of correlations with distance to the US. Columns “China” report correlations with Chinese presence. The last column informs about the share of the product that produce statistically significant results in total US manufacturing export.

Whenever products are substitutes, US exporters face downward pressures on their prices. In terms of their economic significance, the table suggests that 16.2 percent of total US manufacturing exports are affected by Chinese market presence. Half of these effects appear in the machinery and electronics industries.

#### 4.4.4 Competition in the EU

The analysis presented so far assumed that Chinese market entry increased the ZPC ability at which firms can profitably export. A potential concern is that causality goes the other way around. That is, for a product with quality competition ( $\theta_z > 1$ ) a reduction in  $a_{zd}^*$  would allow additional firms to enter the market. This could explain why Chinese firms serve the same market as US exporters, and why US export unit values are reduced. To rule out this possibility, additional information on the amount US firms export is needed. If Chinese market presence is, as assumed in this paper, associated with an increase of  $a_{zd}^*$ , the US would export less to this market and instead have relatively higher exports in markets where China did not enter. To analyze this, the pooled sample is re-estimated for a narrower set of countries in the European Union. They represent the most important destinations of US exports and ensure that

the product-time effects specified in Equation (4.6) cover changes in tariffs and other product-specific trade policies under the common EU framework.

Table 4.6: Chinese Competition in the EU; Pooled Estimation

Model	ln $uv$ : Binary		ln $uv$ : Market Share		$s_{HS4}^{US}$ : Market Share	
	(1)	(2)	(3)	(4)	(5)	(6)
China	-0.027** (0.007)	-0.027** (0.007)	-0.145** (0.049)	-0.152** (0.049)	-0.054** (0.011)	-0.054** (0.011)
# Partners		0.000 (0.001)		0.000 (0.001)		0.000 (0.000)
Herfindahl Index		0.057 <sup>a</sup> (0.030)		0.064* (0.030)		-0.012 (0.007)
Low-wage Countries		-0.021* (0.009)		-0.172 (0.187)		-0.042 (0.030)
Asian LWCs		0.016 <sup>a</sup> (0.009)		-0.005 (0.184)		-0.067** (0.025)
# Observations	136,820	136,820	136,820	136,820	109,424	109,424
# Product-destinations	10,802	10,802	10,802	10,802	8,612	8,612
R-squared (within)	0.287	0.287	0.287	0.287	0.322	0.322

*Note:* Table shows estimates using data from various sources (see text). Columns (1) through (4) report results obtained from Eq. (4.6). Columns (5) and (6) use the share of US HS6 products in HS4 product group as the dependent variable. Measures of Chinese presence vary according to column titles. Robust standard errors in parentheses are clustered at product-destination level; significance: <sup>a</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ . All estimates include country-specific control variables and use product-destination and product-time effects as described in the text.

Columns (1) and (2) of Table 4.6 illustrate that the estimated coefficients for Chinese presence are negative and statistically significant, as in the baseline estimation. In the EU sample, they are quantitatively larger and suggest a reduction of US export unit values of about 2.7 percent on average. The inclusion of additional market specific control variables does not change this coefficient. Columns (3) and (4) suggest that also China's market share within the markets matters. In contrast to the full sample estimated before, China has more stable trade relationships with EU countries, so that the variation at the intensive margin produces observable and statistically significant effects. An increase of China's market share by one percentage point is associated with a reduction of US export unit values by about 0.15 percent on average.

To evaluate whether these patterns reflect a reduction in  $a_{zd}^*$ , the analysis follows related studies on low-wage competition. It analyzes the share of an exposed HS6 good

$z$  within its broader product group at the four digit HS level (HS4) which encompasses also non-exposed products. If this share decreases in presence of Chinese exports, it implies that the US exports less of this good relative to non-exposed but similar products. Columns (5) and (6) show that the import market share of Chinese exports produces a negative and statistically significant coefficient. A one percentage point increase of China's market share is associated with a decrease of US exports by about 0.05 percentage points, relative to similar products which China does not export to the respective destination. This suggests that the structure of US exports changes in response to Chinese market presence and lends support to the assumption that China induces an increase of  $a_{zd}^*$ . The patterns conform to findings in the literature where Chinese import competition induces a reallocation of production to less exposed industries (e.g. Bernard et al., 2006; Bloom et al., 2011).

## 4.5 Conclusion

The paper has analyzed overlaps in US and Chinese exports resulting from China's expansion in international trade over the past two decades. US export unit values were analyzed within narrow product-destination pairs conditional on Chinese presence in the same market. Against widespread conjectures that high-income countries produce and export goods that compete at a quality margin, this paper shows that unit values are lower whenever China enters the market. Statistically significant effects can be observed mostly in cases where the US-Chinese export overlap persists for several years and where China is a major supplier. The US products affected by Chinese market presence constitute about 16 percent of total US manufacturing exports in the years 1994-2006. Half of these effect, products constituting about 8 percent of US manufacturing exports, were found in the machinery and electronics sector, where Chinese exports began to specialize since the 1990s. Overall, the results of this paper suggest that China enters markets primarily where cost-competition prevails. The analysis of heterogeneous patterns across different product categories was critical for the detection of the effects. This supports the argument of Johnson (2012) that econometric analyses in pooled panels tend to underestimate the disaggregate unit value patterns.

The results expand on the findings of Martin and Méjean (2014) who focused on export quality among French exporters. In contrast to their approach, the present paper suggests that strategies other than product upgrading are relevant for competing with

low-wage countries. Studies on low-wage import competition suggest that affected firms adjust in terms of output, market strategies, and product innovation (Bernard et al., 2006; Bloom et al., 2011). This paper provides first insights on complementary patterns in export markets. Studying a narrower sample of export overlaps within EU destination markets, it showed that the decrease in export unit values is accompanied by a lower value of exports relative to non-exposed but similar products. Although the aggregate effects appear to be economically small, the analysis at the individual product level reveals substantial structural reorganizing. Altogether, it appears that China can be a meaningful competitor for US (and possibly other high-income) exporters by forcing them to cut down their nominal prices and thereby production costs.

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# Notes on Chapters

This cumulative dissertation is comprised of one introductory chapter and three self-contained, single-authored articles. While the introduction provides a synthesis of the chapters for the purpose of this dissertation, the individual articles appear as follows in their most recent versions:

- Ch. 2 “Export Diversification and Stages of Economic Development;” an extended version of this chapter has been accepted for publication in the *Review of World Economics (Weltwirtschaftliches Archiv)*, under the title “Export Diversification and Income Differences Reconsidered: The Extensive Product Margin in Theory and Application.”

Keywords: Export Diversification, Extensive Margin, Gravity Equation, Economic Development;

JEL-codes: F11, F14, F43, O40, O11

- Ch. 3 “US Policy Spillover(?): China’s Accession to the WTO and Rising Exports to the EU” mimeo, University of Lüneburg (December 16, 2015)

Keywords: Exports, China, WTO, Policy Uncertainty, Spillover;

JEL-codes: F13, F14, D84, O24

- Ch. 4 “Foreign Competition and Quality Sorting?: Overlaps in US and Chinese Exports” mimeo, University of Lüneburg, (April, 2015)

Keywords: Chinese Competition, Unit Values, Quality, Product Heterogeneity;

JEL-codes: F14, F6

# Eidestattliche Versicherung

Hiermit erkläre ich, Karsten Mau, an Eides statt, dass ich die Dissertation mit dem Titel:

“ESSAYS IN INTERNATIONAL ECONOMICS: CHINA’S EXPORTS, GROWTH, AND COMPARATIVE ADVANTAGE”

selbständig und ohne fremde Hilfe verfasst habe.

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