Doctor of Philosophy

Advisors: Pol Antràs, Ricardo Hausmann & Dina Pomeranz Author: Sebastián Bustos

Essays in International Economics, Development and Globalization

Abstract

My dissertation contains four essays where I explore topics related to the question of how countries can become more competitive and sustain growth in a global economy. The four questions are: 1) how can we measure the productive capabilities of countries and cities; 2) whether there is evidence of a competitive boom and exports diversification as a result of large devaluations; 3) how does the globalization process shape local politics; and 4) whether multinationals firms contribute their fair share in terms of tax collection in a developing country.

Contents

Listing of figures

List of Tables

To Carla, Santiago, Julián and Benjamin, and my parents Ana and Eduardo.

Acknowledgments

What is truth? Growing up I remember having difficulties with my understanding of the meaning of truth. Whenever someone said something that was different to what I knew about an issue, my immediate reaction was to ask myself whether they were wrong, whether they were a credible source on the subject, and whether they knew they were wrong. This skeptical approach wasn't innocuous growing up. My classmates sometimes made fun of me for giving particular attention to irrelevant details, and had many clashes with teachers when I asked too many questions. Strong assertions from people without knowledge on a subject used to irritate me beyond reason. Thankfully, my parents and school teachers helped to tone down my character and channeled my curiosity in different ways, specially towards sciences in general. Still my skeptical spirit remains.

One significant event when I was about ten years old was to return home from school in the afternoon to find my father working on the dinning table. My parents used to arrive home from work late at night, so I knew something was off. That night I heard when he told my mother that he had quit his job to work in Patricio Aylwin's presidential campaign. For any middle class family that was a major event, full of uncertainty. I had become aware in those years that my parents were in strong opposition to the dictatorship of Pinochet who had recently lost the 1988 plebiscite, thus I saw his decisions as a conscious way to contribute to the changes that would occur. After three decades my parents can confidently say that they were active participants in the backstage were history was made. For me this was a lesson that convictions involve inescapable sacrifices. Why it was so important for them to participate in such events?

I decided to study economics after my first year in college. I saw it as a combination of two things. First, as a way to understand how societies organize production and allocate resources. I was particularly interested in how and why countries could have such profound and frequent economic crisis, likes the ones often experienced by Latin American countries. One subject I found fascinating was the political economy of reforms. I remember joyful moments studying with my friends Cristóbal Erazo and Eduardo Ringeling. We had plenty of heated discussions on macroeconomics and politics which shaped significantly my views. Second, economics could provide me with useful tools in order to participate in public policy, something that eventually happened. My upbringing made me conscious that we have the obligation to take part and improve our society.

I joined the Ministry of Finance in 2006 and it has been the place were I have worked more intensively, were I've been more frustrated at times, but were I have learned the most. It was a challenging

job, were everything was urgent and overdue by weeks . Early on I had responsibilities and made decisions beyond the training I had so far training. Subjects and situations were extremely challenging. Years later I would tell my classmates in grad school that I had lead negotiations over a financial reform, and they would not believe the kind of training I had been exposed to. My decision to work at the Ministry of Finance was also motivated by chances to apply to a top grad school in the US. Andrés Velasco was the Minister and had been a professor at Harvard, so a letter of recommendation from him could pave the way to grad school.

I remember vividly when I received my acceptance letter to Harvard. I had applied to only one program, the MPAID program of the Harvard Kennedy School. I got the e-mail before noon just before starting a work meeting. I recall biting my tongue and didn't tell anyone during the whole day, and saved the news for Carla once I arrived home. That night I also told my parents who were extremely happy. I think it was also their accomplishment.

Harvard was challenging and intimidating. It offered me plenty of opportunities that I wouldn't have imagined it existed. It was a world completely different to what I have been exposed so far. I remember one conversation with Michael Kremer who asked how was the economics academia in Chile. Only then I realized that everyday there were more seminars at Harvard than in Santiago during a whole week combining all top econ departments. Most of the time I felt everybody was smarter and better than me. In all honesty, I must recognize I had a hard time with what its call the impostor syndrome, and probably wasn't successful at overcoming it.

Although before applying to the MPAID I had the idea of continuing my studies towards the PhD, I must credit Alberto Alesina with being instrumental in my decision. I did his course on Political Economics, which required writing an empirical paper. I wrote a paper showing that countries with a more similar culture tend to engage in more bilateral trade and do more cross-border investments, for which Alberto gave me the best grade of the course. After the semester he asked me to meet him a Sunday morning in his office to discuss the paper. Suddenly he switch topics and asked me about my plans and whether I would consider doing the PhD. He offered me to write a letter or recommendation. It is very likely that meeting him on a cold Sunday morning changed significantly my professional path.

I owe so much to my advisors. I learned from them much more than lessons in economics or research. Ricardo Hausmann became my mentor, my boss and also a close friend. After graduating from the MPAID, I joined the Center for International Development. I was a perfect spot; it allowed me to remain at Harvard, working in applied research with a flexible job. That was important for me, since Carla was doing her masters in Boston University and was pregnant of Santiago. I worked with Ricardo in many projects, and was his teaching fellow for many years. In spite of seeing the same slides over and over during his lectures, I don't remember getting tired of his stories, anecdotes, and surprising perspectives he had over different topics. When meeting his students, part of my duties as his teaching fellow, they would be surprised when telling them that his son a daughter worked in the entertainment industry. For me it makes perfect sense since they grew up watching him perform. The difference is that Ricardo supports his performance with regressions and economic models. Without a doubt he is a great storyteller.

I'm also very grateful for Ricardo's support and encouragement to seek new and big ideas. When

I was thinking of applying to PhD programs I remember him offering his help. But also warned me saying that it was it was a tough and lonely journey because you became aware of the the little you know, that there are no certainties, and you need to solve all questions on your own. Thankfully, I felt part always home with Ricardo and the team at CID.

After taking International Trade with Elhanan Helpman, the following course I had to take to complete the sequence was the course of advance topics in trade, jointly taught by Marc Melitz and Pol Antràs. Although I knew Marc's research and was told to pay close attention to him, was Pol's research and insights what caught my attention. I got impressed by the insightful and elegant papers by Pol. His idea to explain trade patterns focusing on the contractual incentives and how they shaped the global value chain was something I had not even thought of. His ability to simplify complex economic problems is something I deeply admire. I'm still amazed by his humility, and the patience and kindness he has with all of his students.

I met Dina Pomeranz at a seminar at the NBER. She made super sharp comments and remember being amazed by her bold attitude. We were introduced by Cristóbal Marshall and started collaborating with the idea to do research using administrative tax data. I told her that I was specifically interested in using tax information to understand investment behavior of firms and how firms allocated resources across locations. After researching changes in the Chilean tax code introduced in recent years we settled in a portfolio of ideas. One conversation we had over lunch, after complaining over our difficulties with empirical research, was whether we should look for other ideas which lead the follow up question of how to chose research topics. I told here some raw ideas I had in mind and explained that my main hesitation came from the fact that those topics were not close to my hart. She explained to me that is exactly what I should never do, and gave me examples of the things that were most important for her, all of which boiled down to some kind of fairness in society. For instance, she had ruled out research related to racism or gender bias since in case of finding something against her views she would not behave as a scientific should. Dina explained to me that she didn't have a strong political view on taxes, and for that reason, she felt comfortable doing research on the subject. The lesson taught me to try to be more aware of my own interests from research. Since then its more clear to me that many scholars –specially those that often appear in the media– push particular views in their research and are not true to the scientific method.

I worked in many projects during my time at Harvard. Maybe to many. I benefited greatly from working with other researchers because they forced me support every claim and be more simple in mi thinking. During my PhD I was part of the team that published the Atlas of Economic Complexity, and a paper on the nested structure of industrial activity, both lead by Ricardo Hausmann and César Hidalgo. I learned a lot from my co-authors of the projects that are included in the chapters of this dissertation: José Ramón Morales, Dina Pomeranz, Martin Rotemberg and Muhammed Yildirim. From our research discussions we came up with other ideas, most probably more interesting and relevant than the ones we have finished. I hope we can continue collaborating and write new pieces.

I was deeply inspired by so many teachers. I have specially gratitude for Alberto Abadie, Philippe Aghion, Alberto Alesina, Chris Avery, Jeff Frankel, Dan Levy, Ed Glaeser, Gita Gopinath, Ricardo Hausmann, Elhanan Helpman, Bill Kerr, Asim Khwaja, Michael Kremer, Marc Melitz, Nathan

Nunn, Ariel Pakes, Guillermo Perry, Lant Pritchett, Dani Rodrik, Roberto Rigobon and Andrés Velasco.

I'm also indebted and grateful to Nicole Tateosian who takes care of all HKS doctoral students. Thanks!

There are so many people I meet during my time at Harvard with whom I feel indebted. The MPAID folks: Cynthia Ballock, Alper Bhadir, Brad Cunningham, Andrew Fraker, Johann Harnoss, Sui-Jade Ho, Yen Moi, Nathan Nadramija, Chris Oosterhuis, Max Otto, David Salamanca, Michele Zini, Snezhana Zlatinova. This is the group with whom my journey at Harvard got started. The Chilean grad students when I first arrived who guided me in the first years: César Fuentes, Cristóbal Marshall, Felipe Severino, Rodrigo Wagner, Andres Zahler, and Will Mullins. The Venezuelan crew; Douglas Barrios, Dany Bahar, Ricardo Hausmann, Moncho Morales, Miguel Santos, Ricardo Villasmil. Their commitment towards public services and their opposition to the dictatorship in Venezuela had been a source of inspiration. The members of the Atlas Team lead by Annie White, and the unmatched CS skills of Mali Akmanalp, Brendan Leonard, and Huy Nguyen. The CID research fellows; Jasmina Beganovic, Juan Pablo Chauvin, Michele Coscia, Brad Cunningham, Dario Diodato, Luis Espinoza, Andrés Gomez-Livano, Ljubica Nedelkoska, Frank Neffke, Syd Ravinatula, Stuart Russel, Matte Hartog, Juan José Obach, Carolina Pan, Jorge Tapia and Fernando Yu. More than once Daniel Stock ofered his help to check the write-up of my papers. The CID team leaders: Tim Cheston, Douglas Barrios, Tim O'Brien, Miguel Santos. Those tax experts that patiently answered my question; Pamela Castellon at the SII, and Alberto Cuevas from the Ministry of Finance. The CID staff, who took care of me and Carla for so many years: Andrea Carranza, Marcela Escobari, Carol Finney, Jennifer Gala, Andrea Hayes, Camila Lobo, Chuck McKenney, Catalina Prieto, Salimah Samji and Karen Vanderwillik. Those that helped us accesing and analyzing the administrative tax data; Sebastián Arrechaga, Raul Duarte, Juan Ignacio Elorrieta, Fatima Wagdy, Jose Vila-Velda, and Lucas Zavala. My classmates and friends, Martin Abel, Laura Blattner, Kiril Borusyak, Max Eber, Juan Sebastian Galán, Andy Garin, Siddharth George, Oyebola Okunogbe, Daniel Pollman, Pascual Restrepo, Martin Rotemberg, Alex Segura, Gabriel Tourek, Jack Willis, Lisa Xu, and Lucas Zavala. The chilean 'Bostoneanos': Fran Barros, Martin Bernales, Tomas Butazoni, Steven Cohn, Miguel Fernandez, Doming Godoy, Johanna Gruber, Felipe Heuser, Matías Infante, Ignacia Parodi, Ramón Salinas, Pancho Lagos, Eduardo Undurraga and Eduardo Villablanca. And a special mention to my neighbors with whom I spent so many moments; Megan, Cameron, Gonzalo, Maria, Martina and John.

So what is truth? At Harvard Yard the inscription facing Massachusetts Avenue says, "Enter To Grow in Wisdom". While studying at Harvard I learned that the truth somewhat elusive and mysterious, it's difficult to define accurately and depends on our perspective. Since there is so much uncertainty over what we observe and know its better to be humble and respectful of different opinions. Probably that is why those that know the least about something have severe and strong opinions, while those with deep knowledge are more cautious emphasize.

However, of what I'm completely certain is how fortunate I've been to have the family we have formed with Carla while living in Cambridge doing grad school work. Santiago was born a few months before applying to the PhD, and probably he brought with him the luck needed to be ad-

mitted. I just applied to Harvard and got in. Julian was born after I had completed my courses, and Benjamin was born when I had decided the final papers to include in my dissertation. So many great memories! Raising a family while completing my studies required lots of sleepless nights, to do many side-jobs to pay the rent, and other sacrifices which mostly meant to be far away from family and friends. Completing the PhD was a family effort. The whole process was more difficult and extenuating that I thought at the beginning. But I'm certain it was worthwhile.

I guess the final lesson I learned is that you can only be certain of the things you do with love. That is the true 'Veritas'.

The same gate has an inscription as you leave the Yard: "Depart To Serve better Thy Country and Mankind." That's the beginning of my next journey.

Preface

My research interests have been shaped by my experience working in policy, and by what I see to be a chronic problems faced by my country, Chile. Production is concentrated in a few industries, without significant changes in the diversity of industries in the last four decades, which have been controlled by the same few families and business groups. In particular, the economic performance of the country –which has been praised by International institutions and other countries– is mostly explained by the fate of copper exports. Unfortunately, in recent years the rate of growth has been declining steadily.

Why is it that there hasn't been much innovation and changes in the main industries of Chile? It is a fact that mining, forestry or wine production has not experienced significant changes in their performance, and the technology used for production have remained similar to the ones used decades ago. Could it be that technology and new productive knowledge doesn't flow to the country? If it was as simple as importing machinery and equipment at the technological frontier, or training workers and scientists in the top universities, all what is needed for new products should flow easily across borders. Chile has increased significantly its access to capital, there is abundant local funding for companies and, by any measure, the availability and quality of its human capital is increasing at a fast pace. One possibility to accelerate transmission of new ideas and technology is to import knowledge embedded in multinationals that do investments in our country. Yet, the export basket of Chile –as a measure of the products in which the country has a significant productivity in order to compete in international markets– has not changed its composition in several decades. This is not what we do observe in other countries that have experienced rapid and sustained growth, such as Korea, Finland, Portugal or New Zealand.

This dissertation contains four essays where I explore topics related to the question of how economies can become more competitive and sustain growth in a global economy. The four questions I tackle are: 1) how we can measure the productive capabilities of countries and cities, and whether they help us to understand their growth; 2) whether there is evidence of a competitive boost and export diversification from a large devaluation; 3) how does the globalization process shape the results of local elections, and 4) whether multinationals contribute their fair share in terms of tax collection.

In the first chapter I explore with Muhammed Yildirim the constant structural transformation of cities and countries. Industries need many inputs, such as regulations, infrastructure or productive knowledge, which we call capabilities. And locations are successful in hosting industries insofar as

the capabilities that they can provide. We propose a capabilities-based production model and an empirical strategy to measure the Sophistication of a product and the Production Ability of a location. We apply our framework to international trade data and employment data in the United States, recovering measures of Production Ability for countries and cities, and the Sophistication of products and industries. We show that both country- and city-level measures have a strong correlation with income and economic growth at different time horizons. Product sophistication is positively correlated with indicators of human capital and wages. Our model-based estimations predict product appearances and disappearances through the extensive margin.

In the second chapter, written with Martin Rotemberg, we document the ramifications of a large devaluation episode: the U.K.'s "Black Wednesday" in 1992. Relative to synthetic counterfactual, U.K. export and import prices in pounds increased by roughly 20 percent, a similar magnitude to the nominal devaluation. Inflation declined after the devaluation, although the prices of fuels increased. Contrary to the conventional belief that the UK experienced an export led boom after the devaluation, we find no evidence that exports or nominal GDP increased. We also find no evidence of a "J-curve:" imports declined immediately after the devaluation, and stayed persistently below their counterfactual value. We test a wide variety of theories of elasticity pessimism, and find that none do well at explaining patterns in the data.

With José Ramón Morales I study in chapter 3 how the Mexican access to the US market through NAFTA, measured as tariff drops for Mexican exports to the US, had an effect on the electoral performance of Andrés Manuel López Obrador (AMLO) in Mexico's 2006 presidential election. In an effort to appeal to his rural base, AMLO proposed to unilaterally retain tariff exemptions on imported corn and beans, which were scheduled to drop under NAFTA by the end of 2008. This elevated protectionism in the public agenda during the campaign. We find that local economic gains due to export tariff drops under NAFTA between 1994 and 2001 led to a drop in AMLO's local vote share gains in 2006 with respect to left wing vote share in 1994 or 2000. These effects are contingent to the 2006 election - the only election between 2000 and 2018 in which debates over protectionism played a salient role. Results are robust to controls for local corn and bean growing and Chinese competition. We predict that AMLO would have been elected in 2006 had protectionism not been a salient electoral issue - AMLO seems to have learned about this, as media efforts to strike a conciliatory tone in 2012 were deployed more intensely in localities that benefited more from NAFTA. Our findings suggest export access gains due to globalization undermine local political preferences over national protectionist platforms.

Chapter 4 is a part of a longer research agenda with Dina Pomeranz and Gabriel Zucman on the debate on how to effectively tax multinational corporations. In an increasingly globalized corporate world, the debate on how to effectively tax multinational corporation has become of first order importance for many governments around the world. For this purpose we have partnered withe the Internal Revenue Service of Chile in order to analyze the tax collection of internationally active firms. In 2011, Chile implemented an OECD-inspired reform that strongly increased reporting requirements for multinational firms and created a specialized unit to monitor transfer pricing. This led to higher monitoring costs and higher compliance costs for firms, and increased demand for tax consulting services. It is, however, unknown so far whether it led to more tax collection. Chapter 4

is mostly a descriptive providing suggestive evidence consistent with profit shifting by multinational firms in Chile. Their tax filings indicate that multinational firms have lower profit rates (as a ratio of EBIT /wages) compared to local firms similar in size, industry and region. This is consistent with the notion that they shift part of their profits to lower tax countries, and in line with the findings of Tørsløv et al. (2018) who show that multinational firms in higher-tax jurisdictions tend to have lower profit rates, and those in low-tax countries tend to have higher profit rates compared to purely domestic firms. This lower profitability leads to a lower probability of paying corporate income tax in Chile, and a lower rate of taxes/payroll.

1

Production Ability and Economic Growth

Economic development and growth are tightly dependant on the industrial structure of a location (Marshall, 1890; Jacobs, 1969; Porter, 2003). Industries emerge and sustain their activities in locations where their inputs or needs can be satisfied.[1] Although some of these inputs can

[1] Throughout this chapter, to simplify the terminology, we use the word "location" to refer to cities, statistical areas or countries. Similarly, we use the terms products and industries interchangeably.

be sourced from elsewhere, there are many needs of industries such as property rights, regulations, infrastructure, labor, capital and amenities for workers, that must be provided locally. We refer to all these factors affecting the production ability of a location as capabilities. Locations that have a greater variety of capabilities will, therefore, be able to produce a greater number of products. On the other hand, sophisticated industries that need many capabilities will most likely be found in locations that have high production ability. Although there is no comprehensive list of capabilities, their availability shapes the distribution of industries across locations, which, in turn, is observable. Using the distribution of industrial activity, and by imposing a simple structure on capability needs, we introduce a method that captures what we call the Sophistication of industries and the Production Ability of locations. We then perform two empirical applications: across countries and across cities in the United States. Our results show that countries and cities with higher Production Ability grew faster over time. Moreover, our framework captures the dynamics of industry appearances and disappearances in a location.

We use the term capabilities encompassing everything that is needed for production. Let's turn to an example to elucidate the nature of capabilities. Suppose a businessperson would like to open a new production facility. To do that, first, she needs to understand how local institutions work (whether and how property rights and rule of law are enforced in that location), and needs to obtain the formal permits to operate. She needs access to finance, and a contractor that can build up the physical space, which, in turn, requires the construction materials. To run the plant, she needs access to a power grid, water distribution, energy lines and a sewerage system. She should be able to provide all the necessary inputs for production locally, or else she needs to be able to buy and transport them from other locations, which requires a well-functioning customs mechanism and, again, a suitable infrastructure. Once the plant is ready to make the output, she still has to take her products to her customers. Customers may also want to visit the plant to inspect the standards. Therefore, well-functioning customs, ports, and airports are crucial. Maybe the most important is

the productive knowledge to make the operation possible needs to be brought together: the necessary workforce, including managers, engineers, accountants, human resource specialists, and unskilled workers, to name a few, need to be hired. These workers require places to stay, restaurants to eat, access to healthcare, and schools and daycare centers for their children. This list is by no means comprehensive. Furthermore, industries have different needs of specific capabilities. For instance, natural-resource based industries, in many cases, need to have the raw material available in the same location. Hence, that capability is the most important determinant of hosting natural resource activities.

Locations, on the other hand, must offer capabilities required by an industry to sustainably host it. Some of the capabilities are (non-rival) public inputs usually provided by governments, such as rule of law, infrastructure or specific regulations. Other capabilities are privately provided and organized by markets, raising the issue of positive and negative externalities. By increasing their capabilities, locations compete to become home to new industries. Therefore, the process of economic diversification can be thought as process of accumulating capabilities, something more challenging than just accumulating aggregate factors like capital and labor. Importantly, many of these capabilities are used by multiple industries, enabling for the burden of diversification to be shared among them.[2] Consequently, the distribution of industries and products depends on the capability profile of products and locations.[3]

However, as can be seen in the example above, listing all the capability requirements of industries or capability offerings of locations exhaustively might be unfeasible and inherently prone to mistakes. Properly measuring capabilities could be either an endless or impossible task. Nevertheless, the manifestation of capabilities are revealed in the products and where they are produced; products

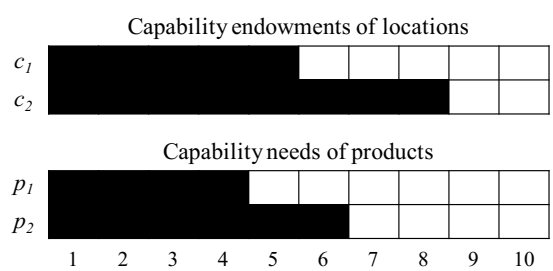
[2] In our model, we will assume that all capabilities are non-rivalrous.

[3] There are well known economic theories that emphasize that the profile of products and locations shape the output process. For instance, in international trade, Hecksher-Ohlin model claims that factor endowment and input requirements explain the pattern of trade.

are these requirements embodiment's. Thus, production is indicative of the capabilities present in each location. This observation is the motivation behind the empirical model used in this paper.

We can formalize the capability framework using a Leontief production function. In Figure 1.1, we show an example of capability endowments of two locations, c_1 and c_2, and capability needs of two products, p_1 and p_2. In total, there are 10 capabilities present. Country c_1 has 5 capabilities, whereas, country c_2 has 8, hence, country c_2 has higher Production Ability. On the other hand, p_1 needs 4 capabilities and $p - 2$ needs 6. In this example, product p_2 is more sophisticated than p_1. Which country makes which products? Country c_1 would be able to make product p_1 but not product p_2 because c_1 does not possess the sixth capability required to produce p_2. On the other hand, country c_2 can make both products because it has all the capabilities required for both of them. It is important to note that in real life, we do not observe the capabilities of locations or requirements of products. Therefore, we need to make inferences of Production Ability and product Sophistication based on the observed distribution of economic activity across locations.

Figure 1.1: An example of capability offerings of locations and capability requirements of products



Note: The figure depicts binary capability endowment vectors of two locations, c_1 and c_2, and capability need vectors of two products, p_1 and p_2. The black shaded squares correspond to the capabilities present or required for locations and products, respectively.

In this paper, we propose a method to estimate the extent of capability needs of products and capability endowments of locations, which we call product *Sophistication* and *Production Ability*, re-

spectively. We build on the Leontief-inspired model introduced by Hausmann and Hidalgo (2011), where locations are able to successfully make a product if they can provide *all* of the capabilities needed by it. Here, we assume a nested structure for capability requirements of products. In this context, nestedness means that if we compare the capability requirements of any two products, one will be the subset of the other (Bustos et al., 2012). In other words, the capabilities of a less sophisticated product is nested under the capabilities required for more sophisticated products and, hence, a less sophisticated product will be made in all locations where a more sophisticated product could be made.[4] Based on this assumption, the product sophistication is simply the norm of the product capability-requirement vector. Consequently, the Production Ability of a location is the highest sophistication of the product made in that location.

The perfect nestedness assumption might be too stringent. It would imply that the Production Ability of a location is a threshold that determines the products made by it. Only products whose sophistication levels are below the threshold will be produced by the location. Consequently, the number of products made (diversity) will capture the Production Ability. Accordingly, a product only made in a few locations (i.e., with low ubiquity) is bound to have high sophistication and only made in high ability places. Yet, we know that this result does not match well with what we observe in the world. For example copper, which is a natural resource product, is made in a few places because of geological luck rather than capability accumulation. Copper, with its low ubiquity, would be wrongly labeled as a highly sophisticated product because of the assumption of perfect nestedness.

In our empirical analysis, we relax the perfect nestedness and Leontief production function assumptions. To relax the Leontief assumption, we introduce tolerance for missing capabilities. For instance, if a product requires 10 capabilities and a location has 9 of them, this location will have

[4] In the example in Figure 1.1, the capability requirements are nested because the all the capabilities required for product p_1 is a subset of those required for product p_2.

a higher likelihood of making the product compared to another location that has only 5 of the required capabilities. To relax the nestedness assumption, we assume that it is fulfilled probabilistically. That is, if a location makes a high-sophistication product then it is more likely to make all the lower sophistication products. With these relaxed assumptions, instead of imposing a hard threshold associated with sophistication –as in the Leontief production function– we introduce two different facets of product sophistication: product Specificity and product Sensitivity. To be explicit, first, there will be a Specificity level associated with a product, and as Production Ability of a location comes closer to and passes this level, the likelihood of making this product will increase. Second, we assume that products differ in their sensitivity to overall capabilities available in a location. For instance, copper needs the raw material in place but is not dependent much on the presence of other capabilities. Hence, we expect for copper to have a low product Sensitivity but high product Specificity. In practice, the likelihood of making a product depends on all three features: Production Ability of the location, product Specificity and Sensitivity. A probabilistic approximation to a Leontief function with these features can be captured by a logit functional form. With this specification, we can estimate the product Sophistication and location ability measures by maximizing a likelihood function to explain observed distribution of products over countries.

An analogy may clarify the concepts behind our framework. Suppose we are asked to identify the mathematical skill sets of a group of students, but the only information we are given is who answered which questions correctly on a test.[5] Both the skills of each student and the skill set required for answering each question are in principle unknown. Can we recover these latent traits (i.e., skill sets) by analyzing the results of the test? We can start with the assumption that a student is more likely to answer a question correctly if she possesses the skills required by the question. Hence, students with higher overall math skills are expected to answer more questions. And the questions that require high skills will only be answered by few students with these skills, hence, with a sensitivity to

[5] In this analogy, the countries are akin to students and questions are similar to products.

student skills. Nevertheless, questions asking for specific knowledge will also be answered by only a few students. For instance, we can think of a question asking the tenth digit of π. Possibly some students who memorized the digits of π will get this question right, but this might not be necessarily related to the overall math skill level of these students. Others will correctly guess the right answer one-tenth of the time. These questions will be highly specific but not necessarily sensitive to student skills.

This analogy helps us to introduce tools developed in the field of psychometrics. Our empirical specification is similar to the latent trait estimation methodology to design and evaluate tests, called "Item Response Theory" (IRT) (Lord, 2012). When IRT is applied to a test, item difficulties and discrimination levels are obtained along with the individual abilities. Historically, the latent structure analysis started with Lazarsfeld (1950), and the probabilistic item factor model was developed by Lord (1952). Rasch (1960) was first to use logit functions in predicting the latent traits and Birnbaum (1968) improved the methodology to allow different item difficulty levels to be predicted.

To illustrate how we can use our framework to estimate Production Ability and Product Sophistication we will perform two applications. We first use international trade data, to measure the Productive Ability of countries and the Sophistication of traded products. Then we perform a second application using the US city level employment data. When we apply our method to the international trade data, we find that the Production Ability has a strong positive correlation with GDP per capita levels. The main outliers are – as expected – countries that export mostly natural resource products. These countries are relatively rich not because they a high Production Ability but due to their natural resource endowments. When we turn to the estimates for products, we find that the product sensitivity levels associated with natural resource are often very low, meaning that there is not much dependence on the ability of the countries. The Production Ability also reflects the potential of economic growth of countries. We estimate growth regressions and find that a country's ability, controlling for the current level of income per capita, is associated with a higher growth rate.

This association remains significant even after controlling for country fixed effects. Interestingly, our model also captures the dynamics of product appearances and disappearances in the trade data.

We then turn to a subnational application. Before going into the results in this context, we would like to highlight three important differences with the international data. First, our results across countries could be related to differences in capabilities which are constant within country borders. Second, movement of goods and factors are easier within a country, which in our setting makes some capabilities more accessible. Third, the subnational data is composed of tradable and non-tradable industries. These differences open up the question to whether our method could capture features relevant for cities, since capturing the importance of capabilities might be more difficult compared to the international setting. To test this, we use industry-employment data at the core-based statistical area (CBSA) level of the United States.[6] We confirm our results from the trade data by finding that cities with high Production Ability have higher income per capita, and that Production Ability has also a strong correlation with growth of income and employment. Consistent with the international case, our model also captures the extensive margin, predicting appearances and disappearances of industries. Using subnational data gives us an opportunity to compare the industry Sophistication measures to other industry characteristics. The Specificity and Sensitivity measures show positive correlation with respect to the payment to production factors, the skills of labor, and they are also informative of the location of industries along the supply chain.

Our work is intimately related to the Economic Complexity Index (ECI) (Hidalgo and Hausmann, 2009; Hausmann et al., 2014). The algorithm behind ECI attempts to capture capabilities of countries and capability requirements of products using a product's ubiquity and a country's diversity. The idea to reward diversity of countries but to penalize for ubiquity of products using non-linear weighing schemes gave rise to other measures, such as the one proposed by Tacchella et al. (2012), labeled by the authors as country fitness and product quality. All of our measures, including

[6] Throughout the paper we use the term *city* interchangeably with CBSA.

Production Ability, Product Specificity and Product Sensitivity, show significant correlations with their relevant counterparts proposed in these studies.

Here, we would like to highlight some differences between our methodology and the approaches of Hidalgo and Hausmann (2009) and Tacchella et al. (2012). Both ECI-PCI and Fitness-Quality attempt to capture the underlying capabilities of countries and sophistication of products. However, the relationships between the capabilities and these measures are established heuristically. Our empirical methodology is formally grounded with in a model with capabilities. Second, in terms of economic importance, when we compare our Production Ability to ECI or Fitness for predicting economic growth in sections 1.4.2 and 1.4.5, the Production Ability turns out to be a better predictor of future economic growth both at country and city levels. Third, we can combine our measures to predict dynamics of industry appearances and disappearances. Such a direct combination for ECI-PCI or Fitness-Quality is not present. Finally, an additional difference between ECI and Production Ability is the consequence of adding new industries on these measures. In the case of ECI, adding new industries to the production portfolio of a location could increase or decrease the value of the index. For instance, a location producing everything would receive an average ECI value, not the maximum. This is at odds with the idea that only a location endowed with all capabilities could, in principle, produce everything. In the case of Production Ability, a location producing everything would receive the maximum score.

The rest of the paper is structured as follows. In the next section, we will conduct a literature review, linking this paper to previous contributions. In Section 3 we introduce the capability-based model and explain how we can obtain product sophistication and country ability measures. Section 4 will describe the datasets and the empirical strategy we use in the rest of the paper. Section 5 will report our results in both international and subnational level. Finally, we conclude in Section 6.

1.1 Literature review

This paper is related to a long literature attempting to capture capabilities that are important in understanding the prosperity of cities or countries. The first strand of literature aims to quantify the extent of capabilities. The second strand is linked to related diversification, since this process could be thought as a consequence of shared capabilities. The third strand of papers focuses on the diversification/specialization debate.[7]

In the first strand of literature, our work can be thought as an extension of studies attempting to capture productive qualities of countries and industries. Hausmann et al. (2007) propose measures that summarize the income level of export baskets and products, showing that what countries export is informative of the their prosperity levels. Subsequently, the Economic Complexity Index (ECI) was formulated algorithmically in Hidalgo and Hausmann (2009) and later formalized in Hausmann et al. (2014) to capture country and product sophistication. The ECI algorithm iteratively corrects the information contained in the diversity of countries by the ubiquity of products using arithmetic means in order to measure the presence of capabilities. Tacchella et al. (2012) use a different rewarding and punishing scheme for diversity and ubiquity, respectively, alternating between harmonic mean and arithmetic mean, to arrive at country Fitness and product Quality measures.[8] In relation to the economic growth, ECI has a high positive correlation with GDP per capita, and it is a strong predictor of growth (Hausmann et al., 2014). However, the dynamics associated with the Fitness measure with the economic growth follows non-linear heterogeneous patterns (Cristelli et al., 2015).

Economic complexity and fitness measures were originally calculated using international trade

[7] There is another strand of literature developed or surveyed by Brahmakulam et al. (2001), Desai et al. (2002), Lall (2003) and Archibugi and Coco (2005) that focuses on indexing technological capabilities using patents, R&D spending, scientific publications, and physical and social infrastructure. Here, we focus on the productive ability inferred indirectly from the patterns of industries or technologies.

[8] There have been some questions about the convergence of this algorithm (Morrison et al., 2017)

data, and have been extended recently to subnational data (Mealy et al., 2019; Fritz and Manduca, 2019). An economic complexity inspired algorithm applied to patent classes and US metropolitan areas shows that the complexity affects spatial distribution of knowledge (Balland and Rigby, 2017) and this approach supplements the previous measure of patent complexity measure proposed by Fleming and Sorenson (2001). Applied to European regions, the complexity of the patent classes imply that moving into higher-complexity areas is beneficial but hard to achieve (Balland et al., 2018). Finally, Balland et al. (2020) analyze the urban concentration of complex economic activities and find that these types of activities increased their concentration in urban areas since 1850.

Recently, the complexity measures have been used by scholars and policymakers extensively. Love and Stockdale-Otárola (2017) provides an overview of how complexity measures could be used for policy in wide range of topics. Product complexity measures have been used in the literature to characterize the sophistication levels of industries or products. For instance, Javorcik et al. (2018) shows that foreign direct investment increases the product complexity levels in regions of Turkey. Felipe et al. (2012) analyzes China's development in light of increasing product complexity. Hausmann et al. (2014) introduce a measure called Complexity Outlook Index by analyzing how well a country is situated vis-à-vis complex products in the product space and this measure also turns out to be important in predicting growth. Product sophistication can be regarded as the step size while climbing the ladders of economic (Verhoogen, 2008; Hallak, 2010; Khandelwal, 2010) or technological development (Petralia et al., 2017). We believe that our product Sophistication and Production Ability measures would be welcomed addition to the toolbox of policymakers and researchers.

In the second strand of the literature, our results are related to diversification of regions. One of our empirical findings is that our model captures the appearance and disappearance of industries. The principle of related diversification (Hidalgo et al., 2018; Boschma, 2017) has been shown to influence the industrial patterns of regions. Relatedness could be though as a measure of shared capabilities between industries. Hidalgo et al. (2007) introduce the concept of product space, showing

that the presence of related products is an important determinant of the pattern of development of countries. Hausmann et al. (2019) further develops this idea and shows that the implied comparative advantage of locations could be inferred from the related industries, and this measure is highly correlated with the current revealed comparative advantage and predictive of the future comparative advantage. Boschma and Capone (2015) shows the importance of institutions in shaping the diversification using the measures from the product space.

At the city level, a consequence of having shared capabilities of industries are what the literature refers to as externalities or spillovers. Marshall (1890) proposes spillovers such as labor sharing, knowledge spillovers, input-output relationships as a cause of agglomeration and industrial specialization of cities. The clusters of industries emerge because of these externalities, and these clusters have been found to cause differential regional growth (Porter, 2003) and improved firm performance (Lee, 2018). Jacobs (1969), on the other hand, emphasizes the importance of diversity of economic activities as a significant determinant of innovation, and therefore city prosperity. All these externalities are difficult to observe but can be thought of as driven by the latent set of capabilities that enhance the Production Ability of cities.

The third strand of literature that our study relates to is on diversification-specialization debate.[9] An important feature of our model is that it rewards diversification, since locations are likelier to have more industries as their production ability increase. This result is consistent with the findings of Glaeser et al. (1992), who show that the diversity of industries is a strong predictor of city growth. Hidalgo and Hausmann (2009) and Tacchella et al. (2012) also use the principle of rewarding diversity while developing their measures. The diversification could also be related to the occupational structures of the cities which has been shown to affect their productivity (Bettencourt et al., 2014). Yet, using manufacturing data Imbs and Wacziarg (2003) show that the relationship between di-

[9] The regional diversification literature have been debating the importance of Marshallian and Jacobsian forces (Beaudry and Schiffauerova, 2009).

versification and economic development follows an inverted-U pattern: as countries increase their income per capita, first they diversify their economic activities, but in later stages concentrate their production. This result is further corroborated by Cadot et al. (2011) using international trade data. For both studies, the reversal point for diversification occurs at a high level of income, with specialization becoming dominant only for a small fraction of countries. In fact, the results of Cadot et al. (2011) suggest that only $\sim 15\%$ of the countries in the sample are beyond the turning point where specialization is dominant.[10] Our interpretation is that for the vast majority of countries, diversification is the relevant strategy.

1.2 Model

We build on the model proposed by Hausmann and Hidalgo (2011). According to this model, a location needs to have every capability needed by a product to successfully make that product, similar in spirit to the production function suggested by Leontief. Let's denote the capability requirement vector of product p with $k_p \in \{0,1\}^m$, where m is the number of capabilities. Location c will make a given product if and only if it has all the required capabilities. Formally:

$$M_{c,p} = \begin{cases} 1 & \text{if} \quad k_p \cdot k_p^{\intercal} = h_c \cdot k_p^{\intercal} \\ 0 & \text{otherwise} \end{cases}$$

where the dot operator $(\cdot)$ represents the vector inner product, $\intercal$ is the transpose operator, $h_c \in \{0,1\}^m$ denotes the ability vector of the location c, and $M_{c,p}$ is the matrix whose entry (c,p) is equal to one if the location c makes the product p, and zero otherwise. $k_p \cdot k_p^{\intercal}$ is the Euclidean 1-norm of the product capability vector.

To explain how this model works, let's turn to an example assuming a single product and 3 capa-

[10] In Table 2 of Cadot et al. (2011) the authors provide the list of countries beyond the turning point.

bilities. Let the product have the capability requirement vector $k_p = [1, 1, 0]$, i.e., product p requires the first two capabilities, but does not require the last one. The Euclidean 1-norm of the product p is 2. Suppose location c has capabilities $h_c = [1, 1, 0]$. According to our model, the location will be able to make product p because $h_c \cdot k_p^\intercal = 2$, which is equal to the norm of the k_p. Now let another country, c', have capabilities $h_{c'} = [1, 0, 1]$. Since $h_{c'} \cdot k_p^\intercal = 1 \neq k_p \cdot k_p^\intercal$, this country won't be able to make product p because it is missing the second capability.

The product-capability space is multidimensional, which implies that by accumulating capabilities, locations can choose between multiple paths of development. However, for empirical purposes, we make a simplifying assumption and focus on finding a single dominant ladder of development. We assume that capability vectors have a nested structure, which is a very stringent assumption that will be relaxed below, but is helpful to simplify the explanation. Nestedness here means that if we take any product pair (i, j), with i requiring less capabilities than j, then the capabilities needed to make product i are a subset of capabilities for j. In other words, if we sort products by their Euclidean 1-norms, the capabilities required by product i could be found "nested" under the capabilities of product j. Thus, we can index products just using the norm of their capability vectors, with product p_1 having the smallest norm and product p_n having the largest norm. With the nestedness assumption, we can write:

$$k_{p_i} \cdot k_{p_i}^\intercal = k_{p_i} \cdot k_{p_j}^\intercal$$

for any $1 \leq i < j \leq n$.

The Leontief production function and the nestedness assumption imply that locations will make all products whose sophistication level is below its ability level. Formally, let's denote the Euclidean 1-norm of product p with $b_p \in \mathbb{R}^+$ which captures the extent of capabilities required by each product, and denote the norm of a country capability vector with $\theta_c = h_c \cdot h_c^\intercal$. Location c will make

product p if $\theta_c \geq b_p$. Hence, we can write:

$$P(M_{c,p} = 1|\theta_c, b_p) = \begin{cases} 1 & \text{if} \quad \theta_c \geq b_p \\ 0 & \text{otherwise.} \end{cases}$$

In other words, the probability of a country making a product is a step function with θ_c as the threshold.[11]

In reality, who produces what is less stringent than implied by the Leontief production function. First, there could be some tolerance to missing capabilities. To allow for that, we assume that the probability of producing p in location c is an increasing function of $(\theta_c - b_p)$. Using this formulation, as θ_c becomes larger, the likelihood of making p increases. Second, we introduce a sensitivity parameter, a_p, which makes the probability of producing p more or less sensitive towards location abilities, θ_c. This assumption is also realistic, since some products –like copper or petroleum– do not depend highly on other production capabilities –such as skilled labor– but rather their presence in a location is a result of other random factors –like the geological lottery–. In particular, we can make the probability of country c producing product p as a function of $(a_p\theta_c - b_p)$. If a_p is close to zero, θ_c is not important in explaining the presence of p. If a_p is large, then the probability of c making p would be sensitive to an increase in θ_c. Hence, the sensitivity parameter allows us to account for how dependent making the product is on capability accumulation.

Combining these assumptions, we would like to choose a functional form that approximates the Leontief model in the limiting cases: As $(a_p\theta_c - b_p) \to -\infty$ the probability limit should be zero, and as $(a_p\theta_c - b_p) \to \infty$ the probability limit should be one. A widely-used probability function that satisfies these properties is the logistic function. In particular, we can write the probability of

[11] See figure 1.2 below. In the figure of the right panel we show the Leontief case depicted with the black line.

location c making product p as a function of country ability (θ_c) as:

$$P(M_{c,p} = 1|\theta_c, a_p, b_p) = \frac{1}{1 + e^{-(a_p\theta_c - b_p)}}. \tag{1.1}$$

The left panel of figure 1.2 shows the logistic function for different values of b_p, which captures the *product specificity*. As b_p increases, the probability curves shift towards the right, so fewer locations are likely to make the product. The right panel shows the logistic function for different values of a_p, which captures the *product sensitivity*. As a_p increases, the functional form better captures the step function implied by the Leontief production function, which corresponds to the black line in the figure. As a_p decreases then the choice of θ_c has less of an impact on the likelihood of making the product.

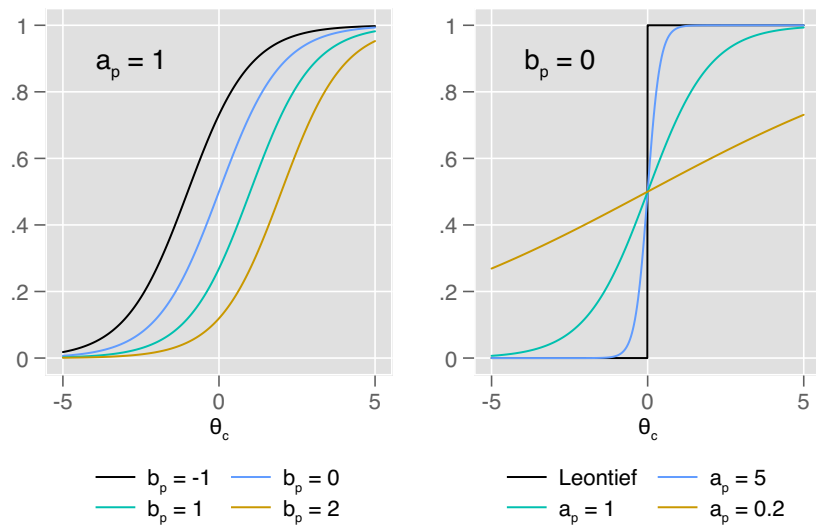
Consequently, a product with high b_p (specificity) and low a_p (sensitivity) will be likely made by few locations, and this probability will not depend too much on θ_c (Production Ability). A product with both high b_p and a_p will be made by few locations as well, which will be most likely by locations with high θ_c. Example for the first set of products can be found in the natural resource products, whereas the second set of products are mostly knowledge-intensive products.

In our empirical estimation we use the information about which location makes what products to estimate three parameters: Production Ability, Sensitivity and Specificity. Using the logistic probability model we introduced, we can write the likelihood of observing the given location-product pairing matrix, $M_{c,p}$ as:

$$L(M|\Theta, B, A) = \prod_{(c,p) \text{ s.t. } M_{c,p}=1} \left(\frac{1}{1 + e^{-(a_p\theta_c - b_p)}} \right) \prod_{(c,p) \text{ s.t. } M_{c,p}=0} \left(\frac{e^{-(a_p\theta_c - b_p)}}{1 + e^{-(a_p\theta_c - b_p)}} \right) \tag{1.2}$$

where Θ denotes the set of Production Ability (θ_c's), A is the set of Product Sensitivity levels (a_p's) and B represents the set Product Specificity levels (b_p's). If we denote the number of locations by

Figure 1.2: Probability distributions



Note: The figures show the values of the probability function formulated in Equation 1.1. In the left-hand panel, we keep the Sensitivity parameter constant ($a_p = 1$) and show the shifts in the graph for different values of the Specificity parameter (b_p). In the right hand panel, we keep the Specificity constant but change the Sensitivity levels. The black line corresponds to the Leontief case.

N_c and number of products by N_p, the maximum likelihood estimation is feasible since there are $N_c + 2 \times N_p$ parameters, and we have $N_c \times N_p$ observations (number of entries in the M matrix). We only need a single restriction for country abilities, $\sum_c \hat{\theta}_c = 0$, for the system to be fully identified.

Coincidentally, the maximum likelihood problem we pose here is similar to the well-known psychometric method called Item Response Theory (IRT), which is widely used to design and assess tests or questionnaires. The framework we propose is equivalent to the 2 parameter (2-pl) model in IRT. In the IRT framework, item discrimination parameter corresponds to product Sensitivity, and item difficulty is equivalent to product Specificity.

1.3 Empirics

We apply our methodology to countries and cities, using international trade data and city-industry employment data for the US. For international trade, we use the cleaned version of UN COMTRADE international trade data by Bustos and Yildirim (2020).[12] Specifically, we use the country-commodity export values following the SITC Rev. 2 classification between years 1962 and 2015. We follow the list of countries used by Hausmann et al. (2014); eliminating countries whose exports are below $1 billion in 2008, and those that experience war, or have severe trade data problems leading to unreliable reports. This leaves us with a list of 125 countries.[13] We eliminate product codes with the smallest export volumes, summing up to 0.5% of world trade in year 2008, and those that we do not observe reported trade throughout the sample duration, giving us a final list of 660 products. We use the World Development Indicators (WDI) collected by the World Bank for country indicators.

For the subnational analysis, we use the County Business Patterns (CBP) database from 2005 to 2015 by the US Census Bureau, which reports employment and number of establishments of

[12] The data can be downloaded from https://dataverse.harvard.edu/dataverse/atlas

[13] Table 1.18 shows the list of 125 countries used in this study.

location-industry pairs. The Census Bureau censors some of the observations of the dataset to avoid disclosing information when particular firms could be identified. For this reason, we use the version of CBP data by Eckert et al. (2020) who developed a method for imputing the censored observations. We convert all the data to follow the NAICS 2012 industrial classification at 4 digits, using the concordance tables provided by the Census Bureau. As a geographical unit, we convert the county-level data to the core-based statistical areas (CBSA) using the 2015 mapping between counties and CBSAs. For brevity we refer to CBSAs, which is composed of both metropolitan and micropolitan areas, as cities. We eliminate cities smaller than 5000 employees and industries with less than 2500 employees in total. The resultant dataset consists of 904 cities and 274 industries. We obtained city-level income per capita levels from the U.S. Bureau of Economic Analysis (BEA). To capture industry characteristics, we use the Input-Output tables from BEA along with the Occupational Employment Statistics (OES) data from the Bureau of Labor Statistics (BLS). Finally, we utilize the O*NET data to calculate the average training intensity and average educational requirement of industries.

Our theory relies on identifying the presence of industries. Hence, we face the challenge of turning our datasets – which are continuous in nature – into a binary variable. That is, we need to turn the intensity of exports or employment into a variable indicating whether countries or cities have or do not have competitive presence in an industry. Following Hidalgo et al. (2007), for the international data, we use the Revealed Comparative Advantage (RCA) measure first introduced by Balassa (1965) and from that measure, we develop the binary country-product matrix, M.[14] Formally, let's assume that the $X_{c,p}$ is equal to the total exports of country c in product p. RCA is defined as:

$$\mathrm{RCA}_{c,p} = \frac{X_{c,p} / \sum_c X_{c,p}}{\sum_p X_{c,p} / \sum_p \sum_c X_{c,p}}. \tag{1.3}$$

[14] Turning a continuous variable into a binary indicator is challenging. Not having any threshold would result in having false positives. Having a high threshold would generate false negatives. Here, following the literature, we opt to minimize false positives.

The numerator of the RCA formula describes the share of country c in exports of product p in the world, whereas the denominator is the share of country c in total world trade in all products. If the country's share in the product p is higher than the share of the country in the world, then we assume the country produces this product more than its *fair share*. Therefore, we use the RCA larger than 1 threshold as our binarization method. Formally, we obtain M from RCA matrix by:

$$M_{c,p} = \begin{cases} 1 & \text{if } \mathrm{RCA}_{c,p} \geq 1 \\ 0 & \text{Otherwise} \end{cases} \tag{1.4}$$

For the subnational case we will use the Location Quotient (LQ), which is equivalent to RCA but using employment levels instead of the trade data. Suppose $\mathrm{emp}_{c,p}$ denotes the employment in a given region in industry p. Then, the LQ can be obtained replacing $X_{c,p}$ with $\mathrm{emp}_{c,p}$ in Equation 1.3. For LQ, the numerator is the employment share of industry i in location c, and the denominator is the share of location c in the total employment nationally.

For the subnational case, we have the problem of industries in small cities having high LQ values with very few number of employees.[15] To eliminate such cases we added the requirement of having a meaningful amount of workers. Here, a simple definition of meaningful size is either (i) the national average establishment size for that industry, and (ii) 10 employees.[16] Mathematically, we can write the M matrix for the subnational presence of industries as:

$$M_{c,p} = \begin{cases} 1 & \text{if } \mathrm{LQ}_{c,p} \geq 1 \;\&\; \mathrm{emp}_{c,p} \geq \widehat{\mathrm{emp}}_p \;\&\; \mathrm{emp}_{c,p} \geq 10 \\ 0 & \text{otherwise} \end{cases} \tag{1.5}$$

[15] An example of calling an industry present in a city with only handful of employees is "Monetary Authorities-Central Bank" (NAICS Code 5211). While the data indicates that the average establishment has over 300 employees, there are close to 20% of locations with $LQ \geq 1$ which have less than 50 workers.

[16] We calculate the average number of employees per establishment in each industry using the National version of the data. This file, fortunately, doesn't have any censored entries.

where $\widehat{\text{emp}}_p$ denotes the average establishment size of industry p in the United States.

We performed the IRT analysis using the Test Analysis Modules (TAM) package of R software (Robitzsch et al., 2018) to obtain estimates of location Production Abilities, product Sensitivity and product Specificity levels. The TAM package uses maximum likelihood estimation to calculate these measures using Equation 1.2.

1.4 Results

1.4.1 Country Ability and Product Sophistication Using International Trade Data

We estimate country Production Ability and product Sophistication levels using international trade data for each year separately, from 1962 to 2015. Table 1.1 shows the top and bottom 10 countries according to Production Ability using the data for year 2015.[17] Germany is at the top of the ranking, followed by Italy, Austria and the United States. China, a manufacturing powerhouse with a spectacular export performance in recent years, is ranked at number 7. The table also shows the worst performers, including Nigeria, Libya and Venezuela. Interestingly, all countries among the bottom performers are countries with extractive economies heavily reliant on natural resources. The list includes Qatar and Kuwait – which have high levels of income per capita – relying on a single extractive industry (petroleum and natural gas, respectively).

We turn the analysis to the correlation of Production Ability and economic output. Panel A of Figure 1.3 shows the high correlation between income per capita of countries and the corresponding Production Ability levels for 2015. It is evident in the figure that countries whose output depends heavily on natural resources (e.g., Qatar, Kuwait, Norway, Gabon and Saudi Arabia) are outliers,

[17] For comparison purposes we show the Production Ability measure normalized for each year to have a mean of zero and a standard deviation of one across countries.

Table 1.1: Countries ranked by Production Ability

Top countries			
Country	ISO-3	Ranking	Production Ability
Germany	DEU	1	1.303
Italy	ITA	2	1.209
Austria	AUT	3	1.177
United States	USA	4	1.112
Czech Republic	CZE	5	1.066
Japan	JPN	6	1.053
China	CHN	7	1.023
Sweden	SWE	8	1.012
Spain	ESP	9	0.994
Slovenia	SVN	10	0.989

Bottom countries			
Country	ISO-3	Ranking	Production Ability
Qatar	QAT	116	-1.722
Congo, Rep.	COG	117	-2.310
Kuwait	KWT	118	-2.311
Papua New Guinea	PNG	119	-2.468
Gabon	GAB	120	-2.469
Angola	AGO	121	-2.596
Algeria	DZA	122	-2.610
Venezuela, RB	VEN	123	-2.717
Libya	LBY	124	-2.776
Nigeria	NGA	125	-3.931

Note: The rankings are based on Production Ability values estimated for 2015. The values shown for Production Ability are normalized to have mean of zero and standard deviation of one.

appearing significantly above the regression line. According to our theory, these are countries that have incomes higher than what we would expect given their production abilities. Hence, in Panel B of Figure 1.3, when we control for the natural resource exports intensity,[18] we find that the (partial) correlation between ability and income per capita increases from 39% to 63%, suggesting that the deviation from the trend for many countries is driven by the exports of natural resources.

There have been several efforts in the literature to capture the latent productivity of countries using the same trade data. We expect the Production Ability to be highly correlated with these measures as well. In particular, we focus on the export Diversity[19] (Hidalgo and Hausmann, 2009), the Economic Complexity Index (ECI, Hidalgo and Hausmann (2009); Hausmann et al. (2014)) and country Fitness (Tacchella et al., 2012). Table 1.2 shows the correlation between these measures for year 2015. These measures are highly correlated with each other, presumably since the variables are indeed capturing the latent productivity that allow countries to compete in international markets.

[18] We proxy for natural resource exports, calculating the net natural resource exports per capita, using the the list of products used by Hausmann et al. (2014).

[19] We calculate Diversity as the number of products in which countries have RCA greater than or equal to one.

If we compare the rankings of countries, the Spearman's rank correlation between Ability and the other measures rises up to more than 90%, surpassing the values using Pearson correlation.[20] This result is indicative of a non-linear relationship among measures. One interpretation is that the other measures do not have as much variation as Production Ability, especially at the bottom of the distribution. This is most clear in the correlation between Production Ability and Fitness.

Table 1.2: Correlation between country measures

	Production Ability	ECI	Diversity	Fitness
Production Ability	1			
ECI	0.804^{***}	1		
Diversity	0.856^{***}	0.786^{***}	1	
Fitness	0.736^{***}	0.877^{***}	0.904^{***}	1

$^{*}\, p < 0.05$, $^{**}\, p < 0.01$, $^{***}\, p < 0.001$

Turning our attention to products, Table 1.3 shows the top and bottom 10 products sorted by an overall ranking combining the Specificity and Sensitivity measures.[21] According to the ranking, the top products are mostly complex machinery, with Nails, nuts and bolts being the only product outside this category.[22] The ranking at the bottom is dominated by products associated mostly with abundance of natural resources (such as oil) or products that require specific climate or soil to be competitive in their production.

How do the Sensitivity and Specificity measures change across product classes? According to our model, rare products should exhibit high specificity. But only those products that are sophisticated should exhibit both high sensitivity and high specificity. Figure 1.4 shows average values for

[20] Figure 1.6 of the Appendix shows the Pearson and rank correlation between Production Ability and the other three measures, for all years.

[21] Specifically we calculate the overall ranking by adding up the rank according to the product specificity and sensitivity and re-ranking the result. In Tables 1.19 and 1.20 of the Appendix, we show the list of products at the top and bottom according to ranking based on the Sensitivity and Specificity parameters, respectively. In these tables we observe that, as expected, the sensitivity parameter severely punishes the natural resource products

[22] Despite what could sound as a simple product, the international trade of Nails, nuts and bolts is dominated by high productivity countries. China, Germany, Taiwan, Japan and the United States account for almost 2/3 of world trade in this product.

Table 1.3: Ranking of products according to Sophistication

Products	SITC-4 Code	Ranking Overall	Ranking Specificity	Ranking Sensitivity
Top products				
Nails, Nuts & Bolts	6940	1	3	1
Working Metal & Metal Carbides Machines N.E.S.	7367	2	1	3
Mechanical Tools For Building	7493	3	12	5
Rolling Mills	7372	4	7	11
Parts Of Paper Making Machines	7259	5	11	8
Internal Combustion Engines For Motor Vehicles	7132	6	13	6
Textile Machinery	7244	7	2	17
Dishwashers	7753	8	8	12
Reciprocating Pumps	7421	9	5	18
Valves	7492	10	24	7
Bottom products				
Lubricating Petroleum Oils N.E.S.	3345	651	591	627
Frozen Fish, Excluding Fillets	0342	652	623	604
Fresh Or Dried Fruit N.E.S.	0579	653	653	574
Bovine & Equine Leather	6114	654	643	584
Wheat Or Meslin Meal Or Flour	0460	655	651	581
Sawlogs & Veneer Logs Of Non-Coniferous	2472	656	600	639
Worked Wood Of Non-Coniferous	2483	657	629	616
Bran, Sharps & Other Cereal Residues	0812	658	613	634
Unwrought Lead & Alloys	6851	659	641	628
Flora In Pharmacy	2924	660	645	638

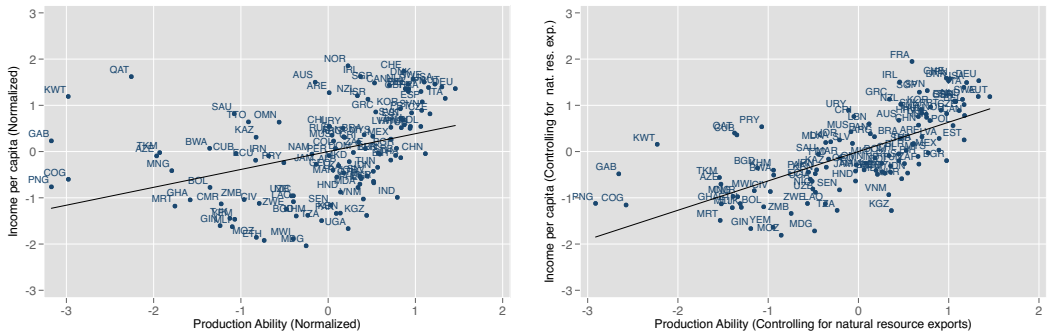
Note: This table shows the ranking of Product Sophistication levels for 2015. The overall score is calculated as the sum of rankings of products according to Sensitivity and Specificity values. Then, the products are re-ranked based on their overall score.

Sensitivity and Specificity parameters within one-digit SITC sections. Consistent with our model, Minerals and Fuels has the lowest average sensitivity, followed by Animal and vegetable oils and fats and Crude Materials. Nevertheless, these sections with low-sensitivity exhibit relatively higher levels of specificity compared to sections like Beverages and Tobacco or Food and Live Animals. The Machinery and Transport Equipment section, on the other hand, has both the highest average sensitivity and highest average specificity values. The Other Manufactured Goods section follows the Machinery and Transport section in terms of average sensitivity.

As we did with the Production Ability at the country level, we can analyze how the sensitivity

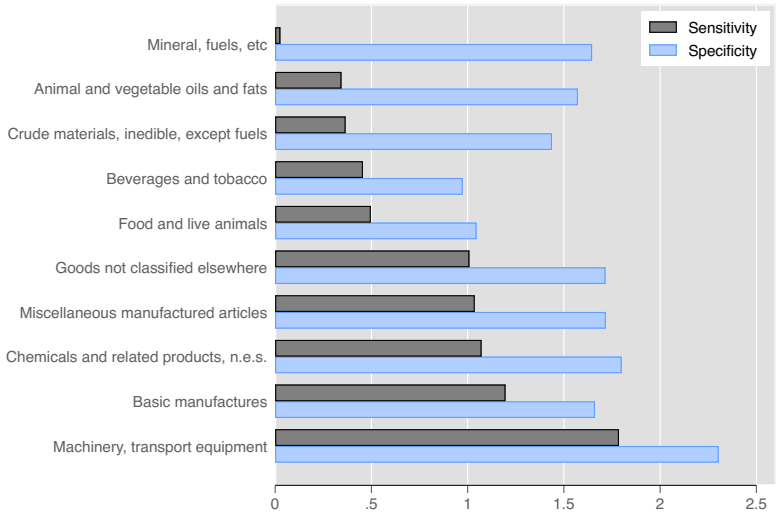
Figure 1.3: Production Ability and country income per capita

(a) Correlation **(b)** Controlling for natural resource exports



Note: The figures show the partial correlation of income per capita with respect to Production Ability using an OLS regression for year 2015. Panel A shows the correlation without any additional controls, while panel B is the partial correlation after controlling for exports of natural resources as a share of total exports. The variables are normalized to have mean of zero and standard deviation of one.

Figure 1.4: Average Sensitivity and Specificity of SITC sections



Note: The figure shows the average of raw product Sensitivity and Specificity values for SITC sections (i.e., first digit of SITC Codes) for 2015. The sections are ranked based on their average Sensitivity levels.

and specificity measures are related with related product sophistication measures in the literature. We use the Product Complexity Index (PCI by Hausmann et al. (2014)), Product Quality based on Fitness (Tacchella et al., 2012) and Ubiquity (Hidalgo and Hausmann, 2009) as comparators.[23] Table 1.4 shows the correlation between these measures for year 2015. Sensitivity is highly correlated with PCI, whereas Specificity is highly correlated with the ubiquity. This is consistent with our model: the Specificity parameter can be thought as a tuner to adjust the number of countries that make the product, and the Sensitivity parameter captures how susceptible is the product to having the necessary capabilities. Finally, Product Quality based on Fitness is highly correlated with both of our product sophistication measures as well.

Table 1.4: Correlation between product measures

	Specificity	Sensitivity	PCI	Ubiquity	Quality
Specificity	1				
Sensitivity	0.559***	1			
PCI	0.607***	0.828***	1		
Ubiquity	-0.880***	-0.305***	-0.513***	1	
Quality	0.763***	0.516***	0.662***	-0.617***	1

$^{*}\, p < 0.05$, $^{**}\, p < 0.01$, $^{***}\, p < 0.001$

Overall, Production Ability and the product Sensitivity and Specificity measures correlate well with the cross-sectional measures like income per capita of the country, ECI or the PCI. Next, we will test whether these measures are also important in the dynamics of country growth and diversification.

1.4.2 Economic Growth of Countries

Does our estimate of Production Ability predict economic growth of countries? Production Ability and income per capita levels are correlated but not perfectly aligned. Using this relationship, we can

[23] Ubiquity is calculated as the number of countries that make each product competitively (RCA larger than 1).

estimate an implied income level associated with each Production Ability level. We expect countries to grow faster if the implied income level is higher than the actual income. Formally, we tackle this question by estimating simple growth regressions –a la Barro (1991)– where after controlling for the country's current income level and other country characteristics commonly used in cross-country growth analysis, we expect Production Ability to be a significant predictor of economic growth. Formally, we estimate the following equation:

$$\text{Growth}_{c,t} = \beta_y \times lny_{c,t} + \beta_a \times \text{Production Ability}_{c,t} + \beta_x X_{c,t} + \lambda_t + \varepsilon_{c,t} \tag{1.6}$$

where $\text{Growth}_{c,t}$ is the annualized growth in income per capita over a span of 5 or 10 years; $lny_{c,t}$ is the logarithm of income per capita of country c and X_c vector represents other country-level controls.[24] We use three specifications in the regressions: First, we only control for initial income per capita in logs and Production Ability. Then we add a basic set of variables suggested by canonical growth models, to control for the effect of accumulation of physical capital, human capital and population growth.[25] And finally, we show estimates with a third specification extending the set of factors that have been found in the literature to determine the rate of growth. We control for investment distortions (proxied by the investment price levels), the composition and density of the population (proxied by the share of population under 15 years old, and urban share of population), and the importance of trade (proxied by trade openness, and intensity of natural resources exports as a share of GDP). We estimate these three specifications by OLS with and without country fixed effects.

Table 1.5 shows our basic results. Columns 1 to 6 present estimates where the dependent variable is the annualized growth rate of income over 5 years, while columns 7 to 12 does the same using

[24] Table 1.17 in the Appendix contains the definition and sources of all the variables we use, as well as some comments and particularities of the cross country data. Table 1.18 contains the list of 125 countries used for calculating Production Ability, and also which countries are used in the growth regressions.

[25] See for instance Mankiw et al. (1992).

growth rates over 10 years. To facilitate comparison across variables and columns, we have standardized all explanatory variables to have mean of zero and standard deviation of one.[26] In column 1 we show the baseline estimate, which indicates that a one standard deviation increase in Production Ability is associated with a 0.68 percentage points increase in income per capita per year, which is significant at the 99% confidence level. When we control for investment rate, years of schooling and population growth, the size of the coefficient of Production Ability reduces to 0.44. And when we add the extended set of controls (column 3) the coefficient indicates that a one standard deviation increase in Production Ability is associated with a 0.55% increase in income per capita per year. In columns 4 to 6, we repeat the specifications of the three previous columns, but now with adding country fixed effects. The country fixed effects capture any unobserved country characteristics invariant over time correlated with economic growth. The estimates of columns 4 to 6 are all highly statistically significant and show that Production Ability has a sizable association with economic growth.[27] Columns 7 to 12 repeat the exercise in first six columns but using annualized growth rate over 10 years as the dependent variable. When comparing across columns with same specification for 5 years and 10 years, it is interesting to note that the coefficient using a longer span of time are larger (and more significant) for Production Ability. This finding suggests that relevance of Production Ability for economic growth increases over longer horizons of time. Our preferred estimate is that of column 12, where we control for the extended set of variables and use country fixed effects. Specifically, the estimate suggests that an increase of one standard deviation of Production Ability is associated with 0.76 percentage points of faster growth in each of the subsequent 10 years.

Does our estimate of Production Ability predict economic growth of countries better than other

[26] We also use constant sample of observations to avoid differences in the estimated coefficients arising from changes in sample size.

[27] One interesting finding shown in this table is that our estimate of Production Ability remains correlated with economic growth in 5 or 10 year periods, despite adding country fixed effects to the estimation. In the extensive empirical literature studying determinants of economic growth, there are not many variables that remain significant after being subjected to this level of scrutiny involving country fixed effects.

Table 1.5: Country economic growth

	5 year periods						10 year periods					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Income per capita, log	-0.55***	-0.98***	-1.32***	-3.11***	-3.31***	-4.71***	-0.71***	-1.18***	-1.71***	-3.69***	-3.76***	-4.71***
	(0.13)	(0.16)	(0.30)	(0.98)	(0.93)	(0.95)	(0.13)	(0.16)	(0.33)	(0.88)	(0.89)	(0.81)
Production Ability	0.68***	0.44***	0.55***	0.77***	0.58**	0.47**	0.85***	0.61***	0.55***	0.95***	0.85***	0.76***
	(0.12)	(0.12)	(0.16)	(0.27)	(0.24)	(0.23)	(0.12)	(0.12)	(0.18)	(0.28)	(0.28)	(0.26)
Investment (% of GDP)		0.49***	0.34***		0.32***	0.24*		0.28**	0.18*		0.10	0.06
		(0.11)	(0.10)		(0.12)	(0.13)		(0.11)	(0.11)		(0.13)	(0.14)
Years of schooling, log		0.24	-0.00		-1.11**	-1.15**		0.34*	0.13		-0.43	-0.67
		(0.14)	(0.16)		(0.54)	(0.52)		(0.18)	(0.18)		(0.45)	(0.46)
Population growth, %		-0.49***	-0.19		-0.61**	-0.14		-0.49***	-0.01		-0.41**	-0.00
		(0.14)	(0.18)		(0.28)	(0.24)		(0.12)	(0.18)		(0.18)	(0.23)
Investment price			-0.40***			-0.57***			-0.31***			-0.48***
			(0.11)			(0.12)			(0.10)			(0.11)
Urban share			0.04			-1.57**			0.26			-0.46
			(0.22)			(0.62)			(0.25)			(0.50)
Population share under 15			-0.86***			-1.71***			-1.05***			-1.30***
			(0.30)			(0.38)			(0.35)			(0.39)
Openness			0.19			0.68***			0.12			0.28
			(0.13)			(0.22)			(0.14)			(0.26)
NNRR exports, % of GDP			0.35*			0.50**			0.15			0.03
			(0.18)			(0.23)			(0.18)			(0.30)
Observations	822	822	822	822	822	822	394	394	394	394	394	394
R-squared	0.15	0.22	0.27	0.41	0.43	0.50	0.23	0.30	0.34	0.60	0.61	0.64
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	-	-	-	yes	yes	yes	-	-	-	yes	yes	yes
Controls	-	basic	extended	-	basic	extended	-	basic	extended	-	basic	extended

Note: The dependent variable is the geometric growth rate of GDP per capita, over 5 and 10 year periods, measured using constant dollars of 2010. All control variables are normalized to have in each year a mean of zero and standard deviation of one. The description of the variables and the sources are provided in Section A.1 of the Appendix. Robust standard errors in parentheses clustered by country. *** p<0.01, ** p<0.05, * p<0.1

measures based on the structure of production? We analyze the predictive power of Diversity, ECI and Fitness on economic growth and put them in a horse-race with Production Ability, to infer which variable better captures the growth potential of countries. Table 1.6 shows estimates where we first introduce variables one-by-one from column 1 to 4, and then we re-estimate the regressions using Production Ability along with each explanatory variable (columns 5 to 7) as a way to assess which variable has a higher correlation with economic growth. As expected, Diversity, ECI and Fitness are all strongly correlated with economic growth (columns 1 to 4), with coefficients ranging from 0.31 (for Fitness) to 0.66 (for Diversity), with all estimates being statistically significant

at conventional levels. The picture changes when we estimate the coefficients also controlling for Production Ability. When we use Production Ability and the other measures in the same regression (columns 5 to 7), the coefficients for the other measures are no longer statistically different from zero, while the coefficient for Production Ability is still statistically significant. In columns 8 to 14 we repeat the analysis, but using 10 year annualized growth rates as dependent variable. The results confirm that Production Ability is a better predictor of economic growth compared to the other three variables, a finding robust to different time horizons.[28]

Table 1.6: Economic growth, competing measures

	5 year period							10 year period						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Income per capita, log	-0.55***	-0.63***	-0.69***	-0.44**	-0.61***	-0.48***	-0.51***	-0.71***	-0.79***	-0.94***	-0.56***	-0.76***	-0.72***	-0.66***
	(0.13)	(0.15)	(0.18)	(0.17)	(0.15)	(0.18)	(0.15)	(0.13)	(0.16)	(0.19)	(0.18)	(0.15)	(0.18)	(0.15)
Production Ability	0.68***				0.51***	0.78***	0.72***	0.85***				0.70***	0.83***	0.90***
	(0.12)				(0.16)	(0.13)	(0.14)	(0.12)				(0.18)	(0.16)	(0.15)
Diversity		0.66***			0.24				0.79***			0.21		
		(0.15)			(0.20)				(0.15)			(0.20)		
ECI			0.62***			-0.17				0.86***			0.02	
			(0.17)			(0.21)				(0.18)			(0.21)	
Fitness				0.31**			-0.10				0.36**			-0.13
				(0.14)			(0.12)				(0.14)			(0.12)
Observations	822	822	822	822	822	822	822	394	394	394	394	394	394	394
R-squared	0.15	0.14	0.13	0.11	0.15	0.15	0.15	0.23	0.20	0.19	0.13	0.23	0.23	0.23
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Note: The dependent variable is the geometric growth rate of GDP per capita, over 5 and 10 year periods, measured using constant dollars of 2010. All control variables are normalized to have in each year a mean of zero and standard deviation of one. The description of the variables are provided in the text. Robust standard errors in parentheses clustered by country. *** p<0.01, ** p<0.05, * p<0.1

[28] As a robustness check, table 1.21 in the Appendix repeats the regressions of table 1.6 using country fixed effects. The conclusions are qualitatively the same, the only difference is that when controlling for Production Ability and Diversity in the same regression, using 5 year annualized growth rates, neither of the two variables appear to be statistically different from zero (column 5). When using 10 year annualized growth rates, Production Ability is found to have a highly significant correlation with economic growth while Diversity is statistically indistinct from zero.

1.4.3 Appearance and Disappearance of Products in Countries

Does our Productive Ability framework predict the exports of new products or countries losing products? According to our model, countries should be exporting a product at a higher likelihood as their Production Ability multiplied by the product Sensitivity is higher than the product Specificity. Hence, if a country does not make a product currently but the product has high likelihood according to our model, we would expect that product to appear in the country in the future. On the contrary, if a country makes a product with a low likelihood level, we expect that product to disappear because it is very likely that the vast majority of capabilities needed for the product are not present in the country.

Predicting appearances and disappearances can be regarded as a dynamic implication of the model in the extensive margin, and can be empirically tested. In particular, we define the likelihood parameter to be:

$$\text{Likelihood}_{c,p} = \left(1 + e^{-(\widehat{a}_p \widehat{\theta}_c - \widehat{b}_p)}\right)^{-1} \tag{1.7}$$

where θ_c is the country Production Ability, a_p is the product Sensitivity and b_p is the product Specificity, all previously estimated (and therefore, the "hat" over each parameter).[29] Equation (1.7) corresponds to the key equation (1.1) of our model, and it is the likelihood of having presence in a given product that goes into the Maximum Likelihood estimation in equation (1.2).

Building on the likelihood parameter, we ask in this section whether products that were absent in an initial year are more likely to appear after a given span of time as the likelihood gets higher. Likewise, we analyze the disappearance of products. But first, we need to establish the definition of product presences and absences. For product presences, we keep our definition from equation (1.4) with $\text{RCA}_{c,p} \geq 1$. For absences, we have two different definitions. In the first one, we call any product not present being absent (i.e., $\text{RCA}_{c,p} < 1$). However, this definition for presence-absence

[29] The distribution of the likelihood variable is given in Figure 1.8 of the Appendix.

may be too permissive, since the idea of a new product implies something that was significantly absent from the export basket. For this reason, in our second definition, we call a product absent if its $\text{RCA}_{c,p} \leq 0.1$.[30]

One other factor we need to control for is that the likelihood function has strong dependency on country and product characteristics. For instance, Germany is the country with the highest Production Ability. According to equation 1.7, Germany will have higher likelihood compared to other countries. Similarly, for a product with high specificity, we will have lower likelihood values compared to other products. For this reason, we need to control for country and product characteristics to have estimates that are not driven by a small group of countries or products. In all our estimations, we control for country and product characteristics using the country Production Ability and product Sensitivity and Specificity variables.

Table 1.7 shows results of logit regressions estimating appearances and disappearances over five year windows.[31] In even-numbered columns, we have a wider set of controls including ECI, PCI, Diversity and Ubiquity. For these dual complexity variables, unfortunately, there is no model-guided way on how to combine them to predict product appearances or disappearances. The first four columns of Table 1.7 show our estimations for appearances, i.e., products not present in the initial year but present in the final year. In all specifications the likelihood variable is estimated to be a strong and highly significant predictor of new products. The final four columns of Table 1.7 show our predictions for the disappearance of the products. As expected, the coefficient for the likelihood variable is significantly negative. Interestingly, the magnitude and the predictive power of the disappearance estimates are higher than the ones for the appearance. The results imply that the countries are less likely to sustainably produce in an industry if they do not have the necessary capabilities, leading to disappearances.

[30] In all columns, we took a moving average of RCA for three years to make the variable more stable.

[31] In Table 1.26 of Appendix, we show the predictions done for ten year windows. The results are similar to Table 1.7.

Table 1.7: Predicting appearance and disappearance of exported products

	Appearances				Disappearances			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Final :	$RCA^{t+5}_{c,p} \geq 1$	$RCA^{t+5}_{c,p} \geq 1$	$RCA^{t+5}_{c,p} \geq 1$	$RCA^{t+5}_{c,p} \geq 1$	$RCA^{t+5}_{c,p} < 1$	$RCA^{t+5}_{c,p} < 1$	$RCA^{t+5}_{c,p} \leq 0.1$	$RCA^{t+5}_{c,p} \leq 0.1$
Initial:	$RCA^{t}_{c,p} < 1$	$RCA^{t}_{c,p} < 1$	$RCA^{t}_{c,p} \leq 0.1$	$RCA^{t}_{c,p} \leq 0.1$	$RCA^{t}_{c,p} \geq 1$	$RCA^{t}_{c,p} \geq 1$	$RCA^{t}_{c,p} \geq 1$	$RCA^{t}_{c,p} \geq 1$
Likelihood	2.418***	3.454***	1.581***	2.099***	-2.927***	-2.685***	-9.600***	-5.295***
	(0.070)	(0.101)	(0.214)	(0.292)	(0.078)	(0.117)	(0.295)	(0.448)
Production Ability	0.324***	0.636***	0.137***	0.579***	-0.080***	-0.123***	-0.269***	0.110***
	(0.013)	(0.021)	(0.023)	(0.039)	(0.011)	(0.018)	(0.020)	(0.033)
Sensitivity	-0.035**	-0.262***	-0.409***	-0.913***	0.320***	0.221***	0.033	-0.449***
	(0.016)	(0.028)	(0.033)	(0.064)	(0.018)	(0.034)	(0.038)	(0.084)
Specificity	-0.131***	0.110***	0.041	0.571***	-0.251***	-0.313***	-0.205***	0.265***
	(0.017)	(0.027)	(0.036)	(0.056)	(0.018)	(0.033)	(0.044)	(0.084)
ECI		-0.416***		-0.347***		0.034*		-0.423***
		(0.016)		(0.033)		(0.020)		(0.050)
PCI		0.118***		0.259***		0.143***		0.481***
		(0.019)		(0.040)		(0.025)		(0.058)
Diversity		0.015		-0.169***		-0.025		-0.892***
		(0.018)		(0.035)		(0.023)		(0.071)
Ubiquity		0.096***		0.335***		-0.052**		0.044
		(0.018)		(0.038)		(0.026)		(0.074)
Observations	386,688	386,688	249,671	249,671	74,921	74,921	74,921	74,921
Switches	17569	17569	3440	3440	15317	15317	2261	2261
Pseudo R2	.048	.054	.023	.034	.034	.035	.181	.195
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the binary appearance and disappearance values for products, based on the limits in the column labels. All control variables are normalized to have in each year a mean of zero and standard deviation of one. Robust standard errors in parentheses clustered by country. *** p<0.01, ** p<0.05, * p<0.1

1.4.4 City Production Ability and Industry Sophistication

Our results using country-level data show that Production Ability and Product Sophistication are important variables towards understanding the prosperity path of countries. In this section, we extend the analysis to a subnational setting using the industrial employment patterns in the United States at Core-based Statistical Area (CBSA) level (or simply cities for brevity). For this, we use the County Business Patterns (CBP) dataset by the United States Census Bureau.[32] Before going into the calculations, we would like to establish the appropriateness of our methodology and analysis in

[32] As explained in the Data section, we use the version of the data provided by Eckert et al. (2020).

the subnational context. Like countries, cities also need to provide industries with the capabilities needed for competitive production. A natural extension of our model would predict that industries are more likely to co-agglomerate if they share capabilities. Both Marshallian and Jacobsian agglommerative forces are not just active in the supply side but also in the demand side. For instance, as an example of Marshallian force, we can think of consumers as a part of the input-output network as terminal nodes, and similarities in consumer tastes could result in agglomeration of suppliers. Similarly in the Jacobsian side, diverse amenities result in more product varieties, which are appealing to consumers. Here, we are agnostic about the supply side and demand side of the agglomeration forces, but we assume that our Production Ability variables capture all these latent aspects.

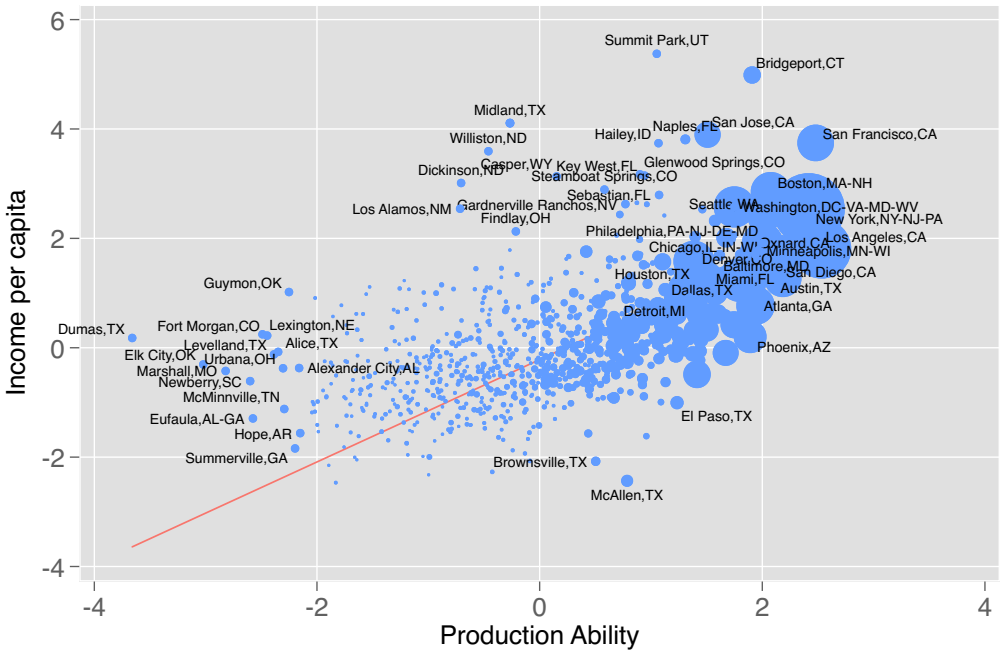
First, we estimate the Production Ability associated with each city.[33] Table 1.8 shows the list of top and bottom ten cities in the US according to the Production Ability estimates using data for year 2015. The ranking has Los Angeles metropolitan area at the top, followed by San Francisco and New York. Boston and Chicago are also listed among the top cities. At the bottom ten, we find cities which are intensive on a few industries, or with industrial production heavily reliant on natural resources.

City Production Ability levels are also correlated with the other complexity measures like ECI, Fitness and Diversity. Table 1.9 shows that these correlations are between 74 and 86% with each measure. Next, we explore whether the Production Ability is correlated with income per capita at the city level. Figure 1.5 shows the relation of average personal income and Production Ability using data for year 2015[34]. In the figure, bubbles are proportional to the total number of workers in each city, according to the Census Bureau. What we observe is that the both size and the income per capita are correlated with the Production Ability levels of cities.

When we shift our attention to industries with a combined ranking of Sensitivity and Specificity,

[33] Figure 1.7 shows the Production Ability levels for all cities in the United States.
[34] Personal income data at CBSA level was obtained from the US Bureau of Economic Analysis.

Figure 1.5: Production Ability and average income of US cities



Note: The figure shows the correlation between Production Ability and income per capita cities in the US (CBSAs) for year 2015. Variables are normalized to have mean of zero and standard deviation of one. The size of the bubbles are proportional to total employment in each city. The CBSAs are labeled with their central city name, along with the states that they are located in. We exclude Jackson, WY from the figure, since it is an outlier in terms of personal income, with a level 8 times higher than the simple mean across CBSAs.

Table 1.8: Top and Bottom Cities in the US According to Production Ability

(a) Top cities **(b)** Bottom cities

Name of CBSA	Code	Rank	Production Ability	Name of CBSA	Code	Rank	Production Ability
Los Angeles-Long Beach-Anaheim, CA	31080	1	2.532	Urbana, OH	46500	895	-2.306
San Francisco-Oakland-Hayward, CA	41860	2	2.478	Alice, TX	10860	896	-2.350
New York-Newark-Jersey City, NY-NJ-PA	35620	3	2.415	Levelland, TX	30220	897	-2.387
Miami-Fort Lauderdale-West Palm Beach, FL	33100	4	2.183	Fort Morgan, CO	22820	898	-2.448
San Diego-Carlsbad, CA	41740	5	2.177	Lexington, NE	30420	899	-2.491
Denver-Aurora-Lakewood, CO	19740	6	2.154	Eufaula, AL-GA	21640	900	-2.576
Austin-Round Rock, TX	12420	7	2.124	Newberry, SC	35140	901	-2.601
Boston-Cambridge-Newton, MA-NH	14460	8	2.074	Marshall, MO	32180	902	-2.822
Baltimore-Columbia-Towson, MD	12580	9	2.035	Elk City, OK	21120	903	-3.023
Chicago-Naperville-Elgin, IL-IN-WI	16980	10	2.025	Dumas, TX	20300	904	-3.660

Note: The cities are ranked according to Production Ability levels for year 2015. The reported variable is normalized to have mean of zero and standard deviation of one.

Table 1.9: Correlation between city-level measures.

	Production Ability	ECI	Diversity	Fitness
Production Ability	1			
ECI	0.780^{***}	1		
Diversity	0.849^{***}	0.458^{***}	1	
Fitness	0.760^{***}	0.607^{***}	0.772^{***}	1

$^{*}\, p < 0.05$, $^{**}\, p < 0.01$, $^{***}\, p < 0.001$

the Monetary Authorities-Central Bank and Cable and Other Subscription Programming industries at the top (Panel A of Table 1.10). Monetary Authorities are present where there is a vibrant economy, and tend to employ highly qualified workers. Along with these industries, there are four industries from the Information Sector (i.e., NAICS codes starting with 51) among the top 10. The bottom of the list is populated with very ubiquitous industries such as Gasoline Stations, Other General Merchandise Stores, Automotive Parts, Accessories, and Tire Stores (Panel B of Table 1.10). The rankings does not change dramatically when we look at the rankings based on Sensitivity and Specificity separately as shown in Tables 1.22 and 1.23 of the Appendix.

Conspicuously missing among the top-ranked industries are manufacturing industries.[35] The

[35] Unfortunately, In the international context, there is no detailed level dataset containing trade in services.

Table 1.10: Industries according to industry sophistication

Industry Title	NAICS-4 Code	Ranking Overall	Ranking Specificity	Ranking Sensitivity
Top Industries				
Monetary Authorities-Central Bank	5211	1	1	1
Cable and Other Subscription Programming	5152	2	2	2
Scheduled Air Transportation	4811	3	3	5
Satellite Telecommunications	5174	4	5	4
Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	7114	5	7	3
Software Publishers	5112	6	4	8
Manufacturing and Reproducing Magnetic and Optical Media	3346	7	8	7
Sound Recording Industries	5122	8	11	6
Other Personal Services	8129	9	6	11
Securities and Commodity Contracts Intermediation and Brokerage	5231	10	9	9
Bottom Industries				
General Freight Trucking	4841	265	257	246
Specialized Freight Trucking	4842	266	261	260
Religious Organizations	8131	267	265	265
Consumer Goods Rental	5322	268	264	268
Death Care Services	8122	269	269	267
Nursing Care Facilities (Skilled Nursing Facilities)	6231	270	271	269
Lawn and Garden Equipment and Supplies Stores	4442	271	270	271
Automotive Parts, Accessories, and Tire Stores	4413	272	272	272
Other General Merchandise Stores	4529	273	273	273
Gasoline Stations	4471	274	274	274

Note: This table shows the ranking of industry Sophistication levels for 2015. The overall score is calculated as the sum of rankings of products according to Sensitivity and Specificity. Then, the industries are re-ranked based on their overall score.

only manufacturing industry in top-10 list in Panel A in Table 1.10 is Manufacturing and Reproducing Magnetic and Optical Media. This might look contradictory with the international context, where the top industries are in manufacturing. But there are some differences between subnational and international cases that we would like to highlight. First, the mobility of goods and factors are not limited (mostly) in the subnational context. Apart from the country borders, also the cultural similarity within a country makes people more mobile. Hence, it might be easier to bring workers and inputs to a small place to build a large factory. For instance, in recent years, many large automobile manufacturing plants have been built in relatively remote places such as the BMW plant in Spar-

tanburg county in South Carolina with its 11 thousand employees. Hence, we expect to see more deviations from our model in the manufacturing industries, with its larger establishments. Consistent with our estimations, Diodato et al. (2018) find that the co-agglomerative forces are more powerful in the service industries compared to manufacturing industries in the United States. Moreover, Fort et al. (2018) document the loss of manufacturing jobs – close to 6.6 million employees – between its peak in 1977 and 2012, and show that until year 2000 the manufacturing employment moved away from north and east to south and west. But since year 2000 the decline in manufacturing employment is found everywhere in the United States. This decline is tied to both international trade and technological change. Fort (2017) shows that the manufacturing firms in high-wage locations in the United States are more likely to fragment their value chains, leading to employment declines in manufacturing part of their businesses.

To test whether manufacturing or service industries drive the overall Production Ability levels observed in the data, we repeat the calculations only using manufacturing or only using services. We then regress the Production Ability using all industries against the ones obtained from manufacturing and services. Table 1.11 shows that ability levels inferred from both manufacturing and service industries are significant determinants of overall Production Ability, with service ability having a three to five times larger coefficient. Interestingly, the overall Production Ability decreases with the share in manufacturing employment.[36] Why do we see such differences between overall, manufacturing and services abilities? The test analogy can be helpful to understand the difference. For instance, the SAT, which is widely-used in the United States for college admissions, is composed of two sections: Math and Evidence-Based Reading and Writing. This test is designed to elicit the ability of students to succeed in college. Students are required to answer both sections and the cor-

[36] The number of cities that we can calculate Production Ability based on manufacturing industries is 789, since for 115 cities we do not have presence of at least three manufacturing industries with $LQ \geq 1$ to be able to do the estimation.

relation between the results across sections is around 58%.[37] At the end, most colleges use the sum of these parts as the final score to measure student ability. Similarly, the manufacturing and service industries need both overlapping and non-overlapping capabilities. Hence, the Production Ability levels estimated from different sets of industries are not expected to overlap completely. But overall Production Ability captures a combination of abilities inferred from manufacturing, services and all other industries.

Table 1.11: Overall Production Ability and Production Ability inferred from only manufacturing or service industries.

	(1) 2005	(2) 2010	(3) 2015	(4) All	(5) 2005	(6) 2010	(7) 2015	(8) All
Production Ability - Manufacturing	0.16***	0.25***	0.28***	0.23***	0.22***	0.30***	0.33***	0.28***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Production Ability - Services	0.91***	0.87***	0.86***	0.88***	0.78***	0.76***	0.73***	0.75***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Manufacturing share					-2.14***	-1.75***	-1.81***	-1.91***
					(0.26)	(0.27)	(0.25)	(0.26)
Services share					-0.58*	-0.12	0.13	-0.13
					(0.31)	(0.29)	(0.26)	(0.26)
Observations	789	789	789	2,367	789	789	789	2,367
R-squared	0.87	0.86	0.87	0.86	0.88	0.87	0.88	0.88
Year FE	-	-	-	Yes	-	-	-	Yes

Note: The dependent variable is (the overall) Production Ability of the year indicated in the column, or using all years as in columns 4 and 8. The dependant and all control variables are normalized to have in each year a mean of zero and standard deviation of one. Robust standard errors in parentheses clustered by city. *** p<0.01, ** p<0.05, * p<0.1

We turn to the correlation of our Product Sophistication with other industry complexity measures from the literature. In Table 1.12, we show that the Sensitivity and the Specificity parameters exhibit high positive correlations with PCI, and Product Quality based on Fitness. The correlation

[37] See raw correlation numbers reported in Table 4 of https://collegereadiness.collegeboard.org/pdf/national-sat-validity-study.pdf

of all variables with Ubiquity is negative and statistically significant. Similar to the international case, the Sensitivity shows the highest correlation with PCI, whereas the Specificity shows highest correlation with Ubiquity albeit with a negative sign. Both measures are correlated with each other because the most sophisticated industries have both high Specificity and Sensitivity.

Table 1.12: Correlation between industry measures (2015)

	Sensitivity	Specificity	PCI	Ubiquity	Quality
Sensitivity	1				
Specificity	0.799***	1			
PCI	0.879***	0.666***	1		
Ubiquity	-0.650***	-0.894***	-0.472***	1	
Quality	0.549***	0.660***	0.489***	-0.335***	1

*** p<0.01, ** p<0.05, * p<0.1

Do our industry variables correlate with other indicators of industry characteristics? To answer this question we take advantage of the available US data to characterize different aspects of industries such as human capital requirements, wages and input-output structures. Table 1.13 reports the results of correlations between our sophistication measures and industry characteristics. The first set of measures come from OES database and are related to employment size and wages in industries. When we correlate the Sensitivity and Specificity measures with the logarithm of the employment size in the industry, both measures are negatively correlated, indicating that industries that have higher sophistication do not hire as broadly. In other words, large industries do not appear to be sophisticated. Last two measures from OES are the average hourly wage and the wage inequality measure calculated by dividing the hourly wage of a worker at 90th percentile with that of a worker at 10th percentile. Both measures are correlated with Sensitivity and Specificity. Hence, sophisticated industries pay higher wages on average but they also have higher pay inequality.

The next set of characteristics are related to the education and training required by an industry. By combining the O*NET's Education, Training, and Experience Category with the Occupational

Table 1.13: Correlations with industry characteristics.

	Sensitivity	Specificity
Employment, Log	-0.22***	-0.48***
Avg. Hourly Wage	0.41***	0.50***
Wage Ineq. (90/10)	0.37***	0.40***
College Graduates, Ratio	0.42***	0.37***
Years of Schooling	0.38***	0.33***
Training	0.24***	0.37***
Upstreamness	-0.06	0.22***
Labor Share	-0.10	-0.16**
Capital Share	0.18**	0.30***

Note: Each cell reports the correlation between the variables in rows and columns. The first three variables, Employment, Wages and Wage Inequality, are obtained from Occupational Employment Statistics (OES). Next three variables, College Graduate Ratio, Years of Schooling and Training, are calculated by merging O*NET's Education, Training, and Experience Category with OES using occupations. Last three variables, Upstreamness (Antràs et al., 2012), Labor Share and Capital Share calculated from the Use Table for 2012 Input Output Tables provided by BEA. Correlations estimated using 274 industries. *** p<0.01, ** p<0.05, * p<0.1

Employment Statistics (OES) data, we came up with the estimated ratio of college graduates, average years of schooling, and average training required for each industry. All three measures are positively correlated with Sensitivity and Specificity, with slightly higher values for Sensitivity in schooling related measures. The Specificity measure shows a higher correlation with training variable compared to Sensitivity.

The final three measures come from the 2012 US Input-Output tables. The first measure is upstreamness (Antràs et al., 2012), which captures how far away an industry is from the final consumer. The Specificity measure is correlated with the upstreamness whereas the Sensitivity is not. The second measure is the labor share, which is calculated as the share of labor compensation to the value added in each industry. This time, Specificity is negatively correlated with the labor share

measure, while Sensitivity has no significant positive or negative relationship with it. The final measure is the capital share, the ratio of surplus in the industry to the value added. Both Sensitivity and Specificity are correlated with the capital share in an industry. Combining last two measures, we can say that highly specific and highly sensitive industries both operate with larger surpluses, but the industries with high specificity do not distribute the value added as income to the employees as much.

1.4.5 Growth of cities

In this section we explore whether Production Ability is predictive of economic growth in cities.[38] Following the literature initiated by Glaeser et al. (1992) we use two indicators of economic growth: growth of average personal income, and growth of total city employment. We use a similar specification as equation 1.6, but instead, our dependent variable is the growth in cities. Table 1.14 shows estimates of city growth over 5 and 10 years, with columns 1, 3, 5 and 7 presenting the baseline estimates. In even numbered columns, we show estimates where we use Production Ability, finding that it is strongly correlated with income and employment growth. The estimated coefficients imply that the cities with an additional one standard deviation in Production Ability are expected to have their average income grow by 0.24 – 0.17% and employment grow by 0.54 – 0.52% faster per year, according to estimates using 5 or 10 year horizon, respectively. Interestingly, the estimate for employment growth is twice as large compared to the one for income growth.

How does the Production Ability compare with other variables in predicting economic growth of cities? Specifically, as previously done for countries above, we explore other proxies of the productive capabilities of cities from the literature. Again, we use Diversity, Economic Complexity (ECI) and Fitness measures as independent variables. Table 1.15 presents the results, with 5-year

[38] In this analysis we restrict our sample to the cities that we have both manufacturing and service ability values, which gives us 789 cities. The unrestricted regressions, as well as the regressions involving manufacturing and service abilities, are provided in the Appendix.

Table 1.14: City income and employment growth

	5 year				10 year			
	income		employment		income		employment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Income per capita, log	-0.02	-0.06	0.10*	-0.00	0.05	0.02	0.14**	0.03
	(0.04)	(0.04)	(0.05)	(0.06)	(0.04)	(0.04)	(0.05)	(0.06)
Employment, log	-0.07**	-0.25***	0.20***	-0.19***	-0.11***	-0.23***	0.17***	-0.19***
	(0.03)	(0.04)	(0.04)	(0.06)	(0.03)	(0.04)	(0.05)	(0.06)
Production Ability		0.24***		0.54***		0.17***		0.52***
		(0.04)		(0.07)		(0.04)		(0.06)
Observations	1,578	1,578	1,578	1,578	789	789	789	789
R-squared	0.04	0.06	0.25	0.29	0.02	0.04	0.07	0.15

Note: The dependent variable is the geometric growth rate of income per capita or employment over 5 and 10 year periods, respectively. All control variables are normalized to have in each year a mean of zero and standard deviation of one. All regressions include year fixed-effects. Robust standard errors in parentheses clustered by city. *** p<0.01, ** p<0.05, * p<0.1

income growth in columns 1 to 7 and 5-year employment growth in columns 8 to 14. As expected, Production Ability, Diversity and ECI are positively and statistically significantly correlated with income and employment growth. Fitness, on the other hand, is only correlated with income growth. Interestingly, when we use Production Ability and add other variables one by one, we find that only for income growth ECI survives as a significant predictor of growth, but in rest of the specifications none of the other variables are significant. Overall, the picture that emerges is that regardless of the measure of the economic growth definition used (either income or employment) Production Ability is more correlated with economic growth of cities than other variables.

Table 1.15: City income and employment growth under competing variables

	Income growth							Employment growth						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Income per capita, log	-0.06	-0.02	-0.07*	-0.03	-0.06	-0.07*	-0.07*	-0.00	0.09	-0.02	0.10*	-0.00	-0.03	0.01
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Employment, log	-0.25***	-0.19***	-0.16***	-0.19***	-0.25***	-0.24***	-0.31***	-0.19***	-0.06	-0.01	0.20***	-0.18***	-0.17***	-0.09
	(0.04)	(0.05)	(0.03)	(0.05)	(0.05)	(0.04)	(0.06)	(0.06)	(0.07)	(0.05)	(0.08)	(0.07)	(0.06)	(0.09)
Production Ability	0.24***				0.24***	0.18***	0.23***	0.54***				0.55***	0.36***	0.56***
	(0.04)				(0.05)	(0.06)	(0.04)	(0.07)				(0.09)	(0.09)	(0.07)
Diversity		0.15***			-0.00				0.33***			-0.02		
		(0.04)			(0.05)				(0.06)			(0.08)		
Economic Complexity			0.17***			0.08*				0.41***			0.23***	
			(0.03)			(0.05)				(0.05)			(0.06)	
Fitness				0.13***			0.08				-0.00			-0.13*
				(0.05)			(0.05)				(0.07)			(0.07)
Observations	1,578	1,578	1,578	1,578	1,578	1,578	1,578	1,578	1,578	1,578	1,578	1,578	1,578	1,578
R-squared	0.06	0.05	0.06	0.05	0.06	0.06	0.06	0.29	0.26	0.28	0.25	0.29	0.29	0.29

Note: The dependent variable is the geometric growth rate over 5 year periods of income per capita or employment. All control variables are normalized to have mean of zero and standard deviation of one in each year. All regressions include year fixed-effects. Robust standard errors in parentheses clustered by city. *** p<0.01, ** p<0.05, * p<0.1

1.4.6 Industry Appearances and Disappearances in Cities

Our model also has implications for emergence or decline of industries in cities. Like in the international case, the likelihood of a city of making a product as formulated in Equation **??** should be predictive of future industry appearances or disappearances.[39] Here, we test this hypothesis using a Logit Model. Instead of RCA, we use the Location Quotient (LQ) measure to determine the presences and absences. We use the same thresholds for the industry presences and absences as in Table **??**. We control for Production Ability, product Sensitivity and Specificity in our main specification for the reasons described in Section 1.4.3. In a second specification, we also add ECI, PCI, Diversity and Ubiquity to control for additional city and product characteristics.

Columns 1 to 4 of Table 1.16 shows that higher likelihood estimated by our model in the initial year leads to a higher probability of appearance in the final year in all cases for five year time hori-

[39] The distribution of the likelihood variable for cities is given in Figure 1.9 of the Appendix.

zons.[40] Columns 5 to 8 show the industries have a lower probability of disappearing with a higher likelihood level in the initial year. The magnitude of likelihood variable is higher for the disappearances than the appearances. The result implies that sustaining an industry requires necessary capabilities but jumping to a new industry involves a choice component.

Table 1.16: Predicting appearance and disappearance of industries

	Appearances				Disappearances			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Final :	$LQ_{c,p}^{t+5} \geq 1$	$LQ_{c,p}^{t+5} \geq 1$	$LQ_{c,p}^{t+5} \geq 1$	$LQ_{c,p}^{t+5} \geq 1$	$LQ_{c,p}^{t+5} < 1$	$LQ_{c,p}^{t+5} < 1$	$LQ_{c,p}^{t+5} \leq 0.1$	$LQ_{c,p}^{t+5} \leq 0.1$
Initial:	$LQ_{c,p}^{t} < 1$	$LQ_{c,p}^{t} < 1$	$LQ_{c,p}^{t} \leq 0.1$	$LQ_{c,p}^{t} \leq 0.1$	$LQ_{c,p}^{t} \geq 1$	$LQ_{c,p}^{t} \geq 1$	$LQ_{c,p}^{t} \geq 1$	$LQ_{c,p}^{t} \geq 1$
Likelihood	2.743***	3.421***	1.018***	3.570***	-2.420***	-2.970***	-6.222***	-6.356***
	(0.070)	(0.092)	(0.199)	(0.334)	(0.075)	(0.097)	(0.185)	(0.287)
Production Ability	-0.252***	-0.164***	-0.532***	-0.161***	-0.091***	-0.044*	-0.488***	-0.111**
	(0.007)	(0.023)	(0.016)	(0.046)	(0.008)	(0.026)	(0.017)	(0.045)
Sensitivity	-0.161***	0.283***	-0.425***	0.612***	0.346***	0.116***	-0.130***	0.259***
	(0.011)	(0.019)	(0.023)	(0.048)	(0.012)	(0.018)	(0.021)	(0.043)
Specificity	0.165***	0.135***	0.400***	0.239***	-0.199***	-0.125***	0.483***	0.617***
	(0.016)	(0.024)	(0.030)	(0.045)	(0.018)	(0.027)	(0.032)	(0.048)
ECI		-0.108***		-0.216***		0.036**		0.097***
		(0.014)		(0.032)		(0.017)		(0.033)
PCI		-0.497***		-1.027***		0.199***		-0.380***
		(0.018)		(0.042)		(0.014)		(0.028)
Diversity		-0.069***		-0.496***		-0.061***		-0.556***
		(0.016)		(0.034)		(0.018)		(0.034)
Ubiquity		-0.121***		-0.393***		0.153***		0.184**
		(0.022)		(0.050)		(0.031)		(0.080)
Observations	245,520	245,520	55,455	55,455	127,502	127,502	127,502	127,502
Switches	29017	29017	6183	6183	29522	29522	7268	7268
Pseudo R2	.028	.033	.038	.060	.045	.048	.215	.227
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the binary appearance and disappearance values of industries, based on the limits in the column labels. All control variables are normalized to have in each year a mean of zero and standard deviation of one. Robust standard errors in parentheses clustered by country. *** p<0.01, ** p<0.05, * p<0.1

[40] Results for ten year time horizons can be found in Table 1.27 of the Appendix.

1.5 Conclusions

In this paper we have developed new measures that capture the productive ability of countries and sophistication of products. Our measures are motivated through a simple capability-based model, which can be estimated empirically using a well-established maximum-likelihood approach.

Production Ability captures information about the extent of capabilities embedded in countries and cities. Interestingly, just by using information on which products or industries are produced in each location, the measures we estimate are strongly correlated with income levels and growth prospects of cities and countries. Our Production Ability and Sophistication measures are also correlated with previously established measures of country and industry characteristics in the literature, yet add valuable information in predicting economic growth compared to these other measures. At the subnational level, it is a well-documented fact that the agglomeration starts at the city level and these agglomerative forces are intimately related to the capabilities that are heart of our models.

Our method estimates two distinct measures of product or industry sophistication: Sensitivity and Specificity. Compared to measures introduced in Hidalgo and Hausmann (2009), which are highly used in the literature, the Sensitivity parameter is highly correlated with PCI, while Specificity is more tightly linked with the ubiquity of products. We also showed that these parameters are differentially correlated with the industry characteristics obtained from the input-output tables or occupational employment statistics. Our results suggest that indicators of human capital in an industry are correlated with our measures. We also find that the larger the industry in terms of employment, the less the importance of capabilities for production. This could be driven by the fact that industries such as restaurants, supermarkets or gasoline stations are among the largest employers in the US and are found ubiquitously in the country. Finally, industries that are dependent of specific capabilities – like cooper or petroleum – tend to be relatively capital intensive and located upstream along the supply chain. Interestingly, from our analysis using employment data across

cities in the US, we conclude that manufacturing industries are not featured predominantly among the top industries, either ranked by Product Sensitivity or Specificity. The manufacturing industry has been undergoing a great transformation in the US, with significant employment losses since the time the manufacturing employment reached its peak in 1977 (Fort et al., 2018). Moreover, many firms transformed their supply chains with the advancements of technology and increase in global trade (Fort, 2017).

We believe that our Production Ability and Product Sophistication measures have the potential to be used widely by policymakers. First, the match between Production Ability and product Sophistication measures could be utilized to generate a yard-stick for development levels. Following the idea of nestedness discussed in the paper, for every location we can come up with the products or industries that should be the next in line by knowing what its being made in that location. Hence, we can establish a "ladder" on which locations climb. Second, our measure gives a way to calculate likelihood of making a product for a location, which can be used to predict product appearance and disappearances. This information can be used to understand surprising absences or un-grounded presences. For surprising absences the policymakers can investigate the missing capabilities. For un-grounded presences, for which the industry might likely disappear in the future, policymakers might design policies that fill in the capability gap. Although, we do not directly reveal the capabilities, the policymakers or analysts can do additional studies to uncover where the binding constraints are. Third, the two-dimensional nature of the product sophistication is a clear advancement over earlier measures like PCI and Quality, as our measures capture complementary dimensions for products. For instance, the appearance of a product exhibiting low-sensitivity and high-specificity could not be achieved just by accumulating capabilities. A product showing high-sensitivity and high-specificity, on the other hand, are the most demanding products capability-wise. As a fourth point, our measures could be used in conjunction with the inter-industry relatedness metrics, like product space (Hidalgo et al., 2007), to identify attractive opportunities for locations,

such as smart specialization patterns (Balland et al., 2018). Last but not least, as we have shown in the empirical section, the data needed for these indicators is readily available and the estimation method is easy to implement. Thus, other researchers could update the estimates and build on these results for new applications.

One important assumption of our current model is that locations are likelier to make more products as they increase their Production Ability. This follows the underlying motivation behind other complexity measures such as ECI (Hidalgo and Hausmann, 2009) and Fitness (Tacchella et al., 2012). However, as shown by Imbs and Wacziarg (2003), as countries grow they first diversify but in later stages they specialize. For vast majority of countries diversification is the dominant strategy. Nevertheless, we can still improve our methodology by incorporating specialization into the model. We estimate the likelihood of a country making a product as a function of the difference between Production Ability of the country and the Sophistication of the product. For this purpose, we use a logistic function, which is always increasing. Instead, one can use a symmetric distribution, such as a Gaussian distribution, to capture specialization. The Gaussian function has a well-defined maximum at zero and the likelihood will be maximized if the difference between the Production Ability and Sophistication is close to zero, which will generate the intended specialization feature. Implementing this change could be a worthwhile extension of the work presented here.

In sum, our approach presents an empirical methodology building on the economic complexity literature, which considers development as the process of accumulating a larger variety of capabilities. This departs from the traditional view, in which the capacity for production is thought to be captured just by accumulating and allocating aggregated factors such as capital and labor. Approaching the problem with the capability angle enabled us to develop model-guided measures that could be in new applications. We believe that this perspective may help research move forward to answer some of the old questions of economic development still pending in a somewhat different take.

1.6 Appendix

1.6.1 Cross Country Economic Growth Regressions

Table 1.17: Variable sources and definitions

Variable	Source	Definition
Growth	WDI	Growth of GDP per capita over five or 10 year periods using geometric rates (2010 U.S. dollars)
Income per capita, log	WDI	Logarithm of initial real GDP per capita (2010 U.S. dollars)
Investment (% of GDP)	WDI	Gross fixed capital formation as a share of GDP
Years of schooling, log	Barro-Lee	Log of the initial average years of schooling attained
Population growth, %	WDI	Growth of total population over the previous 5 years
Investment price	PWT 9.1	Price level of capital formation, price level of USA GDP0 in 2011=1
Urban share	WDI	Urban population (% of total population)
Population share under 15	WDI	Population ages 0-14 (% of total population)
Openness	WDI	Trade openness, calculated as exports plus imports as a share of GDP
NNRR exports, (% of GDP)	Hausmann	Exports of natural resources related products as a share of nominal GDP
Production Ability	This paper	Production Ability calculated using exports from UN Comtrade via Bustos-Yildirim
Economic Complexity Index (ECI)	This paper	
Fitness	This paper	

Additional data comments :

- The data coming from the World Development Indicators was retrieved in October 2019.
- The Barro-Lee education attainment dataset corresponds to the version 2.2, retrieved in October 2019.
- All variables in ratios we calculated using the average of the previous and current periods, in order capture fundamental relations in the regression avoiding short term fluctuations.
- The growth of GDP per capita was winsorized in each year (1 and 99 percentiles) with the

goal of limiting the influence of outliers in the regressions. The point estimates of the regressions are not dependent of this decision, it mostly affects the size of standard errors.

- There is a few cases in which the investment share variable in the WDI (ne_gdi_ftot_zs) is missing some observations while there is data for for the level of investment and GDP at current prices is present. In such cases we updated the missing observations for investment share using the variable created manually.

- We calculate the openness using the exports and imports (tx_val_mrch_cd_wt and tm_val_mrch_cd_wt variables from the WDI) over GDP (ny_gdp_mktp_cd). For cases were the trade variables are not available in the WDI we update the data using total exports and imports coming UN Comtrade via Bustos and Yildirim (2020). Specifically, the cases are Albania (1980 and 1985) and Belgium (1965, 1970, 1975, 1980, 1990, 1995).

- For some countries in a few years there is no data of GDP at current prices, which we need in order to calculate investment as a share of GDP and Trade Openness. To fix those cases we used a regression using the available data for each country and then used the predicted GDP. Specifically we regressed the available data on GDP at current prices (in logs) against GDP at constant prices and the consumer price index (both in logs), and imposed the condition that there must be 20 observations and an R^2 of 90%. Using this procedure we obtained an estimate for the GDP of Albania (1980), Switzerland (1970 and 1975), and Indonesia (1965).

1.6.2 Additional Figures and Tables

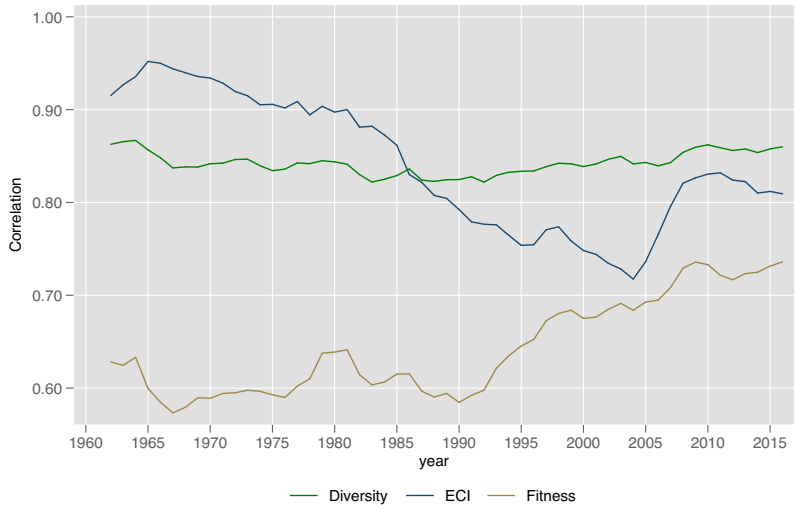
Table 1.18: List of Countries

Albania	Estonia	Lithuania	Saudi Arabia
Algeria	Ethiopia*	Madagascar*	Senegal
Angola*	Finland	Malawi	Serbia*
Argentina	France	Malaysia	Singapore
Australia	Gabon	Mali	Slovak Republic
Austria	Georgia*	Mauritania	Slovenia
Azerbaijan*	Germany	Mauritius	South Africa
Bangladesh	Ghana	Mexico	Spain
Belarus*	Greece	Moldova*	Sri Lanka
Belgium	Guatemala	Mongolia	Sweden
Bolivia	Guinea*	Morocco	Switzerland
Bosnia and Herzegovina*	Honduras	Mozambique	Syrian Arab Republic*
Botswana	Hungary	Namibia	Tajikistan
Brazil	India	Netherlands	Tanzania
Bulgaria	Indonesia	New Zealand	Thailand
Cambodia	Iran, Islamic Rep.	Nicaragua	Trinidad and Tobago*
Cameroon	Ireland	Nigeria*	Tunisia
Canada	Israel	North Macedonia*	Turkey
Chile	Italy	Norway	Turkmenistan*
China	Jamaica	Oman*	Uganda
Colombia	Japan	Pakistan	Ukraine
Congo, Rep.	Jordan	Panama	United Arab Emirates
Costa Rica	Kazakhstan	Papua New Guinea*	United Kingdom
Cote d'Ivoire	Kenya	Paraguay	United States
Croatia	Korea, Rep.	Peru	Uruguay
Cuba*	Kuwait	Philippines	Uzbekistan*
Czech Republic	Kyrgyz Republic	Poland	Venezuela, RB
Denmark	Lao PDR	Portugal	Vietnam
Dominican Republic	Latvia	Qatar*	Yemen, Rep.*
Ecuador	Lebanon*	Romania	Zambia*
Egypt, Arab Rep.	Libya*	Russian Federation	Zimbabwe
El Salvador			

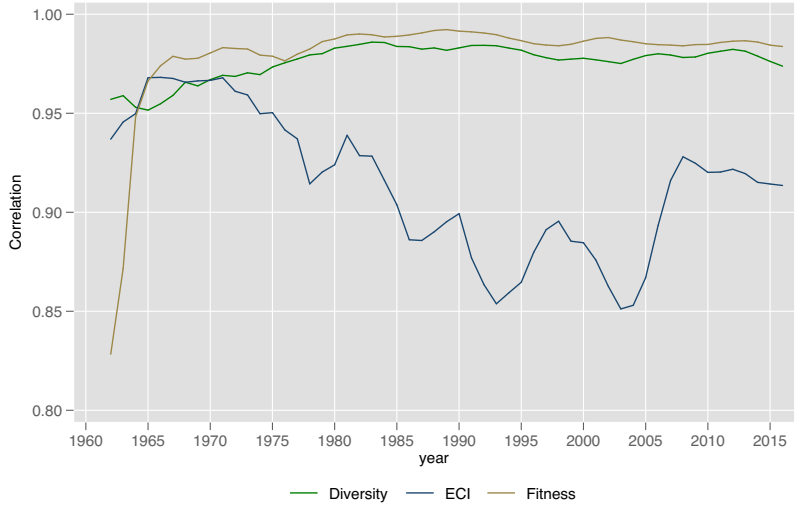
Note: The 125 countries used in the list were used to calculate the Production Ability measure. We denote with an asterisk (*) the 24 countries that are not part of the regression due to missing data in the control variables.

Figure 1.6: Correlation between Production Ability and other complexity measures over time

(a) Pearson correlation



(b) Spearman's rank correlation



Note: This figure shows the evolution of correlation between Production Ability variable with Diversity, ECi and Fitness variables from the literature. Panel (a) is calculated using Pearson correlation, whereas Panel (b) uses Spearman's rank correlation.

Table 1.19: List of products by Sensitivity

Top products

Products	SITC4 Code	Ranking	Sensitivity
Nails, Nuts & Bolts	6940	1	4.409
Other Vehicles Parts	7849	2	4.035
Working Metal & Metal Carbides Machines N.E.S.	7367	3	3.536
Articles Of Iron Or Steel N.E.S.	6997	4	3.488
Mechanical Tools For Building	7493	5	3.476
Internal Combustion Engines For Motor Vehicles	7132	6	3.476
Valves	7492	7	3.298
Parts Of Paper Making Machines	7259	8	3.066
Welding, Brazing & Cutting Machines & Appliances N.E.S.	7373	9	2.828
Other Articles Of Rubber	6289	10	2.803

Bottom products

Manganese	2877	651	-1.449
Other Non-Ferrous Base Metals	2879	652	-1.478
Not Agglomerated Iron Ore	2815	653	-1.542
Petroleum Gases	3414	654	-1.551
Other Sulphurs	2741	655	-1.555
Natural Rubber, Latex & Gums	2320	656	-1.565
Sesame Seeds	2225	657	-1.628
Raw & Roasted Cocoa Beans	0721	658	-1.679
Liquified Hydrocarbons	3413	659	-1.943
Crude Petroleum	3330	660	-2.382

Note: Product Sensitivity levels are for 2015. The reported variable is normalized to have mean of zero and standard deviation of one.

Table 1.20: List of products by Specificity

Top products

Products	SITC4 Code	Ranking	Specificity
Working Metal & Metal Carbides Machines N.E.S.	7367	1	4.249
Textile Machinery	7244	2	3.905
Nails, Nuts & Bolts	6940	3	3.107
Wood-Based Panels	6344	4	3.015
Reciprocating Pumps	7421	5	2.839
Silicones	5827	6	2.604
Rolling Mills	7372	7	2.580
Dishwashers	7753	8	2.580
Asbestos	2784	9	2.528
Photographic Chemicals	8821	10	2.492

Bottom products

Wheat Or Meslin Meal Or Flour	0460	651	-1.846
Paper Packing Containers	6421	652	-1.914
Fresh Or Dried Fruit N.E.S.	0579	653	-1.983
Cement	6612	654	-2.029
Sugar Confectionary (Not Chocolate)	0620	655	-2.030
Iron & Steel Waste	2820	656	-2.206
Edible Products N.E.S.	0980	657	-2.223
Bakery	0484	658	-2.231
Closable Plastic Packing	8931	659	-2.416
Other Non-Ferrous Base Metals	2882	660	-2.856

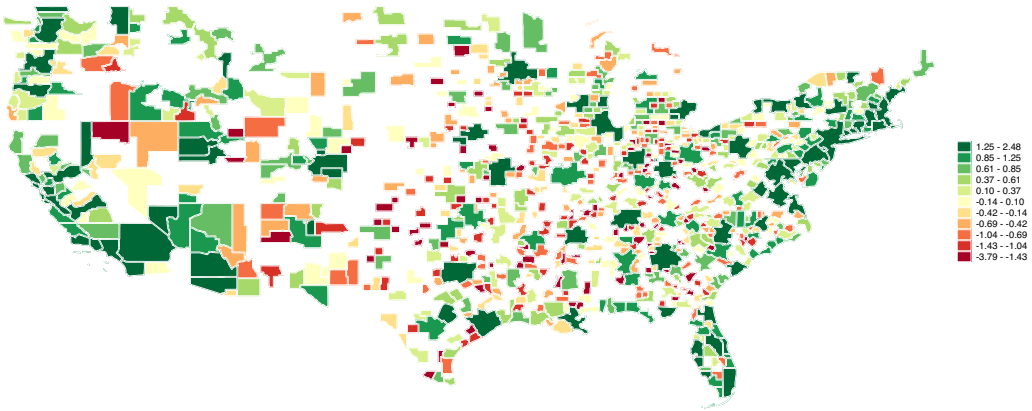
Note: Product Specificity levels are for 2015. The reported variable is normalized to have mean of zero and standard deviation of one.

Table 1.21: Economic growth, competing measures with country FE

	5 year growth rate							10 year growth rate						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Income per capita, log	-3.11***	-3.14***	-2.87***	-3.12***	-3.17***	-2.79***	-3.14***	-3.69***	-3.68***	-3.58***	-3.51***	-3.71***	-3.59***	-3.54***
	(0.98)	(0.89)	(0.96)	(0.87)	(0.93)	(0.95)	(0.90)	(0.88)	(0.81)	(0.86)	(0.84)	(0.86)	(0.92)	(0.86)
Production Ability	0.77***				0.51	1.51***	0.77***	0.95***				0.85**	1.40***	0.97***
	(0.27)				(0.34)	(0.33)	(0.27)	(0.28)				(0.36)	(0.32)	(0.28)
Diversity		1.04***			0.63				0.95***			0.24		
		(0.31)			(0.39)				(0.30)			(0.40)		
ECI			-0.28			-1.41***				0.19			-0.86***	
			(0.33)			(0.37)				(0.34)			(0.32)	
Fitness				0.24			0.05				-0.06			-0.25
				(0.41)			(0.40)				(0.37)			(0.34)
Observations	822	822	822	822	822	822	822	394	394	394	394	394	394	394
R-squared	0.41	0.41	0.40	0.39	0.41	0.43	0.41	0.60	0.59	0.57	0.57	0.60	0.61	0.60
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

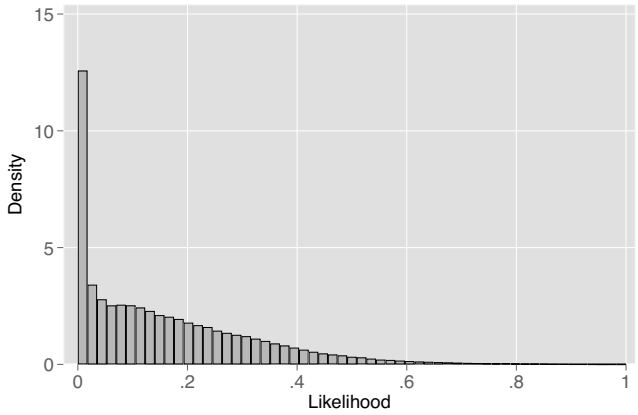
Note: The dependent variable is the geometric growth rate of per capita GDP over, 5 and 10 years, measured in constant dollars of 2010. All control variables are normalized to have mean of zero and standard deviation of one in each year. The description of the variables are provided in the text. Robust standard errors in parentheses clustered by country. *** p<0.01, ** p<0.05, * p<0.1

Figure 1.7: Production Ability of cities in the US



Note: This figure shows the geographical distribution of Production Ability levels across the continental United States using data for 2015. Cities are defined as core-based statistical areas. The highest Production Ability levels are concentrated in cities located in the Southwest and Northeast, followed by the rest of the coastal cities. Interestingly, cities with higher ability are relatively larger than the neighboring ones because they attract people from longer distances. The CBSAs are anchored by a county with population of at least 10,000 people and neighboring counties that are tied to the central county by commuting.

Figure 1.8: Distribution of Likelihood variable for international trade data



Note: The likelihood values is calculated using estimated Production Ability and product Sensitivity and Specificity values as shown in Equation **??**. The figure shows the distribution of likelihood parameter for all sample.

Table 1.22: List of top and bottom industries by Sensitivity

Top Industries

Industry Title	NAICS-4	Ranking	Sensitivity
Monetary Authorities-Central Bank	5211	1	4.304
Cable and Other Subscription Programming	5152	2	3.903
Scheduled Air Transportation	4811	3	2.858
Software Publishers	5112	4	2.718
Satellite Telecommunications	5174	5	2.333
Other Personal Services	8129	6	2.284
Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	7114	7	2.204
Manufacturing and Reproducing Magnetic and Optical Media	3346	8	2.129
Securities and Commodity Contracts Intermediation and Brokerage	5231	9	2.113
Urban Transit Systems	4851	10	2.012

Bottom Industries

Religious Organizations	8131	265	-1.499
Farm Product Raw Material Merchant Wholesalers	4245	266	-1.517
Support Activities for Mining	2131	267	-1.570
Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	8113	268	-1.582
Death Care Services	8122	269	-1.673
Lawn and Garden Equipment and Supplies Stores	4442	270	-1.902
Nursing Care Facilities (Skilled Nursing Facilities)	6231	271	-2.095
Automotive Parts, Accessories, and Tire Stores	4413	272	-2.734
Other General Merchandise Stores	4529	273	-3.327
Gasoline Stations	4471	274	-4.303

Note: Industry Specificity levels are for 2015. The reported variable is normalized to have mean of zero and standard deviation of one.

Table 1.23: List of top and bottom industries by Specificity

Top Industries

Industry Title	NAICS-4	Ranking	Specificity
Monetary Authorities-Central Bank	5211	1	4.610
Cable and Other Subscription Programming	5152	2	4.376
Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	7114	3	2.789
Satellite Telecommunications	5174	4	2.501
Scheduled Air Transportation	4811	5	2.433
Sound Recording Industries	5122	6	2.326
Manufacturing and Reproducing Magnetic and Optical Media	3346	7	2.255
Software Publishers	5112	8	2.253
Securities and Commodity Contracts Intermediation and Brokerage	5231	9	2.008
Other Financial Investment Activities	5239	10	1.857

Bottom Industries

Religious Organizations	8131	265	-1.532
Automobile Dealers	4411	266	-1.637
Death Care Services	8122	267	-1.652
Consumer Goods Rental	5322	268	-1.685
Nursing Care Facilities (Skilled Nursing Facilities)	6231	269	-1.824
Building Material and Supplies Dealers	4441	270	-2.014
Lawn and Garden Equipment and Supplies Stores	4442	271	-2.045
Automotive Parts, Accessories, and Tire Stores	4413	272	-2.813
Other General Merchandise Stores	4529	273	-2.913
Gasoline Stations	4471	274	-3.668

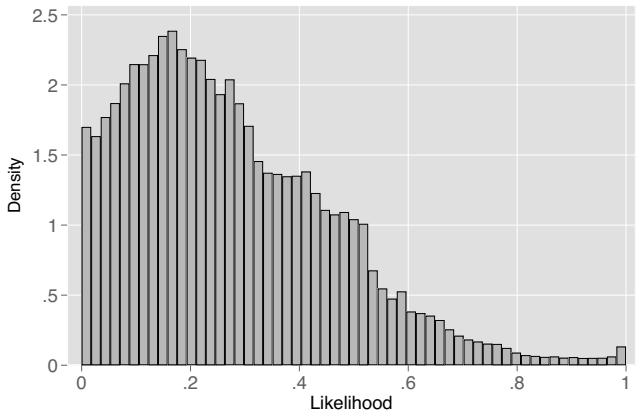
Note: Industry Sensitivity levels are for 2015. The reported variable is normalized to have mean of zero and standard deviation of one.

Table 1.24: City income and employment growth (all sample)

	5 year				10 year			
	income		employment		income		employment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Income per capita, logs	-0.17	-0.43*	0.80***	0.20	0.32*	0.12	0.96***	0.27
	(0.21)	(0.22)	(0.28)	(0.29)	(0.19)	(0.20)	(0.28)	(0.29)
Employment, logs	-0.08***	-0.19***	0.07**	-0.19***	-0.11***	-0.19***	0.05*	-0.20***
	(0.02)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)	(0.04)
Ability		0.20***		0.45***		0.13***		0.45***
		(0.04)		(0.06)		(0.03)		(0.05)
Observations	1,808	1,808	1,808	1,808	904	904	904	904
R-squared	0.03	0.04	0.18	0.21	0.03	0.05	0.04	0.12

Note: The dependent variable is the geometric growth rate of income per capita or employment over 5 and 10 year periods, respectively. All control variables are normalized to have mean of zero and standard deviation of one in each year. All regressions include year fixed-effects. Robust standard errors in parentheses clustered by city. *** p<0.01, ** p<0.05, * p<0.1

Figure 1.9: Distribution of Likelihood variable for the US subnational data



Note: The likelihood values is calculated using estimated Production Ability and product Sensitivity and Specificity values as shown in Equation **??**. The figure shows the distribution of likelihood parameter for all sample.

Table 1.25: City income and employment growth with ability obtained from manufacturing and service industries (5 years)

	Income growth				Employment growth			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Income per capita, logs	-0.06	-0.04	-0.07*	-0.07*	-0.00	0.05	0.02	0.02
	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.05)	(0.05)	(0.05)
Employment, logs	-0.25***	-0.13***	-0.20***	-0.22***	-0.19***	0.13**	0.03	0.03
	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.05)	(0.06)
Share in Manufacturing		-1.43***	-0.69	-0.87*		-5.64***	-5.13***	-5.06***
		(0.51)	(0.47)	(0.51)		(0.83)	(0.78)	(0.86)
Share in Services		0.02	-0.77	-0.83		-2.57***	-3.47***	-3.45***
		(0.57)	(0.60)	(0.60)		(0.93)	(0.94)	(0.94)
Ability - All	0.24***				0.54***			
	(0.04)				(0.07)			
Ability - Manufacturing		0.02		0.03		-0.02		-0.01
		(0.03)		(0.03)		(0.05)		(0.05)
Ability - Services			0.23***	0.24***			0.25***	0.25***
			(0.04)	(0.04)			(0.07)	(0.07)
Observations	1,578	1,578	1,578	1,578	1,578	1,578	1,578	1,578
R-squared	0.06	0.06	0.07	0.07	0.29	0.31	0.31	0.31

Note: The dependent variable is the geometric growth rate of income per capita or employment over 5 years. All control variables are normalized to have mean of zero and standard deviation of one in each year. All regressions include year fixed-effects. Robust standard errors in parentheses clustered by city. *** p<0.01, ** p<0.05, * p<0.1

Table 1.26: Predicting appearance and disappearance of exported products (10 year horizon)

	Appearances				Disappearances			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Final :	$RCA_{c,p}^{t+10} \geq 1$	$RCA_{c,p}^{t+10} \geq 1$	$RCA_{c,p}^{t+10} \geq 1$	$RCA_{c,p}^{t+10} \geq 1$	$RCA_{c,p}^{t+10} < 1$	$RCA_{c,p}^{t+10} < 1$	$RCA_{c,p}^{t+10} \leq 0.1$	$RCA_{c,p}^{t+10} \leq 0.1$
Initial:	$RCA_{c,p}^{t} < 1$	$RCA_{c,p}^{t} < 1$	$RCA_{c,p}^{t} \leq 0.1$	$RCA_{c,p}^{t} \leq 0.1$	$RCA_{c,p}^{t} \geq 1$	$RCA_{c,p}^{t} \geq 1$	$RCA_{c,p}^{t} \geq 1$	$RCA_{c,p}^{t} \geq 1$
Likelihood	2.240***	3.098***	1.412***	2.339***	-2.501***	-2.513***	-7.980***	-4.108***
	(0.086)	(0.123)	(0.232)	(0.317)	(0.098)	(0.147)	(0.308)	(0.459)
Production Ability	0.366***	0.599***	0.197***	0.513***	-0.046***	-0.131***	-0.289***	0.069*
	(0.017)	(0.025)	(0.026)	(0.039)	(0.015)	(0.024)	(0.024)	(0.037)
Sensitivity	0.109***	-0.022	-0.109***	-0.183**	0.333***	0.361***	0.107**	-0.452***
	(0.020)	(0.037)	(0.038)	(0.078)	(0.025)	(0.047)	(0.046)	(0.098)
Specificity	-0.270***	-0.109***	-0.380***	-0.145*	-0.305***	-0.458***	-0.260***	0.245**
	(0.022)	(0.037)	(0.043)	(0.075)	(0.025)	(0.046)	(0.053)	(0.101)
ECI		-0.406***		-0.384***		0.120***		-0.266***
		(0.019)		(0.033)		(0.025)		(0.053)
PCI		0.045**		-0.026		0.040		0.490***
		(0.023)		(0.045)		(0.033)		(0.066)
Diversity		0.085***		-0.038		-0.018		-0.914***
		(0.021)		(0.036)		(0.029)		(0.077)
Ubiquity		0.043*		0.083*		-0.095***		0.078
		(0.023)		(0.045)		(0.034)		(0.083)
Observations	193,210	193,210	127,151	127,151	36,490	36,490	36,490	36,490
Switches	12279	12279	3110	3110	10119	10119	1816	1816
Pseudo R2	.052	.058	.033	.040	.025	.026	.160	.177
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the binary appearance and disappearance values of industries of products, based on the limits in the column labels. All control variables are normalized to have in each year a mean of zero and standard deviation of one. Robust standard errors in parentheses clustered by country. *** p<0.01, ** p<0.05, * p<0.1

Table 1.27: Predicting appearance and disappearance of industries (10 year horizon)

	Appearances				Disappearances			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Final :	$LQ_{c,p}^{t+10} \geq 1$	$LQ_{c,p}^{t+10} \geq 1$	$LQ_{c,p}^{t+10} \geq 1$	$LQ_{c,p}^{t+10} \geq 1$	$LQ_{c,p}^{t+10} < 1$	$LQ_{c,p}^{t+10} < 1$	$LQ_{c,p}^{t+10} \leq 0.1$	$LQ_{c,p}^{t+10} \leq 0.1$
Initial:	$LQ_{c,p}^{t} < 1$	$LQ_{c,p}^{t} < 1$	$LQ_{c,p}^{t} \leq 0.1$	$LQ_{c,p}^{t} \leq 0.1$	$LQ_{c,p}^{t} \geq 1$	$LQ_{c,p}^{t} \geq 1$	$LQ_{c,p}^{t} \geq 1$	$LQ_{c,p}^{t} \geq 1$
Likelihood	3.142***	3.917***	1.359***	4.581***	-2.584***	-3.169***	-5.283***	-6.088***
	(0.091)	(0.117)	(0.255)	(0.406)	(0.098)	(0.125)	(0.209)	(0.315)
Production Ability	-0.265***	-0.217***	-0.525***	-0.315***	-0.092***	-0.119***	-0.532***	-0.309***
	(0.010)	(0.030)	(0.020)	(0.062)	(0.011)	(0.036)	(0.020)	(0.058)
Sensitivity	-0.198***	0.305***	-0.475***	0.719***	0.386***	0.175***	-0.218***	0.283***
	(0.013)	(0.025)	(0.030)	(0.062)	(0.015)	(0.024)	(0.025)	(0.052)
Specificity	0.217***	0.117***	0.408***	0.116*	-0.207***	-0.094**	0.610***	0.876***
	(0.020)	(0.032)	(0.040)	(0.060)	(0.024)	(0.038)	(0.039)	(0.062)
ECI		-0.089***		-0.152***		0.075***		0.250***
		(0.019)		(0.043)		(0.023)		(0.041)
PCI		-0.533***		-1.123***		0.173***		-0.520***
		(0.023)		(0.054)		(0.019)		(0.035)
Diversity		-0.044**		-0.373***		-0.008		-0.454***
		(0.021)		(0.043)		(0.025)		(0.043)
Ubiquity		-0.175***		-0.524***		0.185***		0.468***
		(0.030)		(0.063)		(0.041)		(0.093)
Observations	122,790	122,790	26,731	26,731	63,721	63,721	63,721	63,721
Switches	18636	18636	4156	4156	19141	19141	5283	5283
Pseudo R2	.033	.040	.038	.065	.053	.055	.215	.230
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the binary appearance and disappearance values of industries, based on the limits in the column labels. All control variables are normalized to have in each year a mean of zero and standard deviation of one. Robust standard errors in parentheses clustered by country. *** p<0.01, ** p<0.05, * p<0.1

2

Elasticity Pessimism: Economic Consequences of Black Wednesday

On September 16, 1992, the British Pound devalued in nominal terms by around 20 percent after speculators successfully pushed the U.K. out of the European Exchange Rate Mech-

anism.[1] The conventional wisdom is that the devaluation caused a "boom," since it was followed by increased growth.[2] However, we show that the economies of similar countries who did not devalue experienced similar growth rates. This result is consistent with a growing body of empirical studies of exchange rate movements that find muted responses on exports (Obstfeld and Rogoff, 2000; Ruhl, 2008; Leigh et al., 2017). We use Black Wednesday as a laboratory to test a variety of leading theories which have been developed to explain this empirical regularity, but find that none do well at explaining the patterns in the data.

First, we show how the devaluation affected real prices. The local prices of imports and exports both increased after the devaluation.[3] However, the British CPI *decreased* relative to its counterpart in comparable countries,[4][5] with energy the only sector with a significant increase.[6] We argue that the surprising decrease in inflation may be due to the (ex-post successful) implementation of an inflation target following the devaluation.

Having documented the effect of the devaluation on real exchange rates and prices, we turn to trade flows. The existing empirical literature on the topic tends to either (a) fail to reject the null

[1] All nominal exchange rates in this paper are in local currency units per dollar.

[2] For instance, a 2005 statement by Lord Norman Lamont, who was Chancellor of the Exchequer in 1992, highlighted the "enormous gains the economy experienced" after the devaluation, a view shared by the financial and local press (including the Economist , the Financial Times, the Guardian, and the Telegraph), and the Office of National Statistics . Furthermore, at the time the devaluation was expected to have a beneficial effect for the British economy, hence the well-known (if probably apocryphal) "story of the British Chancellor of the Exchequer 'singing in the bath' (Frankel, 2004). Much of the the academic research we've found on the topic (Hughes-Hallett and Wren-Lewis, 1995) has also argued that the devaluation was associated with economic benefits, which Gordon (2000) describes as the "conventional view."

[3] Similar to Burstein et al. (2005), we find that import and export prices at the dock (in pounds) increased by almost as much as the nominal price of dollars.

[4] At the time, British ministers explicitly maintained the peg in order to avoid inflation (Bonefeld and Burnham, 1996).

[5] Campa and Goldberg (2005) find that increases in consumer prices tend to be smaller in magnitude than changes in the exchange rate. Burstein et al. (2007); Alessandria et al. (2010); Forbes et al. (2016) develop theories of why prices move slowly in the direction of exchange rates, by respectively appealing to stickiness, inventory behavior, and the underlying cause of the price change, but all of the theories predict relative price increases after a devaluation.

[6] We have data on the 19 sectors used by Imbs et al. (2005).

that real devaluations do not affect the trade balance (Rose and Yellen, 1989), or (b) find that devaluations are followed by a J-curve,[7] with an immediate decline in the trade balance followed by its gradual improvement (Branson, 1972; Junz and Rhomberg, 1973; Backus et al., 1994; Alessandria et al., 2015). In contrast, we find that imports (in dollars) immediately declined after the devaluation and stayed persistently lower for several years, while both export quantities and values did not increase relative to comparable countries.

A depreciation is a relative change: for the UK's currency to depreciate (in real terms), the currencies of at least some of its trading partners must have appreciated (in real terms). This type of spillover makes it difficult to use the standard tools of the treatment effects literature (Rubin, 1974). We alleviate this concern by studying the effects of the U.K.'s devaluation within markets,[8] and find that the results are robust to focusing on within destination or sector-based flows.[9]

In order to evaluate theories of the effects of exchange rate movements, we implement tests in the spirit of Rajan and Zingales (1998).[10] The theories have empirically testable predictions about how the effects of the devaluation will vary across sectors. For instance, exchange rates may not affect trade flows if prices are sticky in a foreign currency (such as the trading partners' or in dollars), since foreign consumers would not change their consumption if the prices they faced did not change.[11] If sticky prices were the underlying friction preventing exchange rate movements from affecting trade

[7] Or a "horizontal-S" curve.

[8] Looking at relative effects within markets also avoids bias coming from contemporaneous shocks to other countries or sectors to which the U.K. was particularly exposed, such as the establishment of the European Single Market in January 1993.

[9] The results are also robust to disaggregating trade flows by 1-digit-sector by destination dyads.

[10] Many explanations for limited effects of exchange rate movements appeal to the relatively transitory nature of price shocks (Hooper et al., 2000; Ruhl, 2008; Drozd et al., 2014; Fitzgerald and Haller, 2014). However, the U.K. devaluation was large and persistent and its effects stay relatively similar over the next five years. Furthermore, Figure 2.2 shows that the 12-month forward price of the pound fell at the devaluation (it had been increasing in the summer of 1992), and then stayed persistently lower. Since imports responded quickly to the devaluation, models whose predictions include "nominal prices should not affect trade flows" are generically unable to rationalize our results.

[11] See, for instance, Krugman (1986); Burstein and Jaimovich (2012); Burstein and Gopinath (2014); Asprilla et al. (2015); Casas et al. (2016).

flows, then the U.K.'s devaluation would have increased exports relatively more in sectors with a world price, pound pricing, or with high exchange rate pass-throughs. We test each of these theories in turn, and find no increases in the dollar value of exports for commodities traded on exchanges nor tourism expenditure, and find no significant evidence that trade flows in sectors with higher measured pass-throughs responded more to the devaluation (Gopinath and Rigobon, 2008).

Devaluations (and exchange rate movements more broadly) have underlying causes, which themselves may affect the local economy. In this setting, the proximate cause of Black Wednesday is well understood: speculators correctly predicted that the Bank of England would be unwilling to maintain its (relatively nascent) obligations to the exchange rate mechanism (ERM), leading to a "self-fulfilling" currency crisis (Eichengreen and Wyplosz, 1993; Eichengreen et al., 1995).[12] Nevertheless, there were no corresponding financial or political crises in the U.K.,[13] nor was the devaluation part of a package of policy reforms aimed at boosting the economy. Furthermore, our results are similar when we compare the U.K. to countries whose currencies were similarly overvalued before 1992, or to countries who had similar nominal exchange rate movements.

We estimate the U.K.'s counterfactual no-devaluation outcomes using a weighted average of countries who did not devalue, with the weights chosen to most closely match the pre-devaluation characteristics of the U.K., a method known as synthetic controls (Abadie and Gardeazabal, 2003; Abadie et al., 2015).[14] The synthetic control method is appropriate given the event-study nature of

[12] Of course, the fact that the U.K. abandoning its peg led to a large devaluation implies that there were other fundamental causes as well. However, it is unlikely that the fundamentals would lead to a sharp change in economic activity exactly in September 1992.

[13] Cooper (1971) and Frankel (2004) show that governments are substantially more likely to lose power after devaluations.

[14] Firpo and Possebom (2016) provides a thorough bibliography of papers using the method. Several papers generate synthetic counterfactuals for countries as they joined the European Union (Zudel and Melioris, 2016; Gomis-Porqueras and Puzzello, 2014; Fernández and García Perea, 2015) with Campos et al. (2014) arguing that that joining the EU increased growth for the U.K., while Saia (2014) argues that not joining the Euro in 1999 lowered British exports by around 13 percent. To the best of our knowledge, we are the first to use synthetic controls to generate counterfactuals for a devaluing country.

our setting,[15] and we describe the assumptions needed for our estimates to be unbiased even in the presence of unobserved factors which affected both the U.K.'s exchange rate and its economy more broadly.[16] Gordon (2000) studies the ERM crisis using a casually similar method: comparing the outcomes of six "leaver" countries with five of the "stayers".[17]

The effects of major macroeconomic shocks are mediated by subsequent fiscal, monetary, and political responses, so the U.K.'s performance may be driven by policy responses in the aftermath of the devaluation. For instance, in addition to other institutional changes, the British government adopted an inflation targeting regime in October 1992 (Bean, 2004), which may be directly responsible for the decrease in inflation. Had the government responded differently, so too may the consequences of the devaluation have been different. The patterns for the U.K. likely do not represent the effects of exchange rate movements across all countries and times. Nevertheless, many of U.K.'s policy changes would not have taken place but for the devaluation, so we are comparing the U.K. relative to its counterfactual outcomes, even if we cannot pin down the exact mechanisms for how the devaluation affected the economy.

Due to its policy implications, there is an enormous empirical literature measuring the effects of exchange rate movements. Many of those studies rely on within-sector within-time variation

[15] Furthermore, in Appendix Section 2.7.2, we describe a parsimonious model that describes both potential mechanisms for how a devaluation can affect outcomes and why a synthetic control-type approach is useful for generating counterfactuals.

[16] Furthermore, synthetic controls require weaker identification assumptions than time-series or panel regressions, since as Abadie et al. (2015) discuss, they are unbiased even in the presence of time-varying unobservable confounders. For comparison, the identifying assumption for difference-in-differences regressions is that had the devaluation not happened the U.K.'s outcomes would have followed a parallel path to the observed average of the control units. While this assumption is not directly testable, most researchers proxy its validity by verifying parallel trends in the pre-treatment periods (Xu, 2015). In Appendix Section 2.7.1, we show that the U.K. trade flows did not experience pre-devaluation trends parallel to OECD countries who did not devalue.

[17] Gordon (2000)'s results are different than ours: for instance, he finds a leaving the ERM is associated with increases in real exports, real imports, and the GDP deflator, whereas we find no impacts on the former and declines for the latter. The difference in estimates comes from the fact that the synthetic counterpart for the U.K. is never made up of only countries in Gordon (2000)'s "stayer" sample, since we can improve pre-devaluation fit including other countries as well.

in prices, therefore estimating what Feenstra et al. (2014) describe as "micro" elasticities between foreign suppliers (Berman et al., 2012; Amiti et al., 2014). Two of the papers in this literature most closely related to ours are Rodnyansky (2016) and Lewis (2017). Rodnyansky (2016) exploits a recent set of policy changes in Japan known as "Abenomics," which included the devaluation of the Yen. He finds that exporters grew less than purely domestic firms, and highlights the importance of imported intermediates and dollar pricing.[18] Lewis (2017) finds a limited effect of exchange rate movements on exports and that trade elasticities, price stickiness, and imported intermediate shares have little predictive power. However, Lewis (2017) finds that depreciations are associated with an increase in imports, which is the opposite of what we find for the UK.

The trade movements we study - overall imports and exports - are driven by a "macro" elasticity (between home and foreign). Many studies of this phenomenon, like ours, focus on a finite number of identifiable shocks to study the effects of currency movements (Branson, 1972; Cravino and Levchenko, 2015). Related to our paper, Artus (1975) studied the 1967 depreciation of the Pound Sterling, and found that exports increased in the time series. For the 1992 episode, using other countries in order to generate counterfactuals, we do not find an increase in British exports following its devaluation (neither in the short nor the medium run). In the following sections we describe the events leading up to the 1992 U.K. devaluation and the data that we use, its effects on prices, and the inability of standard measures of cross-sectoral heterogeneity to explain the null effect on exports.

2.1 Black Wednesday

In 1985, Prime Minister Thatcher rejected attempts for the U.K. to join the Exchange Rate Mechanism (ERM) of the European Monetary System. Nevertheless, starting around 1987 Chancel-

[18] In the earliest years for which we have found data, 1999 and 2002, over half of U.K. exports were invoiced in pounds. See goo.gl/C5g2NG and goo.gl/eqPdCN.

lor of the Exchequer Lawson informally sought to stabilize sterling's exchange rate against the Deutschmark.[19] In 1989, the Madrid conditions were agreed to as pre-requisites for the U.K. to join the ERM, which were announced to have been met in October 1990. At the time, headline inflation was 10.9 percent, and interest rates were 15 percent.

Originally, the ERM was "halfway" between floating exchange rates and a single currency. Each country was responsible for keeping its currency within agreed upon bands - while there were realignments after the inception in 1979, there had not been any for over five years before the 1992 crisis (Eichengreen and Wyplosz, 1993).

By August of 1992, a variety of factors, including high interest rates in post-reunification Germany, led to doubts about the future sustainability of the ERM. By this point, futures contracts to buy the Franc and Lira traded at prices below their respective bands (Future U.K. market expectations for the Pound remained within its band until September 15). Finland abandoned its peg on September 8, and Sweden raised short-term rates to 500 percent, to defend its own peg. Many speculators, famously including George Soros' Quantum Fund, shorted billions of pounds in mid-September, with the expectation that the U.K. would not have the political will to hold the peg (Ferguson and Schlefer, 2009). On September 16, the Bank of England spent almost half its total foreign-exchange reserves in an ultimately futile effort to support the pound. That evening, the government announced that it was temporarily suspending its participation in the ERM and dramatically lowered interest rates. Italy left the ERM later that day (although it first devalued over the weekend of September 12), and Spain devalued by 5 percent. Spain and Portugal left the ERM on November 23 and the Irish Punt floated on February 1, 1993. Due to the passage of a French referendum on the ERM question, as well as intervention from the Bundesbank, the Franc never floated despite heavy speculation (Bank of England, 1993).[20]

[19] As a result, we start our empirical analysis in 1988. We end our empirical analysis in 1996, since in 1997 the party in power switched and the Bank of England was given independence from political control.

[20] France widened its band in 1993, so the Franc did lose value even as it stayed in the ERM.

We show both nominal (local currency per dollar) and real monthly exchange rate movements during the period in Figure 2.1, comparing the U.K. to other countries who did not float their currencies.[21] The changes due to the ERM crisis were much larger than any others during the period.[22]

2.2 Data and Empirical Strategy

In order to describe the aftermath of the devaluation, we bring together multiple data sources from national and multilateral statistics agencies, as well as sectoral characteristics reported in various papers.[23] At the annual level, our primary data is 4 digit SITC revision 2 trade flows, from the Center for International Development cleaning of the UN-COMTRADE data (Bustos and Yildirim, 2020).[24] Data on services exports and imports comes from the World Trade Organization (which is generated from national accounts). We collected information about nominal GDP from the IMF's World Economic Outlook database, and PPP adjusted GDP per capita from the Penn World Tables. We use measures of currency mismatch estimated by Couharde et al. (2017). At a higher frequency, our measures of exchange rates come from Darvas (2012), who converts nominal to real exchange rates using CPI-based REERs and constant trading weights. The OECD reports monthly information on prices and trade flows (including values and quantities). From Bloomberg, we collected information on the 12 month forward prices for currencies in dollars.[25] We normalize the nominal,

[21] We plot the movements in exchange rates for all of the countries who devalued in Figure 2.17.

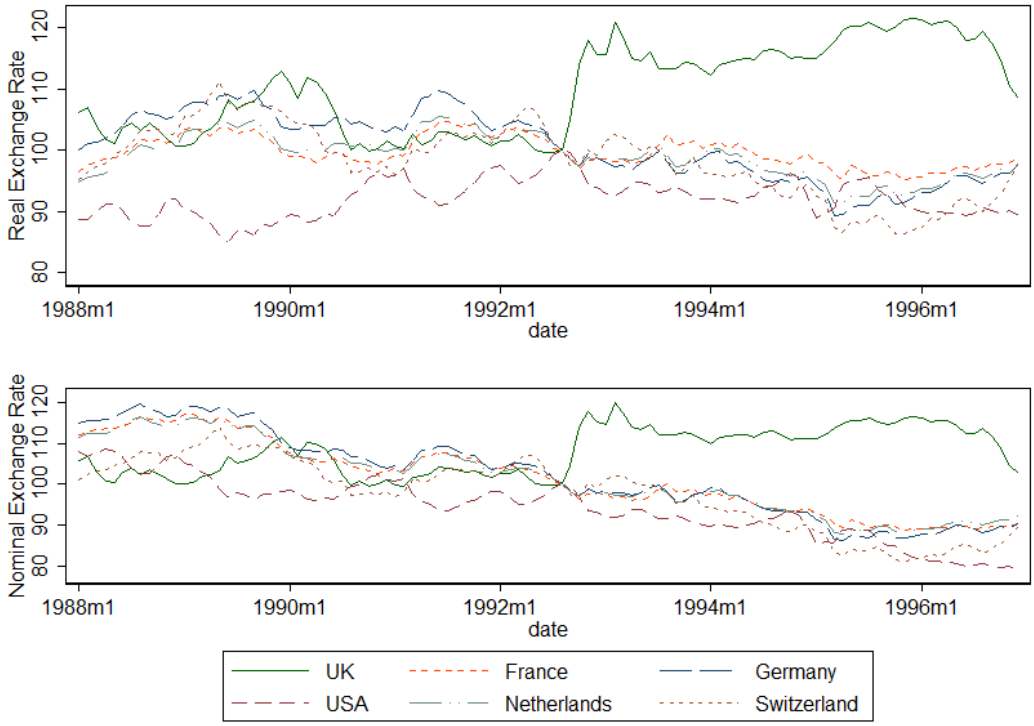
[22] The real exchange rate is not directly observable (Chinn, 2006), but clearly declined due to the shock. We plot the data reported by Darvas (2012), where the 1991 to 1993 decline in the real exchange rate was 12 percent. In IMF's measure of Relative Unit Labor costs the decline was have been 16 percent, and it was 8 percent in Campbell (2016)'s measure of the Balassa-Samuelson Adjusted Weighted Average Relative Unit Labor Cost, which incorporates the effect of changes in trading partners as well as changing prices. Throughout the paper, we describe the nominal and real exchange rates such that increase after a devaluation, for instance the plotted nominal exchange rate for the U.K. is pounds per dollar (normalized to the pre-devaluation level).

[23] We are grateful to the authors for making their data publicly available.

[24] Some of our measures of sectoral characteristics are at more aggregate levels (or using different coding schemes), we aggregate and concord the data to the most detailed possible level for each test.

[25] We were only able to collect forward prices for most countries starting in January 1989.

Figure 2.1: Exchange Rate Movements, 1988-1996



Notes: This figure plots exchange rate movements from 1988-1996 for six OECD countries (Darvas, 2012). Real Exchange Rates are CPI-based, using constant trade weights. Nominal exchange rates are local currency per dollar, and the real exchange rate is similarly decreasing in the value of the local currency. Of the countries shown, only the U.K. broke a currency peg, and it is the only country denoted with a solid line.

unitless, and high-frequency data to equal 100 on the final date before the devaluation.[26]

To exploit sectoral heterogeneity in the intensity of their exposure to the mechanisms mediating the effects of the devaluation, we bring together a variety of measures. We digitized several Yearbooks of the World Tourism Organization in order to get information on tourist activity.[27] To calculate domestic value added shares, we collected the 1990 U.K. supply and use tables, and calculated the share of the total production coming from imported inputs for each of 80 sectors.[28] Measures of external finance dependance come from Rajan and Zingales (1998) via Beck et al. (2008). Measures of the trade elasticity come from Feenstra (1994), Caliendo and Parro (2015) (via Imbs and Mejean 2015), and Broda and Weinstein (2006). Measures of price stickiness come from Gopinath and Rigobon (2008).

2.2.1 Empirical Strategy

In order to estimate the effects of the U.K.'s devaluation we must address the "fundamental problem of causal inference" (Rubin, 1974): we can never observe what would have happened to the U.K. had it not devalued. In this context,[29] the issue is particularly acute because the U.K. did not devalue arbitrarily - some features of the U.K. caused the policy change, and those characteristics may have directly affected the outcomes of interest as well.

Our goal, therefore, is to find countries with similar characteristics to the U.K. Ultimately, we use a weighted average of other countries' outcomes in order to estimate a "synthetic" U.K.[30] Assuming

[26] The U.K. was running a trade deficit in 1992, so we do not normalize net exports either in order to preserve the negative sign.

[27] This information had already been digitized starting in 1995, and is available in the World Development Indicators.

[28] We hand-generated a concordance between SITC codes and the U.K. commodity descriptions, which we are happy to share.

[29] Nakamura and Steinsson (2017) argue that causal identification is particularly difficult in macro.

[30] The synthetic U.K. represents the counterfactual for the U.K. for only one policy change, the devaluation itself. For this reason, we start our analysis when the U.K. (implicitly) joined the ERM, and stop our analysis in 1997, when the Bank of England gained independence from political control.

that a factor model describes the evolution of outcomes (Abadie et al., 2010), then the "synthetic" U.K. behaves like the U.K. itself, even if country characteristics have a time-varying effects.[31] We first describe the factor model, and then our strategy for estimating the synthetic U.K.[32]

Consider i to be the treated unit.[33] The potential outcome for unit i in period t if it did not devalue, $Y_{it}(0)$, is given by a factor model (Abadie et al., 2010):

$$Y_{it}(0) = \theta_t Z_i + \mu_i \phi_t + \varepsilon_{it},$$

where Z_i is a vector of observed covariates (including a constant), θ_t a vector of unknown parameters, ϕ_t a vector of unobserved common factors, and μ_i is a vector of unobserved factor loadings. The corresponding potential outcome for a unit who did devalue is

$$Y_{it}(1) = Y_{it}(0) + \alpha(Z_i).$$

For the most part, we assume that α is constant at the country level - there is an effect of the U.K.'s devaluation. We also consider sector-specific heterogeneity, in which case the effect of the devaluation is a function of observables (such as the elasticity of substitution).

Using the language of potential outcomes, we are interested in estimating $Y_{it}(1) - Y_{jt}(0)$, the causal effect of the devaluation. However, $Y_{it}(1)$ is unobserved for $t \leq T_0$, and $Y_{it}(0)$ is unobserved for $t > T_0$.

Define J to be the set of N_J possible control units, known as the donor pool, who did not experience the shock. X_i is the vector of pre-treatment characteristics for the treatment unit (including the

[31] In Appendix 2.7.1 we show that time-varying confounders are an important concern in this setting, since there is no evidence of common pre-trends between the U.K. and the OECD before the U.K.'s devaluation.

[32] In Appendix Section 2.7.2 we describe a potential microfoundation for a factor-type of model, coming from shocks to trade parterns.

[33] In this context, the treated unit is normally the U.K. or a particular sector within the UK.

outcome of interest), and X_J is the corresponding matrix for the donor pool. The synthetic control weights vector $\hat{\lambda}$ solves

$$\hat{\lambda} = \arg\min_{\{\lambda\}} (X_i - \lambda \cdot X_J)' \, \Omega \, (X_i - \lambda \cdot X_J) \tag{2.1}$$

with the weight matrix Ω chosen to minimize the average squared prediction error of just the (pre-treatment) outcome variable.[34] Since the set of possible donors (the number of countries) is often larger than the number of characteristics we are trying to match (outcomes for the U.K. from from January 1988 through August of 1992), there may be many possible solutions. In order to choose one, we follow (Abadie et al., 2015) by picking the best weights who sum to 1 and are all weakly positive.[35]

The synthetic control for the U.K. in each period t is therefore

$$\widehat{Y_{it}}(0) \equiv \sum_{j=1}^{J} \hat{\lambda}_j Y_{jt}, \tag{2.2}$$

which we can visually plot over time to compare to the observed series Y_{it}. Since the synthetic U.K. is constructed to have similar Zs and Ys to the U.K. itself, it must also have similar μs. As a result, the difference between the observed U.K.'s outcomes after the devaluation and its synthetic counterpart, what we call the "gap," is an unbiased estimate of α (Abadie et al., 2010, 2015).

However, the "gap" will be large both if the treatment effect is large and if sampling bias makes the synthetic control an imprecise estimate. In order to describe sampling bias, we follow Abadie

[34] Abadie et al. (2015) suggest a cross-validation method in which Ω is chosen in a different period from $\hat{\lambda}$. However, many of the data series we use are not available for many years before the devaluation, precluding that strategy in this context.

[35] One further issue is how best to calculate the weights - we use the best fit from the several methods built in to the synth STATA package. Athey and Imbens (2016) suggest using penalized regression (LASSO) models to generate unique weights instead, but we found that in practice for this application the Abadie et al. (2015) constraints were better at prediction in the pre-period.

et al. (2010, 2015) and report

$$\sqrt{\sum_{t=1}^{T_0} T_0^{-1} \left[\ln\left(Y_{it}\right) - \ln\left(\widehat{Y_{it}}\right)\right]^2} \tag{2.3}$$

as a measure of the fit in the pre-period. We further report the average of the difference between the U.K.'s outcome an its synthetic control in 1993 as a measure of the short-run effect, and the average of 1994-1996 as a measure of the medium run effect. In Appendix 2.7.4 we report the synthetic control weights for the five most important countries in each donor pool. This allows for qualitative verification that the countries who are used to generate the U.K. counterfactuals are plausibly similar (for instance, Soviet/Russian exports might be an uncredible counterfactual for the UK).

Abadie et al. (2010, 2015) suggest using the ratio of the pre and post period root mean squared difference between the actual and synthetic series as a measure of the p-value of an effect. Firpo and Possebom (2016) show that under standard assumptions (the stable unit treatment value assumption and exchangability)[36] this statistic can be used to test the hypothesis of no effect of the devaluation. More formally, the test statistic we use is[37]

$$\theta_i = \sqrt{\frac{\sum_{t=T_0+1}^{T} \frac{\left[\left(Y_{it}\right)-\left(\widehat{Y_{it}}\right)\right]^2}{T-T_0}}{\sum_{t=1}^{T_0} \frac{\left[\left(Y_{it}\right)-\left(\widehat{Y_{it}}\right)\right]^2}{T_0}}}, \tag{2.4}$$

[36] The former assumption isn't literally true in the data, as changes in British trade flows must mechanically correspond to changes for at least one of its trading partners. However, within each series this issue isn't as important: changes in British imports, for instance, do not have a mechanical relationship with changes in Japanese imports.

[37] We have used the expression in (2.4) as the test statistic as well, which measures the average absolute deviation instead of the root mean square deviation, but this does not particularly affect the results.

and the corresponding Fisher Exact p-value is[38]

$$p = \frac{\sum_{j=1}^{N_J} 1\left(\theta_j > \theta_i\right)}{N_J + 1}. \tag{2.5}$$

We are not only interested in measuring the relationship between aggregate U.K. outcomes and their synthetic controls after the devaluation, but also if certain sectors are particularly affected. In the next subsection, we describe how to extend the single-country estimates of the treatment effect to one for each sector separately.

2.2.2 Cross-Sectoral Heterogeneity

In order to estimate the effects of the devaluation in each sector seperatly, we generate a synthetic counterfactual for each sector s,

$$\widehat{Y_{ist}}\left(0\right) \equiv \sum_{j=1}^{J} \hat{\lambda}_{js} Y_{jst},$$

using the same methods for finding the optimal weights $\hat{\lambda}_{js}$ as for the aggregate cross-country comparisons. We only use within-sector information to generate the synthetic controls.[39] We then calculate the "gap" for each sector as the average gap in post-devaluation period:

$$gap_{is} = \frac{\sum_{t=1993}^{1996} \left(Y_{ist} - \widehat{Y_{ist}}\right)}{4}. \tag{2.6}$$

[38] For many of the values, we do not have very many countries in the donor pool, and so the tests are relatively underpowered. Given the restriction on income and not-devaluing, even the variables with the largest donor pool (exchange rates, which are available everywhere) have under 25 donors. Even the nominal exchange rate, for which the U.K. was the only country in the pool to devalue in 1992, only has a p-value of .05.

[39] While including other sectors can improve the pre-devaluation fit, they may not be subject to the same price shocks afterwards, and therefore may not be appropriate synthetic counterfactuals.

We predict each sector's gaps using sectoral characteristics

$$gap_{is} = \beta_i X_{is} + \beta_0 + \varepsilon_{is} \tag{2.7}$$

weighting each sector by its share of British economic activity.[40] We generate permutation tests using a similar strategy to the aggregate synthetic control figures: for each country/sector in the donor pool, we measure the gap in the post-treatment period between the observed and synthetic series, and calculate the resulting coefficient for each country j:

$$gap_{js} = \beta_j X_{js} + \beta_{0j} + \varepsilon_{js}. \tag{2.8}$$

The corresponding Fisher Exact p-value is

$$p = \frac{\sum_{j=1}^{N_J} 1\left(\left|\beta_j\right| > \left|\beta_i\right|\right)}{N_J + 1}. \tag{2.9}$$

In order to capture potential non-linear effects, we show a scatterplot of the relationship between gaps and sectoral characteristics, and the fit of a Fan (1992) regression.

2.2.3 Implementation

Each outcome has its own factor structure, and in order to create a synthetic counterfactual that matches the unobserved factor loadings, we must calculate counterfactuals for each outcome separately. We also must calculate different weights for practical reasons, since data availability varies by outcome. For the aggregated outcomes (such as exports or the nominal exchange rate), we report the

[40] Some sectors, mostly ones which are small and noisy, are difficult to predict using synthetic controls. In order to prevent uninformative outliers in the gaps, we only report values for sectors with root mean squared log errors of less than 10 percent.

top five weights in Table 2.15.[41][42]

As a robustness check, we apply the weights from the exchange rate counterfactuals - nominal exchange rates and exchange rate misalignment - to calculate a synthetic U.K. for imports and exports. This is a theoretically appropriate strategy if the underlying model is that the factors lead to exchange rate movements (or misalignment), and that the exchange rates are a sufficient statistic for predicting trade flows.

2.3 Effect on Prices

We start by documenting the effect that the devaluation had on prices. Figure 2.2 shows, in Panel a, that the nominal exchange rate of the U.K. (in dollars) was relatively stable before the devaluation, and is well-predicted by the synthetic controls. The devaluation led to a mechanical discrete jump in Pounds per Dollar, which did not happen for the synthetic counterfactual (by construction, none of the countries in the counterfactual broke their pegs if they had one). The post-devaluation U.K. nominal exchange rate was around 20 percent lower than its synthetic counterfactual. There were no expectations that this would revert quickly, as seen in Panel b, which shows that the 12 month forward price fell by at least as much, and then remained at the equivalent level.

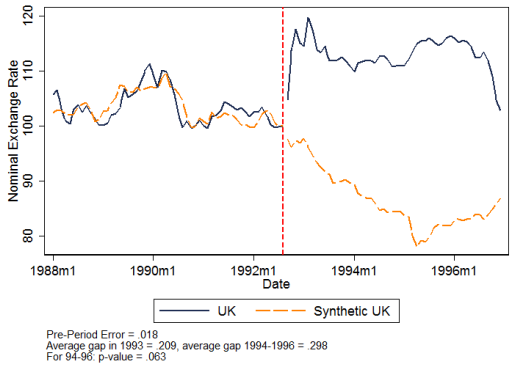
Consistent with Campa and Goldberg (2005) and Shambaugh (2008), we find that export and import prices (panels c and d, respectively) increased for the U.K. following the devaluation, and the short run effect is around two-thirds of that of the nominal exchange rate.

[41] We do not report the sector-level or destination-level weights for space constraints, but they are available by request

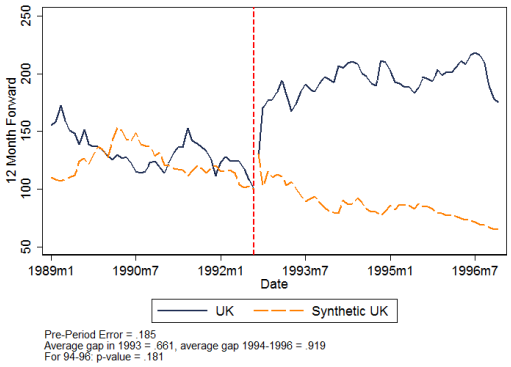
[42] We constrain the donor pool to countries whose PPP-adjusted GDP per capita in 1990 was between 50 percent and 150 percent of the U.K.'s in the Penn World Table (Feenstra et al., 2015), whose populations were between $\frac{1}{20}$ and 20 times the U.K.'s, and who were not Dependent Territories. We did this in order to reduce the extent of interpolation for generating the set of synthetic counterfactuals (Abadie et al., 2015). The results are not particularly sensitive to the choice of caliper. For generating the synthetic control from the donor pool, in addition to the outcome of interest we also use countries' 1990 values of PPP-adjusted GDP per capita and share of exports coming from natural resources as pretreatment characteristics (the Zs) to match

Figure 2.2: Effects of the Devaluation on Prices

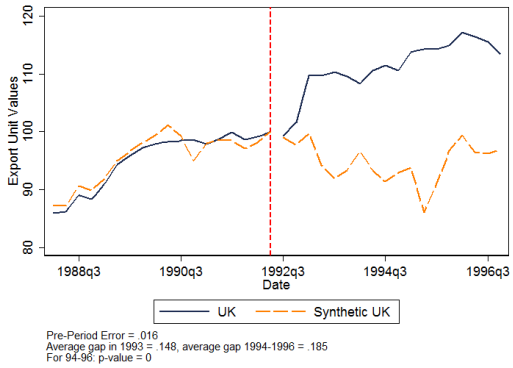
(a) Nominal Exchange Rate, National Currency Units per US Dollar



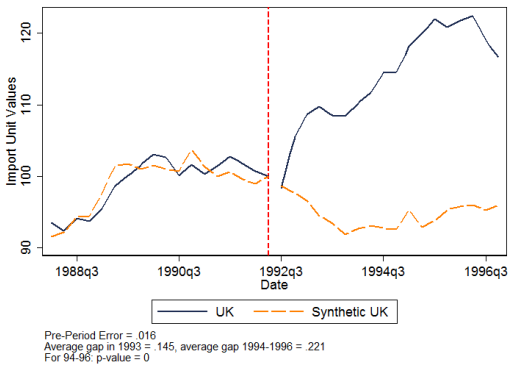
(b) 12 month Forward Price of US-Dollars per National Currency Unit



(c) Trade Unit Values - Exports



(d) Trade Unit Values - Imports



Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For each graph, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from Darvas (2012), Bloomberg, and the OECD.

While the effects of devaluation on import and export prices are consistent with complete pass-through, the effects on other prices, shown in Figure 2.3, are not. There was no immediate change in the consumer price index (shown in Panel a) following the devaluation, instead the growth rate for prices fell in response to the devaluation.[43] Note that the growth rate for the synthetic control's CPI also declined - so extrapolating the U.K.'s pre-devaluation trend may not be a reasonable counterfactual - but that the U.K.'s decline was larger. Panel b shows nominal price path for fuels and energy also increased in the U.K. relative to its counterfactual (Imbs et al., 2005), which is a useful sanity check since those prices should be pinned down by international prices. However, the magnitude of the increase is around 5-10 percent, less than the size of the devaluation itself, as in Goldberg and Campa (2010). None of the other 18 sectors whose prices are reported by Imbs et al. (2005) showed a significant increase in prices following the devaluation, and several, including alcohol, domestic appliances, and leisure, experienced significant decreases in nominal prices.[44] Consisent with these results, the effects of the devaluation on the real exchange rate (in Panel d) are not smaller than for the nominal exchange rate.

2.3.1 Inflation Targeting in the UK

Following the devaluation, the Bank of England and treasury felt that they needed a nominal anchor, and within a few weeks had settled on an inflation target (King, 1997a,b), a practice which had first been instituted in New Zealand a few years before (Svensson, 2010). Initially the target was a band of $1 - 4$ percent, with the goal of lowering the high end of the target below a level below 2.5 percent within the next five years.

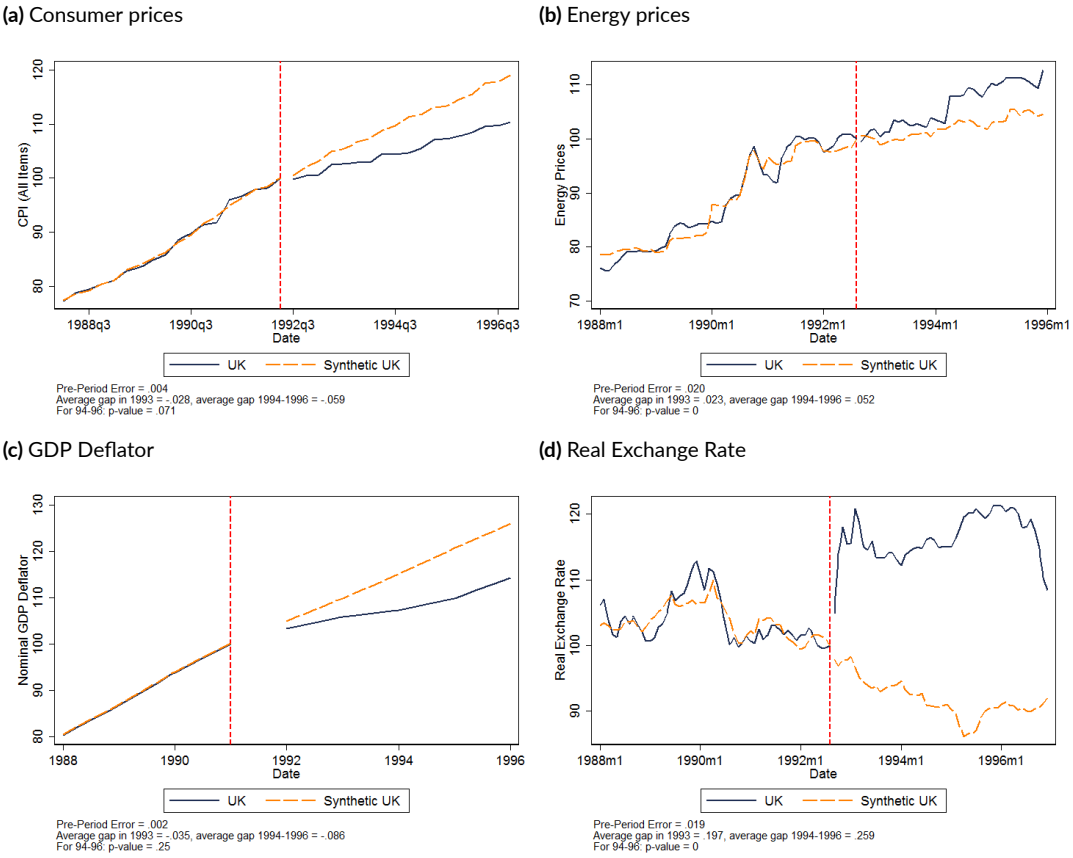
The Bank understood that the target needed to be credible in order to have predictable effects.

on.

[43] The nominal GDP deflator, shown in Panel c, also declined after the devaluation.

[44] This decomposition is helpful for showing that the result on the change in prices is not an artifact of aggregation bias (Imbs et al., 2005; Chen and Engel, 2005).

Figure 2.3: Effect of the Devaluation on Domestic Prices



Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For each graph, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from Imbs et al. (2005), Darvas (2012), the OECD and Eurostat.

One immediate step was towards transparency, with the introduction of a quarterly *Inflation Report*, which includes the Bank's projections of the probability distribution for inflation over the subsequent two years. Within 18 months, the Bank also started releasing minutes of their monthly meetings within six weeks.

Given these large-scale policy changes, it is impossible to isolate just the direct effect of the devaluation. In particular, the path of prices was likely sensitive to the choices made by the Bank of England. Had the Bank been unwilling or unable to credibly promise a relatively low inflation target (or institute another regime that had a similar effect on expectations), the consequences of the devaluation may have been different. However, given that the U.K. was able to keep the rate of price changes low, its nominal devaluation led to a real devaluation of a similar magnitude.

2.4 Effect on Trade

In this section, we study whether the real devaluation had an impact on trade flows. First, we show results for aggregate U.K. outcomes. Synthetic counterfactuals do a good job of tracking U.K. prices and trade flows before the devaluation, and so we use them to study the aftermath. Subsequently, we study cross-sectoral heterogeneity. For each sector, we generate a separate synthetic counterfactual for the U.K.'s performance, and then use sectoral characteristics and the gap between observed and counterfactual outcomes to investigate several hypotheses predicting differential sectoral responses to the devaluation.

In Figure 2.4, we show the results of comparing the trade performance of the U.K. and the synthetic counterfactual. Panels a and b show the results using monthly outcomes. Even at a relatively high frequency, the synthetic control closely matches outcomes for import and export dollar values before the devaluation, including the seasonal fluctuations. There was a large and persistent decline in imports, and a small (or negative) impact on exports, in each case relative to its counterfac-

tual. Combining the results for exports and imports, the trade balance improved immediately after the devaluation. This suggests that the Marshall-Lerner conditions held in this context. Finally, in panels e and f we show quarterly measures of unit volumes. Much like for values, import volumes declined following the devaluation, and export volumes weakly declined relative to their counterfactuals.

We also compare the U.K. to counterfactuals generate from only information on exchange rates (instead of matching trade flows directly. First, we generate counterfactuals using information on nominal exchange rates, as in Figure 2.19a.[45] Alternatively, we use measures of currency mismatch developed by Couharde et al. (2017). For this, we explicitly compare the U.K. to countries with similar levels of currency mismatch before the U.K.'s devaluation.[46] As shown in Figure 2.20, the U.K.'s change in mismatch was significantly larger than any other country's in the period after its devaluation.

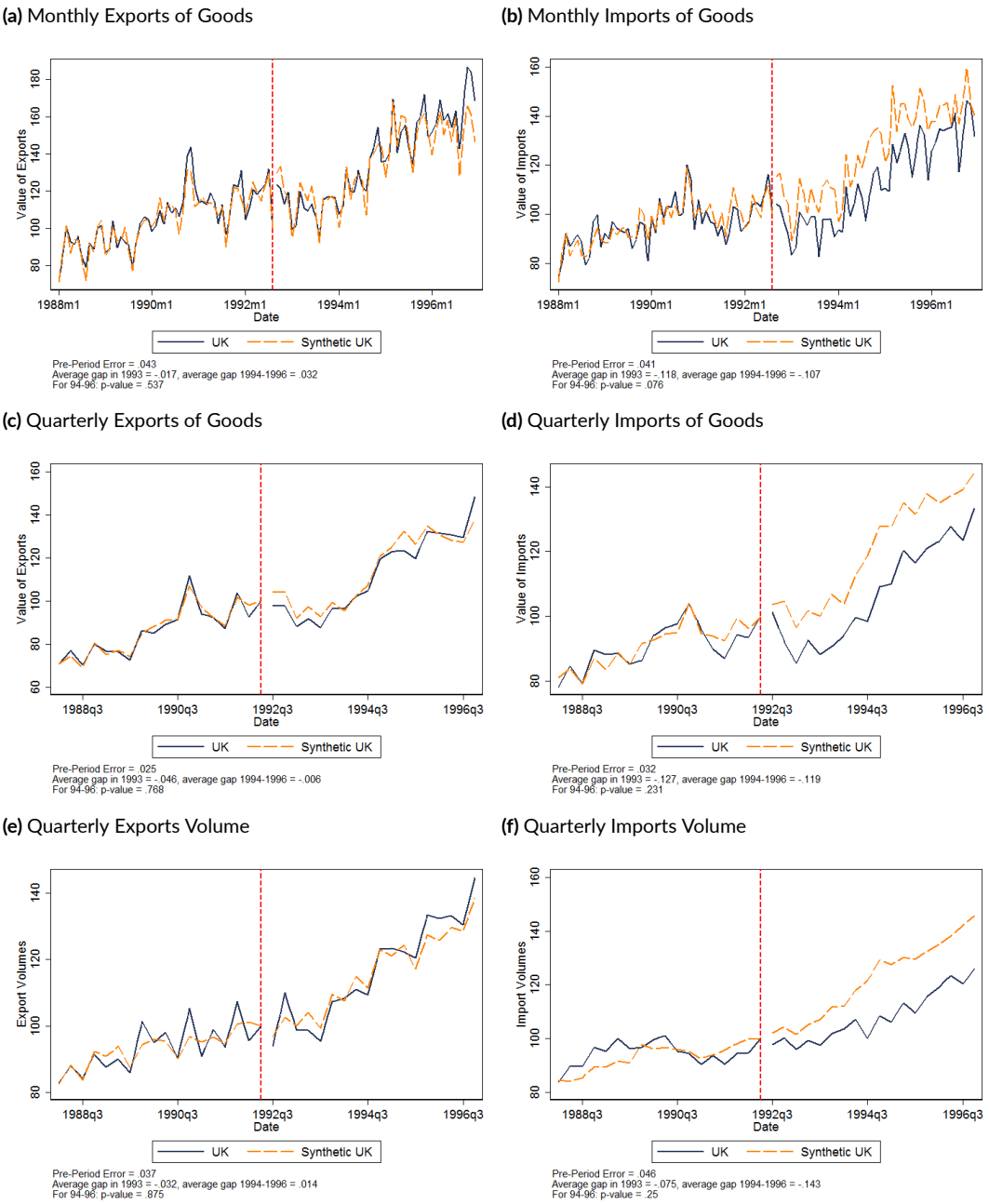
As shown in Figures 2.19 and 2.20a, the counterfactual U.K. behaves similar when constructed using exchange rate movements as when constructed directly using trade flows. For exports, there is no large difference between the UK and its exchange-rate-generated synthetic counterfactuals, and those counterfactuals do a good job of matching the cyclical movements in export flows, not just the trend. The pre-devaluation fit is worse for imports than it is for exports (especially when using the nominal exchange rate), but as in Figure 2.4 the U.K.'s imports after the devaluation are below that of its synthetic counterpart.

An important concern for measuring treatment effects is that the ERM crisis had direct effect on the European countries who did not devalue. If that were true, then the synthetic U.K. would not truly represent the counterfactual outcomes for the U.K. since the factor model would be misspec-

[45] In particular, these weights are .36 Switzerland, .28 France, .22 Japan, .11 Australia, and .03 Israel. Note that France did devalue its currency without leaving the ERM, but nevertheless the gap between the UK's nominal exchange rate and that of its synthetic counterpart is significant.

[46] The weights are 0.371 Canada, 0.283 Switzerland, 0.202 Japan, and 0.144 Austria.

Figure 2.4: Exports and Imports, 1988-1996 - Monthly and Quarterly



Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For each graph, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from the OECD.

ified. In light of this concern, in Figure 2.21 we compare the U.K. to OECD countries outside of Europe. Both the magnitudes and signs are similar to the overall comparison: around a $15 - 20\%$ decline in imports, and a limited effect on exports.[47]

We follow with our analysis using data with annual frequency, shown in Figure 2.5. With annual data, the effect of the devaluation exports and imports of goods is similar to the OECD data (panels a and b): there was a limited effect on exports, and a decline in imports.[48] A similar pattern shows up for services (panels c and d).

On their own, Figures 2.4 and 2.5 push against the conventional wisdom about the U.K. devaluation. Relative to plausible counterfactuals, there was no increase in aggregate British exports (even as the trade balance improved). However, this does not necessarily suggest that the devaluation itself had no effect on exports in any sector. Depending on the reason for why the devaluation had a limited effect, exports for some sectors may nevertheless have increased. To examine this, we exploit cross-sectional heterogeneity in sectoral characteristics.

2.4.1 Heterogeneous Effects by Sector

Trade models often predict that sectors with different characteristics will respond differently to devaluations.[49] We consider several sources of variation. First, for a given change in prices, imports and exports should respond more in more elastic sectors.[50] We therefore use sectoral measures of trade

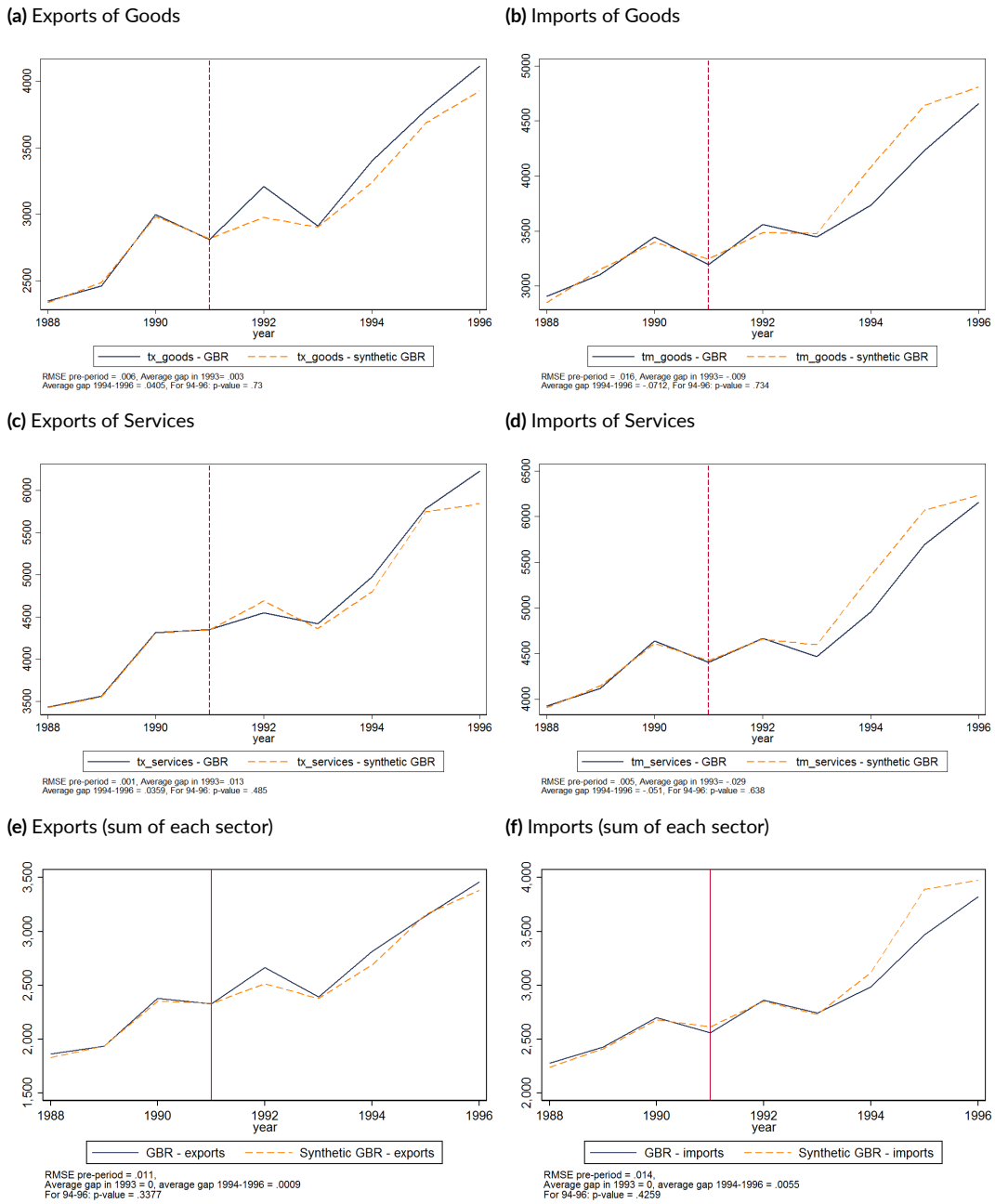
[47] A related concern is of spillovers: effects to trade flows in the U.K. may have a mechanical effect on trade flows from its trade partners. Our results suggest that spillovers are unlikely to explain why there was no export response for the U.K. The decline in imports for the U.K. would, if anything, *lower* exports from its trading partners, biasing our results upwards. Furthermore, our results are similar if we create counterfactual U.K. removing the U.K. as a trade partner for the countries in the donor pool.

[48] Note that unlike in Figure 2.4, Figure 2.5 shows per capita exports instead of normalized exports. The gaps relative to the synthetic control are similar using either strategy.

[49] We do not formally model these arguments since the basic comparative statics are somewhat straightforward. Lewis (2017) and Rodnyansky (2016) present thorough calibrations of many of the same features.

[50] The "trade elasticity" takes into account how both demand and supply elasticities interact in general equilibrium. For instance, food is relatively trade inelastic due to the fact that the combination of food producers and food consumers responds relatively less to price movements than their combined counterpart for

Figure 2.5: Exports in Goods and Services, 1988-1996 - Annual



Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For each graph, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation, the rest are dollars per capita. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (also is more precisely defined in Section 2.2.1). Data from UN-COMTRADE and the World Bank Development Indicators.

elasticities (Feenstra, 1994; Broda and Weinstein, 2006; Caliendo and Parro, 2015) in order to determine its effect on the response to the devaluation, and do not find evidence that more elastically traded sectors responded by more.[51]

Another factor limiting the effects of the devaluation could be that pre-existing contracts, pricing-to-market, or dollar pricing constrain firms' ability to take advantage of the increase in relative "competitiveness" (Magee, 1973; Colacelli, 2010; Gopinath, 2015). However, we do not find any increase of exports for homogenous products traded on organized exchanges (Rauch, 1999).[52] Following Kehoe and Ruhl (2013), who find large responses of the least-traded goods (the new-products margin) after trade liberalizations, we investigate whether the least exported or imported products before the devaluation experienced a disproportionate change relative to their counterfactuals, but they did not. We also find no increase in (dollar) tourism expenditure.

Products with relatively low within-UK domestic value added, such as cotton goods, are likely to have their foreign-currency marginal cost be less affected by the devaluation, and therefore are likely to have their exports respond less than for products with limited imported costs, such as coal and petroleum (Amiti et al., 2014).[53] Another potentially "imported" input is finance, since firms (or banks) who borrowed in dollars saw their pound cost of repayment increase after the devaluation. While we do not have direct measures of currency mismatch, we use measures of external finance dependence (Rajan and Zingales, 1998) to proxy for potential balance sheet effects.

In order to exploit variation in sectoral characteristics, we adapt the synthetic controls method.

---

other sectors.

[51] We do not have measures of the trade elasticity for services, but Figure 2.5 is in a similar spirit to this test. In addition to showing our result is robust across different measures of the trade elasticity, we use the three measures both because they are available at different levels of aggregation and they are calibrated using different sources of variation.

[52] Since many of those products' exchanges are literally in London, some of the trade flows may be less sensitive to local British prices, however our result hold just for sectors where the U.K. was originally a net exporter.

[53] We calculate intermediate input import exposure using the U.K. Supply and Use Table. We compare sectors in the U.K. to those same sectors in other countries.

We predict counterfactual U.K. exports within each market or sector (the exact level of aggregation depends on the measure used). We then predict the post-period "gap" between observed and predicted sectoral exports as a function of the sector's characteristics. When we calculated counterfactuals for aggregate U.K. trade flows, sectoral mix is in principle the type of unobserved factor loading for the U.K. that the synthetic counterfactual is generated to match. Consistent with the success of the synthetic control of matching the aggregate flows, the sum of synthetic controls for each sector is similar to the synthetic control for overall flows flows, as shown in Figure 2.5, Panels e and f.

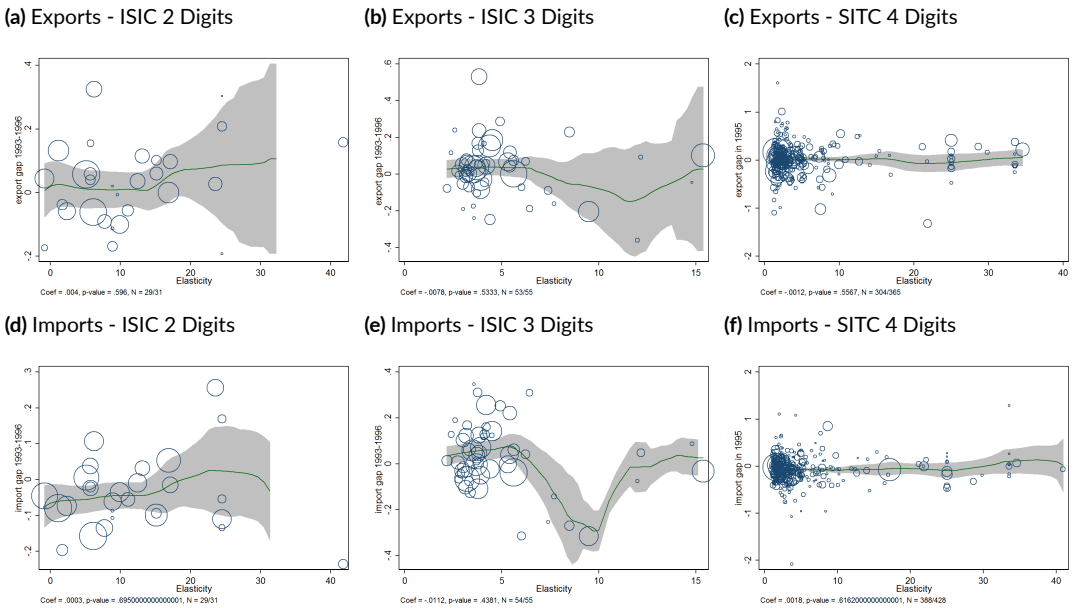
As described above, the mechanisms which mediate the effects of devaluations are present in some sectors more than others. As a result, sectors should respond differently to the devaluation, and sectors who respond by more will have correspondingly larger gaps from their synthetic counterfactuals. We test this formally by, for each mechanism, comparing the relationship between the mediator (such as the elasticity of substitution) and the gap between the actual U.K. post-devaluation outcomes and its synthetic counterfactual.

The Role of Trade Elasticities

One reason why exchange rates might have a limited effect on trade flows is that foreign goods are imperfectly substitutable for domestically produced ones Itskhoki and Mukhin (2016). We test the cross-sectoral implications of this argument in Figure 2.6, by considering the relationship between the (negative) trade elasticity and the average log-gap in trade flows from 1993-1996.[54] The left panels use the Caliendo and Parro (2015) elasticities, the middle panel those from Feenstra (1994), and

[54] The size of the bubbles are proportional to the share of the sector in the trade baskets in 1991. We have only included sectors for which the method found a good fit in the pre-period, which we set as a root-mean-squared error of less than 10 percent. P-values are calculated by running the same exercise for countries who did not devalue, and calculating the share with a regression coefficient with a smaller magnitude.

Figure 2.6: Heterogeneous Effects of the Devaluation by the Trade Elasticity



Notes: Each graph shows the relationship between the indicated market characteristic and the average (percent) gap between the sector's indicated outcome and its synthetic counterfactual in 1993-1996. The x-axis shows the characteristic, and the y-axis is the measured gap. Each graph shows kernel-weighted local polynomial lines, with each market's bubble weighted by its share of the total outcome in 1990-91. Markets are dropped if their pre-devaluation mean-squared error is over 10%. The notes for each graph report (i) The coefficent from a univariate regression of the predicted gap and characteristic, weighting by ex-ante share of trade flows, (ii) the share of countries who did not devalue with a larger coefficient, as described in Section 2.2.1, and (iii) the number of markets with a good-enough pre-devaluation fit to be included. Trade data from UN-COMTRADE, and the calibrated elasticities are from Caliendo and Parro (2015) Feenstra (1994), and Broda and Weinstein (2006), who respectively are in ISIC-2, ISIC-3 and SITC-4 classifications.

the right panels use the elasticities from Broda and Weinstein (2006).[55] In all three cases the relationship between elasticity and the gap is close to zero. The export response with the largest magnitude (using the Caliendo and Parro (2015) measure) has the wrong sign relative the the theoretical benchmark,[56] and none of the estimates are significant at the 5% level. These results do not support the argument that the U.K.'s lack of export response to the devaluation was due to the fact that it produced mostly inelastically traded goods, and are more broadly consistent with elasticity pessimism.[57]

[55] The measures are sorted by level of disaggregation and are respectively following the classifications ISIC (2 and 3 digits) and SITC (at 4 digits).

[56] In theory, exports should increase more in more-elastic sectors

[57] Furthermore, by comparing the effects across sectors, we also avoid aggregation bias (Imbs and Mejean, 2015).

The Role of Pre-Existing Contracts

If pre-existing contracts constrain short-run responses to exchange rate movements, as argued by Magee (1973), then sectors less exposed to those contracts should experience changes in exports and imports following devaluations. In this subsection, we test this hypothesis by looking at two types of sectoral characteristics. First, following Rauch (1999), some sectors are traded over exchanges, and therefore may not be constrained by medium or long-run contracts.[58] In panels a and b of Figure 2.7, we plot the aggregate U.K. trade in products classified as traded in "exchanges" and the synthetic counterfactual for other country's total exports of the same products. Commodities exports declined relative to their counterfactual on impact, and only in 1994 recovered to the counterfactual level.[59] Imports of commodities, conversely, increased at the devaluation, and only declined relative to the counterfactual in 1994. One concern with this approach is that the U.K. is an intermediary for some of these products without being a producer, and that type of exporting behavior is theoretically less likely to be affected by a devaluation (for instance, the Bank of England Vault contains thousands of tons of gold, so while gold is a large British export, it was not being mined in the UK). Therefore, in panels c and d, we constrain the sample to commodities for which the U.K. was a net exporter in 1987, and similarly find insignificant and negative estimate of post-devaluation. There is therefore no evidence that there was a larger increase in exports (or decrease in imports) for products traded on exchanges.

Second, we test the role of pre-existing contracts using actual trade flows, instead of product characteristics. Following Kehoe and Ruhl (2013), we study the effect of the devaluation on the new-products margin by sorting products by their contribution to export or imports baskets in 1990-1991, and focus on the 10 percent least traded products. Those products with low export

[58] Salas (2015) argues that undifferentiated goods prices are relatively quickly adjusted, consistent with the argument that optimal pricing for commodities does not involve pricing-to-market.

[59] We plot results using Rauch's "liberal" definition of commodities, but instead constraining to the "conservative" set also generates has a post-devaluation gap that is insignificant from zero.

exposure are the ones unlikely to be constrained by previously-written contracts, and therefore potentially would have the most scope for expansion.[60] The results shown in panels e and f of Figure 2.7 show that the effects of the devaluation were not larger for these sectors either. There is therefore no evidence that there was a larger increase in exports (or decrease in imports) for products for whom trade flow changes would have come on the extensive margin.

Third, we examine tourist flows. Since tourists buy goods and services domestically, the purchases tend to be in local currency. Therefore, once in the U.K., tourists were able to fully take advantage of the relatively cheaper dollar prices due to the devaluation. This would encourage the arrival of tourists, and has an ambiguous effect on the dollar expenditures of tourists. In Figure 2.8 we test this directly, using information collected from the World Tourism Organization. The direct decline in dollar tourism expenditures due to the devaluation was offset by more pounds spent per tourist. Panel a shows that there was an immediate (small) increase in tourist arrivals per capita in 1992, which continued to increase through 1995, while Panel b shows that there was essentially no change in dollar tourist expenditure per capita.

The Role of Imported Inputs

In this section, we instead study potential heterogeneous marginal costs movements, by exploiting variation in how much the production of goods was exposed to international markets.[61] First, we look at the imported intermediates share - sectors with higher shares of imports in the production process should have had their costs (in dollars) less affected by the devaluation.[62] We show the rela-

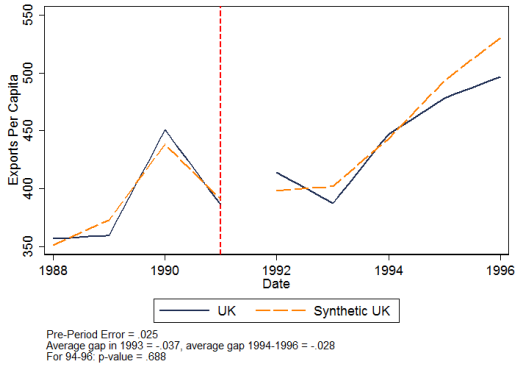
[60] Kehoe and Ruhl (2013) and Guzman et al. (2017) discuss other reasons why these sectors may more generally respond the most to trade shocks.

[61] Since here we focus on features of domestic production, we do not look at imports in this subsection.

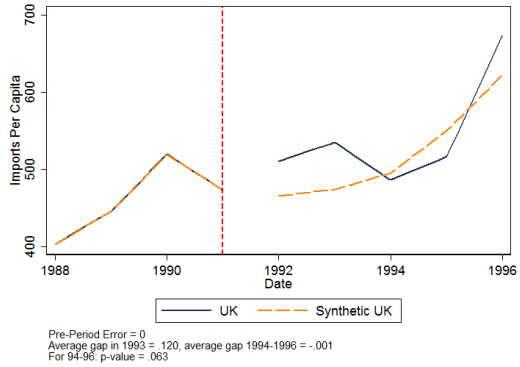
[62] In equilibrium, what matters is not only how much a particular sector imports, but also the imports of its other inputs. In order to account for this, we also show results using the product of the Leontief inverse of the input-ouput matrix and the vector of sectoral value added shares as a measure of the share of inputs coming from imports..

Figure 2.7: Effect of the Devaluation for Goods Not Bound by Contracts

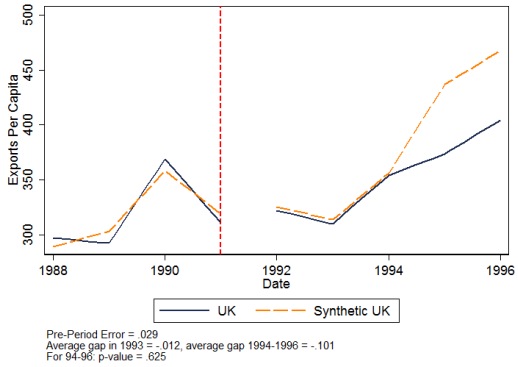
(a) Exports - Exchange traded



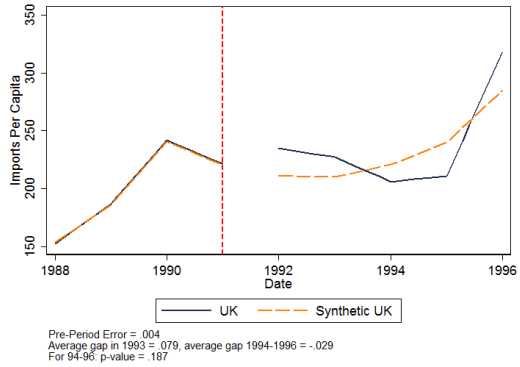
(b) Imports - Exchange traded



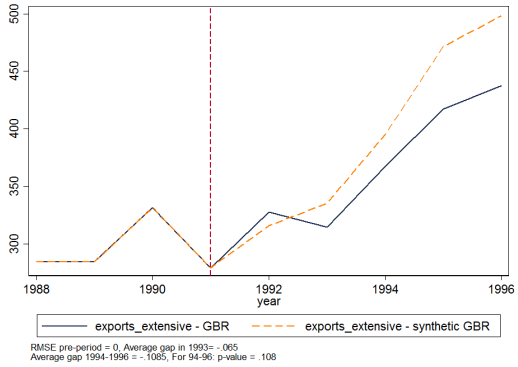
(c) Exports - Exchange traded
(and U.K. is a net exporter)



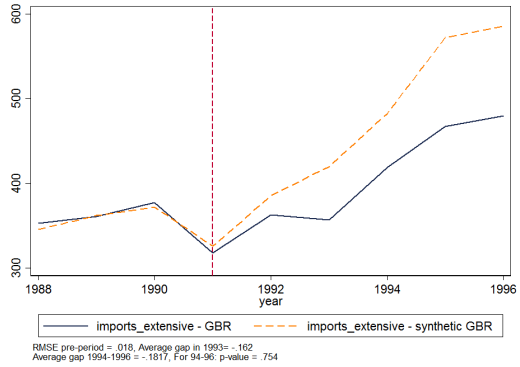
(d) Imports - Exchange traded
(and U.K. is a net exporter)



(e) Exports - New products Margin



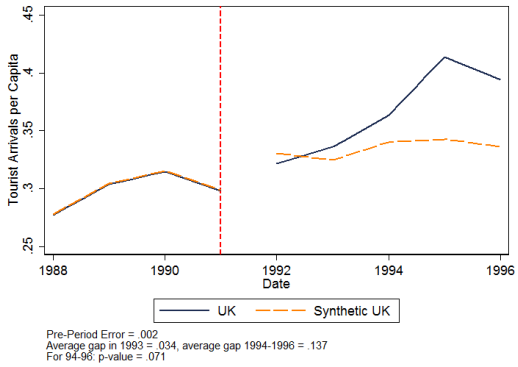
(f) Imports - New products Margin



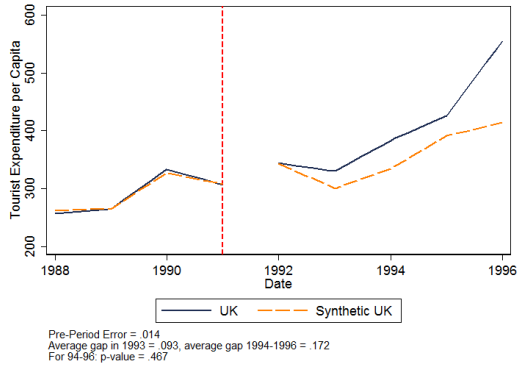
Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For each graph, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from Rauch (1999), (Kehoe and Ruhl, 2013), and UN COMTRADE.

Figure 2.8: Effect of the Devaluation on Tourism

(a) Tourist Arrivals per Capita



(b) Tourist Expenditure per Capita



Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For each graph, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from the World Tourism Organization.

tionship between the sectoral share of imported costs and their synthetic control gaps in Figure 2.9 Panels a and b, weighing by sectoral shares. We do not find evidence consistent with the argument that the limited response of U.K. exports was due to relatively high imports of inputs – the export gap is increasing in imported intermediates (that is to say, importing more intermediates predicts increasing exports more after the devaluation). This result holds both for the direct share of imported intermediates, and after accounting for the full equilibrium effects along the supply chain.[63]

Another input whose price may be a function of the exchange rate is borrowing (Lane and Shambaugh, 2010). Ideally, we would have measures of currency mismatch for firms and their financial institutions (Amiti and Weinstein, 2011; Paravisini et al., 2015). We are limited to more standard measures of financial dependance/vulnerability from (Rajan and Zingales, 1998). We plot the gaps

[63] We calculate the full supply chain effect with the product of sectoral import shares and the 'Leontief Inverse' of the Input-Output matrix.

relative to the financial dependance measure in Figure 2.9 Panels c and d. Much like in Panels a and b, there is no evidence that potential increased exposure to foreign prices decreases exports following a devaluation - the slope of the line is negative, but small and insignificant.

The Role of Price Stickiness

In this section, we exploit observed heterogeneity of price duration across sectors in order to compare the response of sectors with short price durations with those with stickier prices. In particular, Gopinath and Rigobon (2008) report sectoral level variation in import price elasticities.[64] In Figure 2.10, we plot the relationship of the gaps for sectors with different levels of price pass-through, with the top panel presenting the main Gopinath and Rigobon (2008) estimates. Exports increase by more in sectors in sectors with higher pass-through, consistent with the logic that exports should increase by more in sectors where the price falls by more after the devaluation. However, the coefficient for the U.K. is smaller in magnitude than that for most countries, and is also larger than the corresponding estimates for imports (which in theory would fall by more in sectors whose price in the U.K. increased by more after the devaluation). The lower panels of Figure 2.10 show that the results are similar if we drop the sectors with extreme measures of price-pass through.[65]

The Role of Geography

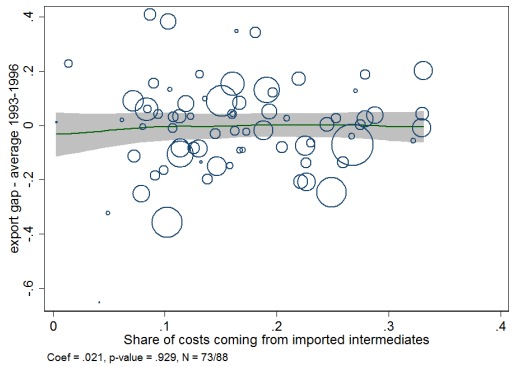
Another important source of heterogeneity is at the destination level instead of within sectors. The logic is that features of the relationship the U.K. has with its trading partners could explain the effects of the devaluation on trade flows. In Figure 2.11 Panel a, we run an exercise similar in spirit to that in Figure 2.5: first we construct a synthetic flow for each destination for the U.K., and then ag-

[64](The β coefficient in a regression predicting the price of the product using the exchange rate)

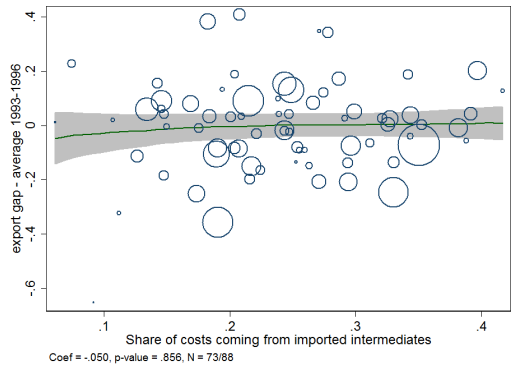
[65]Specifically, we drop "live animals and animal products" (with negative measured pass-through) and animal and vegetable fats and oils (with a passthrough of 0.85, which is much larger than the rest of the estimates).

Figure 2.9: Heterogeneous Effects of the Devaluation by the Domestic Value Added and Financial Dependance

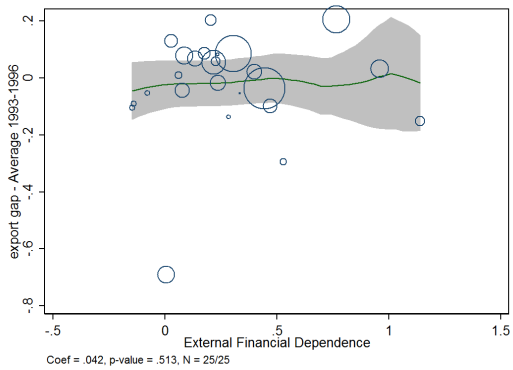
(a) Exports: Direct Share Imported



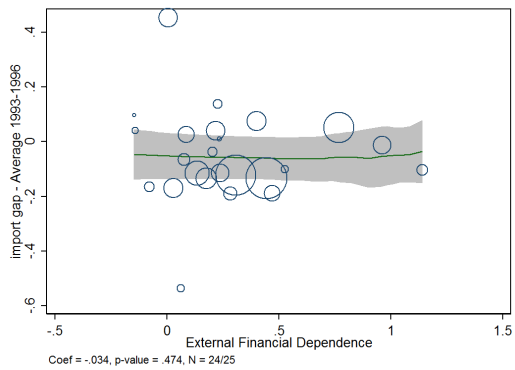
(b) Exports: Leontief Inverse × Share Imported



(c) Exports: Financial Dependance



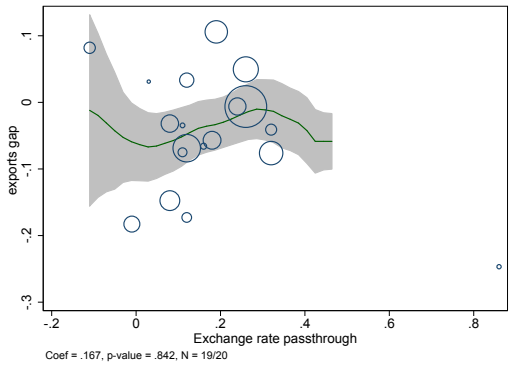
(d) Imports: Financial Dependance



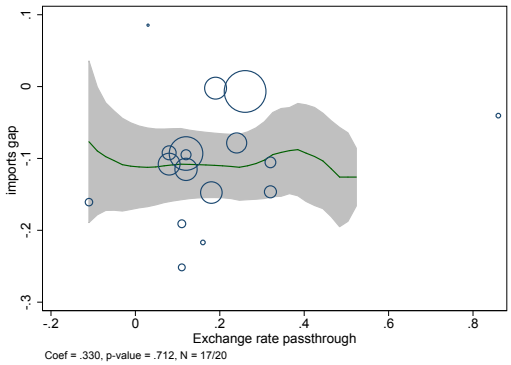
Notes: Each graph shows the relationship between the indicated market characteristic and the average (percent) gap between the sector's indicated outcome and its synthetic counterfactual in 1993-1996. The x-axis shows the characteristic, and the y-axis is the measured gap. Each graph shows kernel-weighted local polynomial lines, with each market's bubble weighted by its share of the total outcome in 1990-91. Markets are dropped if their pre-devaluation mean-squared error is over 10%. The notes for each graph report (i) The coefficent from a univariate regression of the predicted gap and characteristic, weighting by ex-ante share of trade flows, (ii) the share of countries who did not devalue with a larger coefficient, as described in Section 2.2.1, and (iii) the number of markets with a good-enough pre-devaluation fit to be included. Imported inputs calculated from the U.K.'s 1990 Supply and Use Table, and measures of external finance dependance are from Rajan and Zingales (1998). Trade data from UN COMTRADE.

Figure 2.10: Heterogeneous effects of the devaluation by measured pass-through

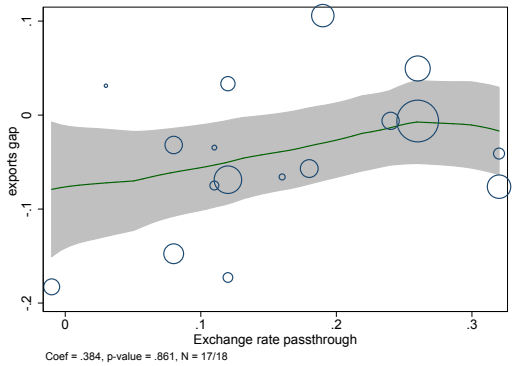
(a) Price Pass-Through - Exports



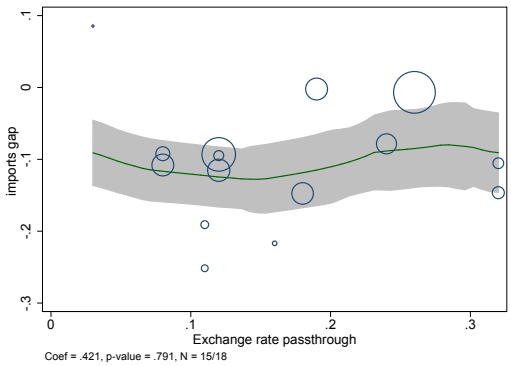
(b) Price Pass-Through - Imports



(c) Price Pass-Through, Dropping Outliers - Exports



(d) Price Pass-Through, Dropping Outliers - Imports



Notes: Each graph shows the relationship between the indicated market characteristic and the average (percent) gap between the sector's indicated outcome and its synthetic counterfactual in 1993-1996. The x-axis shows the characteristic, and the y-axis is the measured gap. Each graph shows kernel-weighted local polynomial lines, with each market's bubble weighted by its share of the total outcome in 1990-91. Markets are dropped if their pre-devaluation mean-squared error is over 10%. The notes for each graph report (i) The coefficent from a univariate regression of the predicted gap and characteristic, weighting by ex-ante share of trade flows, (ii) the share of countries who did not devalue with a larger coefficient, as described in Section 2.2.1, and (iii) the number of markets with a good-enough pre-devaluation fit to be included. Measures of exchange rate pass-through from Gopinath and Rigobon (2008). Trade data from UN-COMTRADE.

gregate both the actual flows and the synthetic flows. The sum of synthetic exports is similar to the synthetic counterfactual for all exports. Panel b tests three different models for why exports may not respond to devaluations. Panel a, inspired by Fitzgerald (2008), looks at the effects on distance,[66], while Panel b uses income per capita and Panel c uses trade shares before the devaluation as a destination based proxy for the extensive margin of trade (Bernard et al., 2009). None of the measures successfully predict heterogeneous effects of the devaluation over the destinations.

In this section, we found both that exports did not increase relative to its counterfactual, and that exports did not increase relatively more in sectors which theoretically would be more responsive to currency movements. While imports fell, we are also unable to predict cross-sectoral variation in the magnitude of the fall of imports across sectors. In the next section, we shift the focus to output and prices.

2.5 Effect on Domestic Outcomes

Currency movements should affect outcomes beyond trade flows. In this section, we focus on output. As in the previous section, we generate synthetic controls for the U.K. for each outcome, and use the post-devaluation gap as measure of the effect of the devaluation itself.

A large empirical and theoretical literature has found that (at least in the medium-run), per-capita GDP is insensitive to exchange rates (Obstfeld and Rogoff, 2000; Eaton et al., 2015). This is also what we find for the UK. Figure 2.12, Panel a plots the relationship between Nominal GDP per capita (NGDP) in the U.K. and NGDP in its synthetic counterfactuals, normalizing NGDP to 100 in 1992.[67] The pre-fit is very close (within .2 percent) and diverges following the devaluation, with the U.K.'s NGDP growing more slowly than its counterfactual. Panel b shows the results for

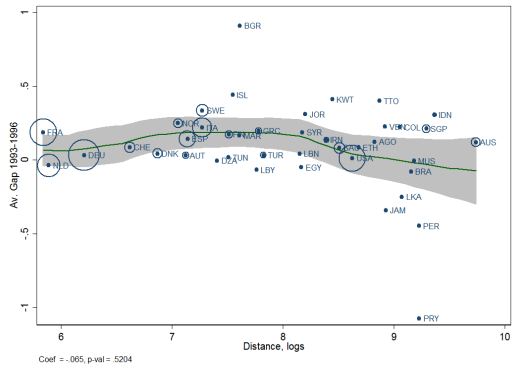
[66] Fitzgerald (2008) argues that trade costs mute the effects that exchange rates have on inflation, for instance if shipping costs are sticky in dollars.

[67] It is well-known that nominal GDP for the U.K. did increase (Sumner, 2016) after the devaluation.

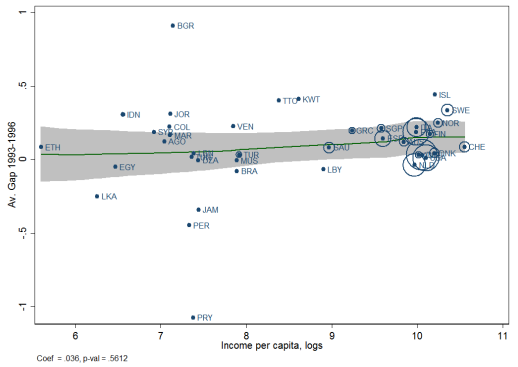
Figure 2.11: Heterogeneous effects of the devaluation by geographic characteristics

(a) Aggregated Destination Flows

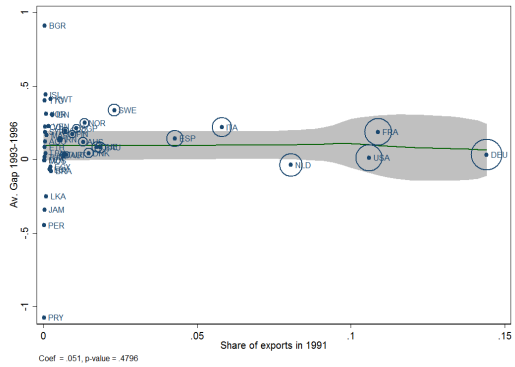
(b) Distance to Destination



(c) Income of Destination



(d) Destination's Share of Total Exports



Notes: Panel (a) compares the actual indicated outcomes for the U.K. relative to the sum of the desination-based synthetic counterparts. For each destination, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. The note describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1).
For Panels b-d, each graph shows the relationship between the indicated market characteristic and the average (percent) gap between the sector's indicated outcome and its synthetic counterfactual in 1993-1996. The x-axis shows the characteristic, and the y-axis is the measured gap. Each graph shows kernel-weighted local polynomial lines, with each market's bubble weighted by its share of the total outcome in 1990-91. Markets are dropped if their pre-devaluation mean-squared error is over 10%. The notes for each graph report (i) The coefficent from a univariate regression of the predicted gap and characteristic, weighting by ex-ante share of trade flows, (ii) the share of countries who did not devalue with a larger coefficient, as described in Section 2.2.1, and (iii) the number of markets with a good-enough pre-devaluation fit to be included. Trade data from UN-COMTRADE.

GDP in current dollar terms, which show even more of a fall (for partially mechanical reasons). As a measure of future expectations of nominal GDP, Panel c shows the effect on stock market prices.[68] There is a small but insiginificant increase in share prices in the U.K. relative to its counterfactual in the months after the devaluation, but there is no difference by 1994.

Figure 2.13 compares the components of nominal GDP to their synthetic counterfactuals. Nominal consumption increased slightly, nominal government expenditure shrank (or, more accurately, stopped growing while the synthetic counterfactual maintained its trend), and there was an large decline in capital formation. One argument for why devaluations may have a delayed effect on boosting exports is the time it takes to build new investments to respond to the shock. That fact that investment decreased after the devaluation is consistent with the finding that exports did not increase in the long run either.

2.6 Discussion

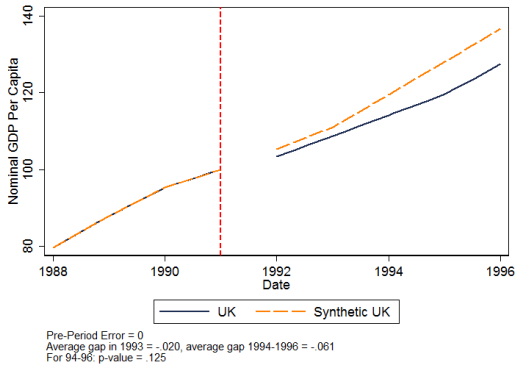
We document the performance of the United Kingdom following its unexpected nominal devaluation in September 1992. First, we show that prices of imports and exports (at the dock) increased by a similar order of magnitude to the devaluation. However, with the exception of goods in the energy sector, there was not a corresponding increase in other prices in Pounds, which is qualitatively consistent with the introduction of a credible inflation target in October 1992.

While the conventional wisdom is that the U.K.'s real devaluation was followed by an export-driven boom, we show that this is likely overstated. We do so by comparing the U.K. to a data-driven counterfactual U.K., and we neither find relative increases for GDP per capita nor exports in the observed U.K. time-series. Nevertheless, there was improvement in the trade balance, driven by an immediate decline in imports (contrary to theories of J- or S-curves).

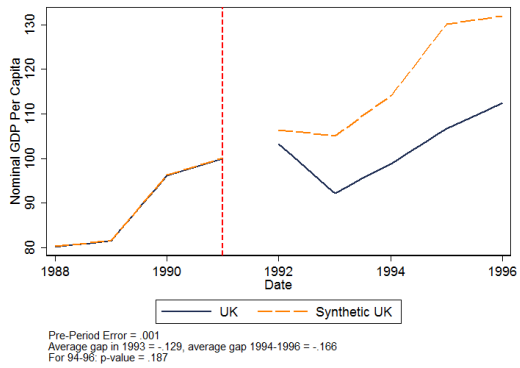
[68] The OECD share price indices for each country are calculated as the average price of common shares of a basket of companies traded both on local and foreign stock exchanges.

Figure 2.12: Effect of the Devaluation on Nominal GDP

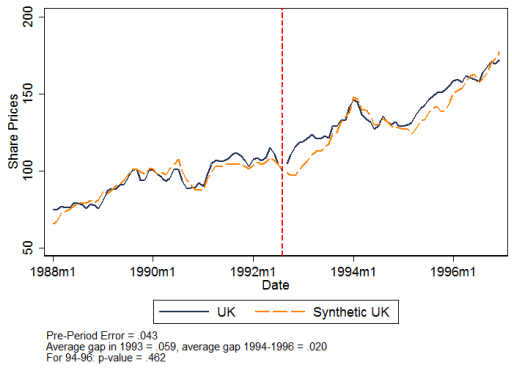
(a) GDP Per Capita, Current Prices, Local Currency



(b) GDP Per Capita, Current Prices, US Dollars



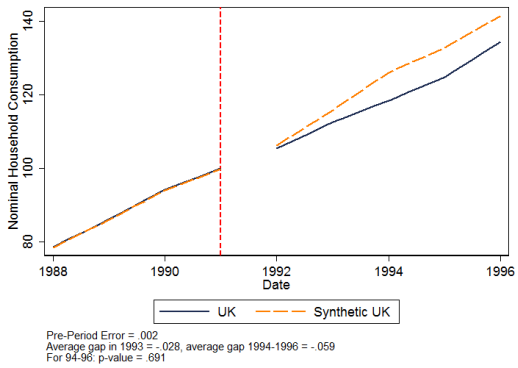
(c) Share Prices, US Dollars



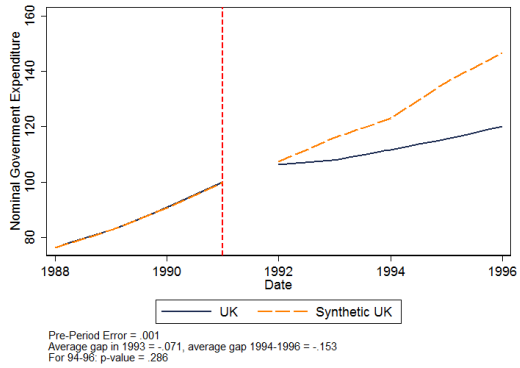
Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For each graph, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from the World Bank and the OECD.

Figure 2.13: Effect of the Devaluation on GDP Components

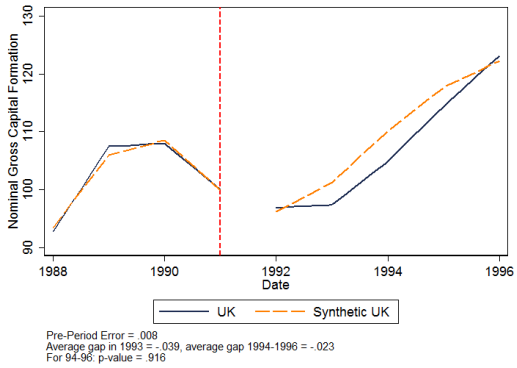
(a) Household Consumption



(b) Government Expenditures



(c) Gross Capital Formation



Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For each graph, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from the World Bank.

It is relatively common to find no export response to exchange rate movements (Ruhl, 2008). However, we show that many of the common explanations for this phenomenon were not present in this setting. Unlike most month-to-month exchange rate movements, the U.K.'s devaluation was large, unanticipated and (subsequently expected to be) persistent. Furthermore, cross-sectoral heterogeneity does a poor job of explaining cross-sectional variation in the response to the devaluation. For instance, there is no evidence that there was even an export boom in the short or medium run for commodities with a lower share of imported intermediates. However, we do find an increase in tourism following the devaluation, consistent the Economics-101 model that quantity demanded increases as prices decrease.

Countries no longer committed to defending their peg can and do enact other policies in order to encourage investment and economic activity (such as lowering interest rates on their treasury bills, which the U.K. did). Our finding is therefore not that the devaluation was the proximate cause of all potential subsequent changes. However, the lowered interest rates may not have happened in the absence of the currency crisis, so the devaluation may still have been the underlying cause of any changes in economic performance: the policy-relevant information involves understanding the effects of a devaluation, including all of the other corresponding policy changes. Since few (if any) countries devalue without doing anything else, a "pure" devaluation may not be a relevant counterfactual. We exploit new methods in order to understand the overall effects of the U.K.'s devaluation, and find that it had a puzzling limited effect on exports.

2.7 Appendix

2.7.1 Empirical Motivation for Synthetic Controls

Given the event-study nature of the analysis, standard linear regressions may not be the most appropriate empirical strategy. To show this practically, figure 2.14 shows the visual patterns at the monthly level for ln(imports) and ln(exports), and excluding the countries who devalued from the set of control countries.

We run two regressions, one at the aggregate level:

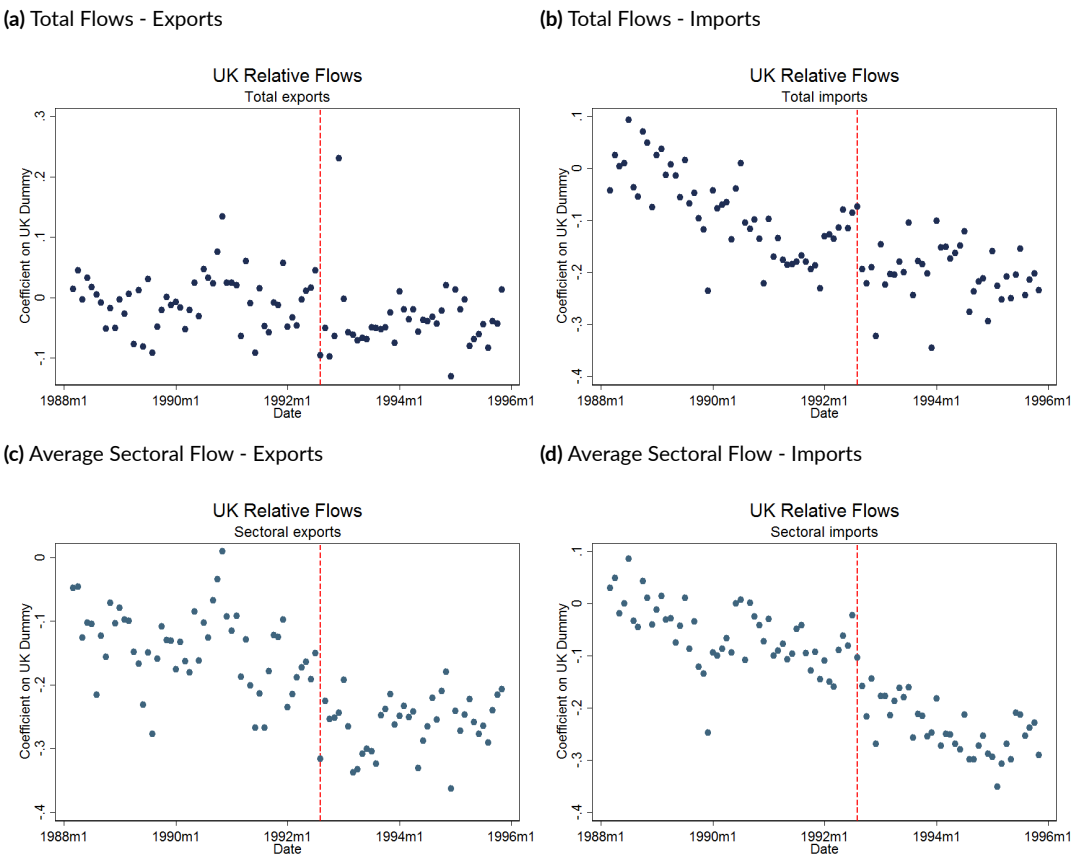
$$\ln(y_{ct}) = \sum_{u \in T} \beta_t \left(\alpha_{t=u} \cdot 1_{c=UK}\right) + \alpha_t + \gamma_c + \varepsilon_{ct}$$

and the other at the sectoral level (weighting each industry by its respective share in each country's exports in 1987).

$$\ln(y_{ict}) = \sum_{j \in I} \sum_{u \in T} \beta_t \left(\alpha_t \cdot \xi_j \cdot 1_{c=UK}\right) + \gamma_{ci} + \gamma_{ti} + \varepsilon_{ict}.$$

Panel a plots the coefficients for the U.K. relative to its peers (the βs in Equation 2.7.1), Panel b plots the β coefficients for Equation 2.7.1. The results in the two graphs are largely similar: there is no evidence of an increase in exports, and imports are lower after the devaluation than they were before, although that might be on-trend: the pre-trends for U.K. relative to the OECD are not zero and are often non-linear. The synthetic control strategy is designed to alleviate this concern: we only compare the U.K. to countries whose combination exhibits a similar pre-trend. While inference is difficult with this approach, the sign and magnitude of the U.K.'s performance relative to its counterfactual is nevertheless informative about the "effect" of the devaluation.

Figure 2.14: Differential Pre-Trends and Monthly U.K. Relative Exports, 1988-1996



Notes: These graphs compare the actual indicated outcomes for the U.K. relative to all of the countries with trade flows reported by the OECD (relative to that same relationship in January 1988). Specifically, each dot comes from the time-varying coefficients for the U.K., coming from from Equation 2.7.1 in Panels a and b and Equation 2.7.1 in Panels c and d (where sectoral flows are weighted by the average share in 1991). Data from the OECD.

2.7.2 A Model of a Devaluations

The synthetic control approach is particularly useful for studying outcomes such as export behavior, because the dynamics of a particular country's trade flows can be driven by shocks to its trade partners, which may be difficult to account for using exporter-specific controls in a traditional regression framework. The correct counterfactual for the U.K. should experience similar export shocks. As long as the only change to the underlying factor model for the U.K. is its own devaluation, the synthetic control approach allows us to construct the correct counterfactual.

In this section, we describe a simple partial-equilibrium model of production and trade that captures how the evolution of export behavior is driven both by shocks to the exporter as well as shocks to all other countries, weighted by how important those countries are in the export basket. While the model is intentionally parsimonious, it also captures several of the forces which have been proposed to mediate the effect of devaluations on exports: demand elasticities, intermediate good intensities, and the extent of exchange rate pass through.

There are many countries and two periods, with unexpected shocks between the two. In country c, the final good in sector s (of S sectors), Y_{cs}, is produced perfectly competitive aggregators with production function $Y_{cs} = \left(\sum_{j=1}^{N_s} q_{sjk}^{\rho_s}\right)^{\frac{1}{\rho_s}}$, where q_{sjk} is the consumption in country c of the production in s of firm k in country j. The production function for firm sjk is

$$q_{sjk} = A_{sj} L_{sjk}^{\gamma_{Ds}} M_{sjk}^{\gamma_{Is}}$$

where A is a country-sector specific TFPQ shifter, L is a domestically produced factor (including labor and domestically sourced materials), and M is a factor which is purchased on international markets. We assume constant returns to scale: $\gamma_{Is} + \gamma_{Ds} = 1$.

In the initial period, firm profits are given by

$$\pi_{sj,0} = p_{sjk,0} q_{sjk,0} - w_{j,0} L_{sjk,0} - P_{sj,0} M_{sjk,0},$$

where w_{sj} the price of the domestic factors, and P_{sj} the price of the international factors in the sector. Assuming that firms are myopic and do not internalize how their choices affects the overall price index and demand, profit maximization implies

$$p_{sjk,0} = \frac{\sigma}{\sigma - 1} \frac{1}{A_{sjk}} \left(\frac{w_{j,0}}{\gamma_{Ds}} \right)^{\gamma_{Ds}} \left(\frac{P_{sj,0}}{\gamma_{Is}} \right)^{\gamma_{Is}}$$

and export revenue is therefore

$$r_{sjk,0} = p_{sjk,0} q_{sj,0} = p_{sj,0}^{1-\sigma} D_{sj},$$

where $D_{sj} \equiv \sum_{i \neq j} \alpha_s I_i \left(P_{is,0} \right)^{1-\sigma} \tau_{ij}^{1-\sigma}$, $P_{is,0}$ is the initial price index in sector s of country i, I_i is overall expenditure in country i, α_s is the share of expenditure in s and τ_{ij} is the iceberg trade cost of shipping goods to i from j.

The set-up in the second period is similar, with three changes. First the price of domestic market factors has changed idiosyncratically in country j, perhaps due to a devaluation: $\hat{w}_j < 0$, while the price of the international intermediates remains the same $P_{sj} = 0$. Second, only a fraction χ_s of firms can change their output price (Calvo, 1983).[69] Finally, other countries face shocks their income (I_i), preferences α_{is}, and production technologies A_{si}.

[69] Given the data we have on pass-through, we assume that prices for inputs and outputs are set (and sticky) in dollars

For the firms who are able to adjust their prices

$$\hat{p}_{sjk}^{\text{adust}} = \gamma_{Is}\hat{w}_j, \tag{2.10}$$

and therefore

$$\hat{r}_{sjk}^{\text{adust}} = (1-\sigma)\,\gamma_{Is}\hat{w}_j + \hat{D}_{sj},$$

where

$$\hat{D}_{sj} \equiv \sum_{i\neq j}\left[\hat{\alpha}_s + \hat{I}_i + (1-\sigma)\,\hat{P}_{is} + (1-\sigma)\,\hat{\tau}_{ij}\right]\frac{\alpha_s I_i\,(P_{is,0})^{1-\sigma}\,\tau_{ij}^{1-\sigma}}{\sum_{\ell\neq j}\alpha_s I_\ell\,(P_{\ell s,0})^{1-\sigma}\,\tau_{\ell j}^{1-\sigma}}.$$

For firms who do not adjust their prices

$$\hat{r}_{sjk}^{\text{not adust}} = \hat{D}_{sj}. \tag{2.11}$$

Combining equations 2.10 and 2.11, the overall change in exports for each sector is

$$\hat{r}_{sj} = \chi_s\,(1-\sigma)\,\gamma_{Is}\hat{w}_j + \hat{D}_{sj}. \tag{2.12}$$

If β_{sj}, represents each sector's initial share of j's exports

$$\hat{r}_j = \sum_s \beta_s\left(\chi_s\,(1-\sigma)\,\gamma_{Is}\hat{w}_j + \hat{D}_{sj}\right)$$

Equation 2.12 captures several of the main features of our empirical analysis. An important source of the evolution of a country's exports come from shocks to foreigners, including sector specific shocks (such as changes in the preferences $\hat{\alpha}_s$), destination specific factors (such as changes in destination income $\hat{I}_i$, and destination-sector specific factors (such as changes in the sector/country price index $\hat{P}_{is}$). This encourages our use of the synthetic control framework for generating counter-

factual outcomes for the U.K. (in effect, trying to predict the $\hat{D}_{sj}$ for the post-devaluation period). Furthermore, consistent with a wide literature (although not supported by our empirical results), for a given decrease in $\hat{w}_j$ (due to a devaluation in our context), the corresponding increase in export revenue is larger in sectors with (a) larger pass through, (b) larger demand elasticities, and (c) smaller shares of imported intermediates.

2.7.3 Other European Devaluations

We find similar patterns for the other devaluations during the ERM crises. Between September 1992 and September 1993, seven other European countries - Finland, Ireland, Italy, Norway, Portugal, Spain, and Sweden - abandoned the ERM, which resulted in their currencies devaluing by 10-25 percent. We focus on the U.K.'s devaluation since it was particularly unexpected - futures markets for the Pound did not predict its devaluation until the day before - and it was not associated with a corresponding financial, sovereign debt, or political crisis (Budd, 2004; Bussière et al., 2010). [70] In Figure 2.16, we predict the change in trade flows as a function of the size of each country's devaluation). On the x-axis, we plot the (endogenous) average change in the exchange rate when countries floated their currencies (the average value 1993-1996 divided by the average value 1990-1992), as a measure of how much the shock might be expected to have mattered. On the y-axis, we plot the average gap in imports, exports, and nominal GDP per capita. There is no evidence that countries who experienced larger devaluations started to export more, while the imports gap is decreasing in the size of the devaluation. Nominal GDP is decreasing in the size of the nominal devaluation (although increasing in the size of the real devaluation). Our findings for the other devaluations during the ERM crisis are consistent with the results for the UK.

[70] In Figure 2.17, we show the exchange rate movements for those countries from 1988-1996.

2.7.4 Synthetic Control Weights

The Synthetic Controls method generates a weighted average of countries from the donor pool in order to most closely match the target in the pre-devaluation period. In the Figure 2.15, we describe weights for each of the synthetic control graphs. Similar outcomes often have very different donor pools, likely due to the non-linear nature of synthetic controls. For instance, the weights vectors for monthly and quarterly exports have a correlation of .56.

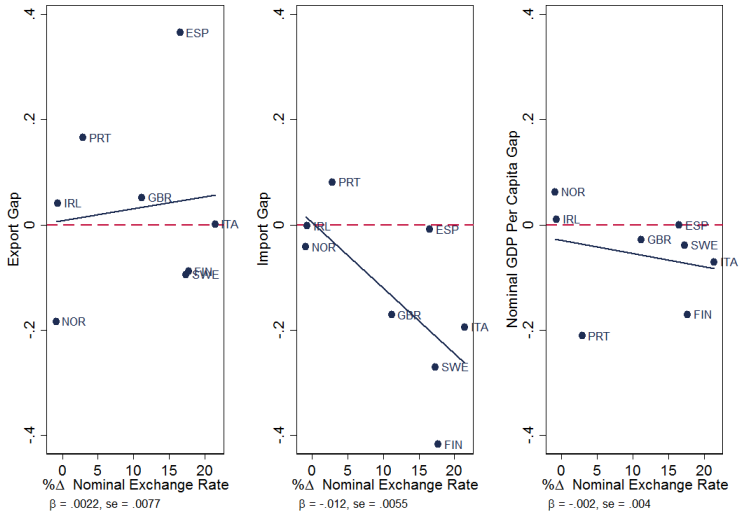
Figure 2.15: Synthetic Control Weights

country	Australia	Austria	Canada	Denmark	France	Germany	Greece	Israel	Japan	Netherlands	New Zealand	Saudi	Singapore	Switzerland	United States
12 Month Forward			0.84				0.16								
CPI (All Items)		0.03	0.17				0.15	0.14	0.48	0.04					
Energy Prices					0.38		0.13			0.36					0.13
Export Unit Values									0.91		0.09				
Export Volumes			0.25			0.46			0.11	0.19					
Exports Per Capita (Commodity, all)				0.03				0.34	0.59			0.04			
Exports Per Capita (Commodity, net exporter)		0.48		0.28				0.25							
GDP Per Capita (Current Dollars)	0.05	0.08	0.04	0.07	0.09	0.05	0.08	0.05	0.04	0.07	0.03	0.06	0.10	0.14	0.04
GDP Per Capita (Current Local Currency)	0.45	0.02	0.02	0.02	0.03	0.02	0.04	0.16	0.03	0.02	0.03	0.05	0.05	0.03	0.03
Gross Capital Formation (Current Dollars)	0.58		0.39								0.04				
Household Consumption (Current Dollars)	0.10	0.03	0.00	0.03	0.04	0.03	0.01	0.02	0.04	0.03	0.10	0.02	0.38	0.03	0.12
Import Unit Values			0.07			0.48			0.21		0.24				
Import Volumes					0.24						0.14				0.62
Imports Per Capita (Commodity, all)	0.05	0.01	0.49	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.32		0.04	0.00	0.03
Imports Per Capita (Commodity, net exporter)		0.22					0.07				0.68			0.03	
Nominal Exchange Rate (Quarterly)	0.14				0.19		0.03		0.41					0.23	
Nominal Exchange Rate (Monthly)	0.11				0.08		0.03		0.39					0.39	
Nominal GDP Deflator	0.40	0.02	0.02	0.02	0.02	0.02	0.16	0.11	0.02	0.02	0.09	0.06	0.02	0.02	0.02
Real Exchange Rate (Quarterly)							0.73		0.27						
Real Exchange Rate (Monthly)							0.62		0.28					0.10	
Share Prices	0.23			0.15			0.04	0.10	0.02	0.46					
Tourist Arrivals	0.02	0.00	0.01	0.02	0.07	0.45	0.08	0.14	0.17	0.02			0.01	0.00	0.01
Tourist Expenditure	0.16			0.31			0.50						0.02		
Value of Exports (Monthly)		0.21			0.15		0.10			0.01	0.17			0.36	
Value of Exports (Quarterly)	0.12	0.57					0.02		0.07					0.22	
Value of Imports (Monthly)	0.14	0.13												0.29	0.43
Value of Imports (Quarterly)			0.03	0.20										0.23	0.54

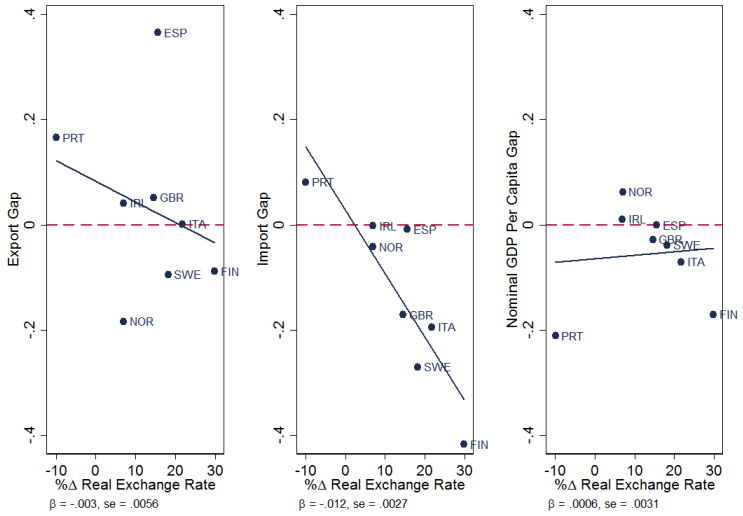
Notes: We report the synthetic control weights for each of the figures in the text. The outcomes are listed in alphabetical order.

Figure 2.16: Cross-Country Effects of the ERM Devaluations

(a) Nominal Exchange Rate Movements

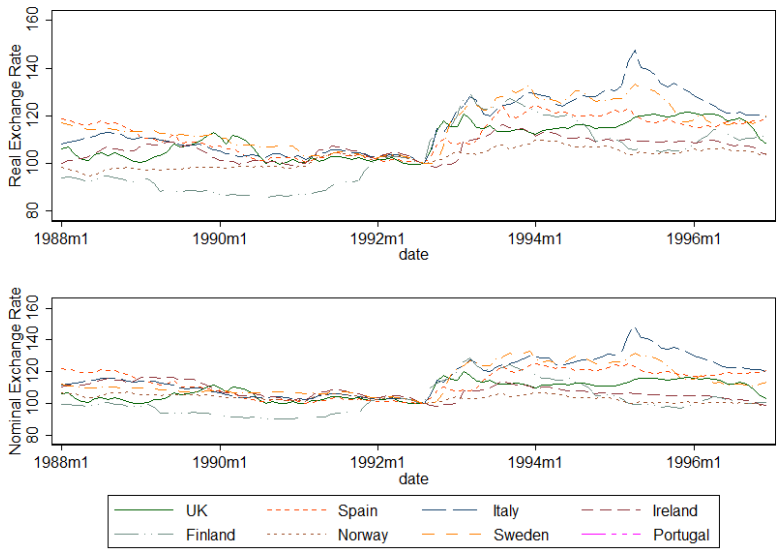


(b) Real Exchange Rate Movements



Notes: Each graph shows the relationship between the average change in the nominal or real exchange rates for each of the European countries who floated their currencies during the ERM crisis and the average (percent) gap between each country's indicated outcome and its synthetic counterfactual in 1993-1996. The x-axis shows the size the devaluation, and the y-axis is the measured gap. Each graph shows the regression line, and the notes for each graph report (i) the coefficent from a univariate regression of the predicted gap and characteristic, weighting by ex-ante share of trade flows, (ii) the standard error of that estimate. Data from Darvas (2012), UN COMTRADE, and the IMF.

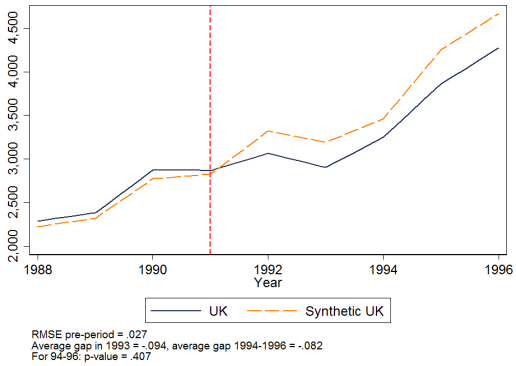
Figure 2.17: Exchange Rate Movements for devaluing countries, 1988-1996



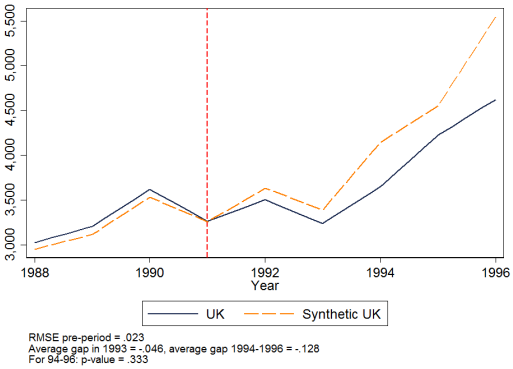
Notes: This figure plots exchange rate movements from 1988-1996 for the 8 countries who devalued during the ERM crisis (Darvas, 2012). Real Exchange Rates are CPI-based, using constant trade weights. Nominal exchange rates are local currency per dollar, and the real exchange rate is similarly decreasing in the value of the local currency. The U.K. is the only country denoted with a solid line.

Figure 2.18: Trade by partner-product, 1988-1996 - Annual

(a) Exports of Goods



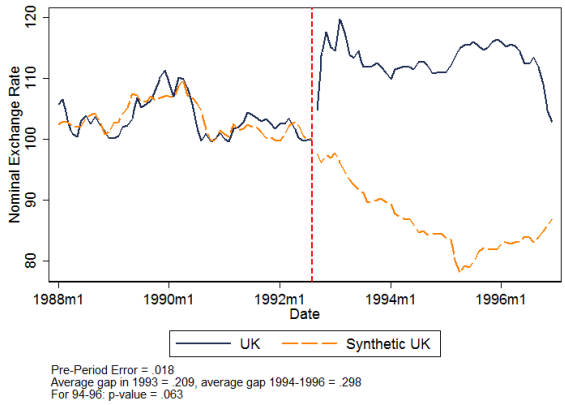
(b) Imports of Goods



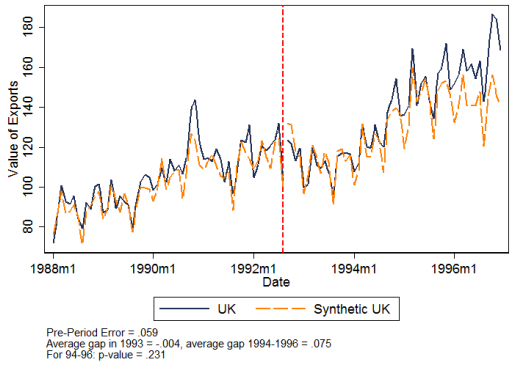
Notes: The graphs compare the actual indicated outcomes for the U.K. relative to the sum of the destination/1-digit-sector dyad-based synthetic counterparts. For each destination/sector, the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. The note describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from UN COMTRADE.

Figure 2.19: Exports and Imports, 1988-1996 - Synthetic Counterfactuals from Nominal Exchange Rates

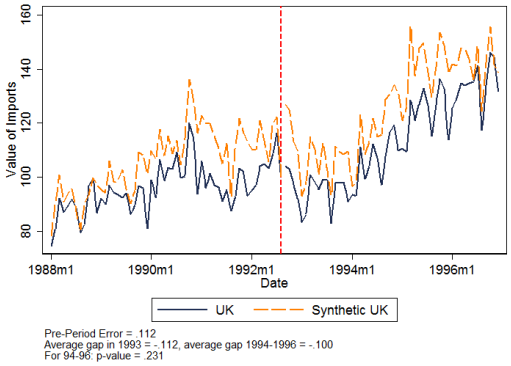
(a) Nominal Exchange Rate



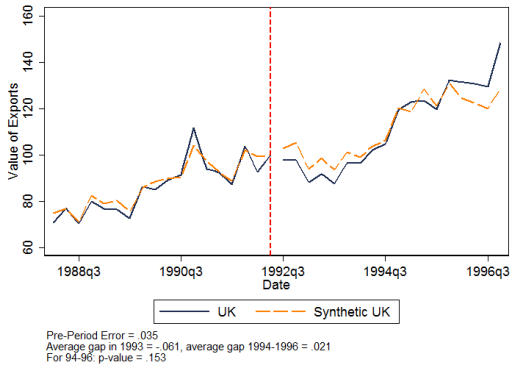
(b) Monthly Exports of Goods



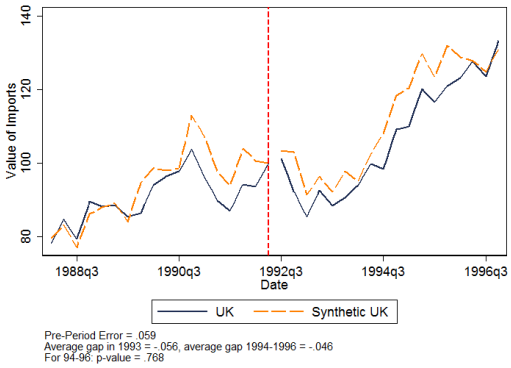
(c) Monthly Imports of Goods



(d) Quarterly Exports of Goods



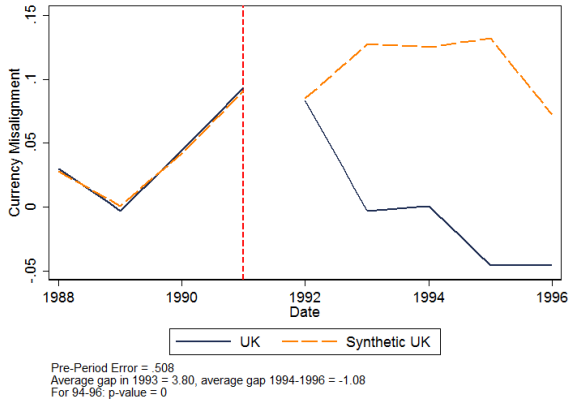
(e) Quarterly Imports of Goods



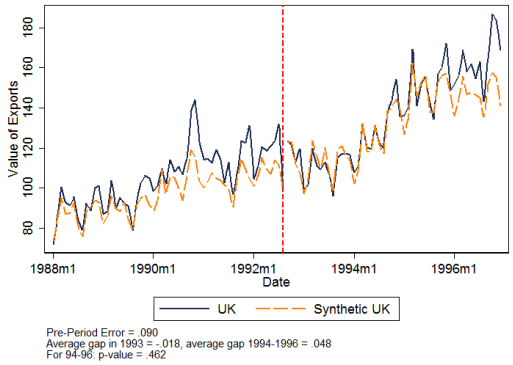
Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For Panel (a), the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. For the other panels, the weights are the same as for Panel (a). Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from the OECD and Darvas (2012).

Figure 2.20: Exports and Imports, 1988-1996 - Synthetic Counterfactuals from Exchange Rate Misalignment

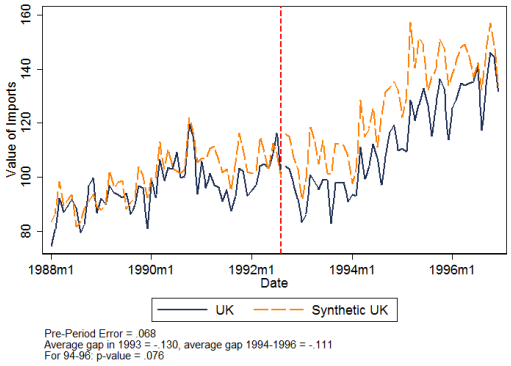
(a) Exchange Rate Misalignment



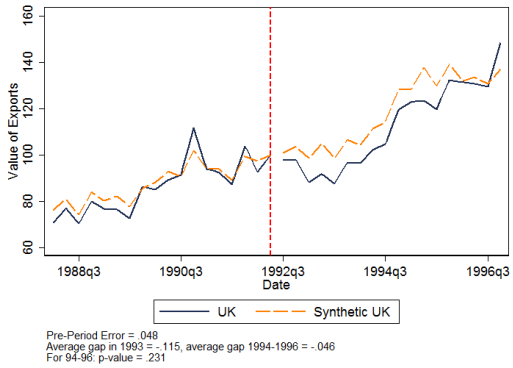
(b) Monthly Exports of Goods



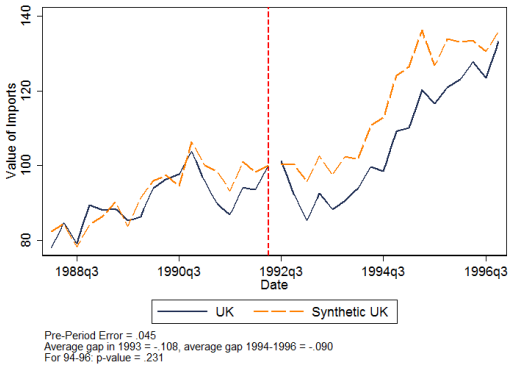
(c) Monthly Imports of Goods



(d) Quarterly Exports of Goods



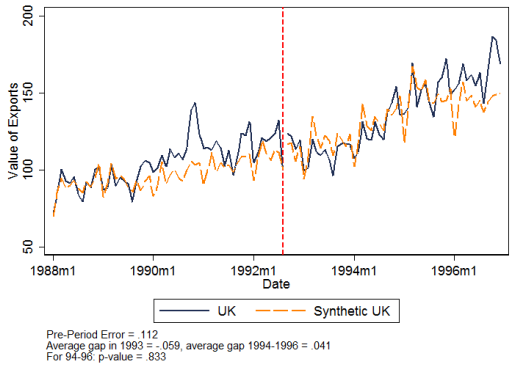
(e) Quarterly Imports of Goods



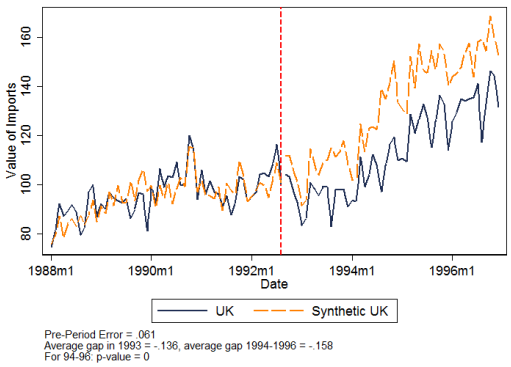
Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. For Panel (a), the synthetic control for the U.K. is generated by matching the indicated outcome in each pre-devaluation period, as well as per capita gdp and the share of exports coming from natural resources in 1990. For the other panels, the weights are the same as for Panel (a). Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from the OECD and Couharde et al. (2017).

Figure 2.21: Exports and Imports, 1988-1996 - Synthetic Counterfactuals from outside of Europe

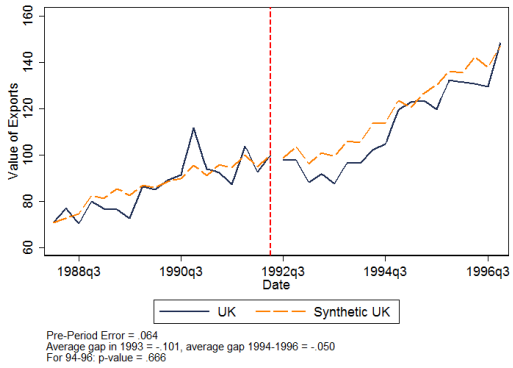
(a) Monthly Exports of Goods



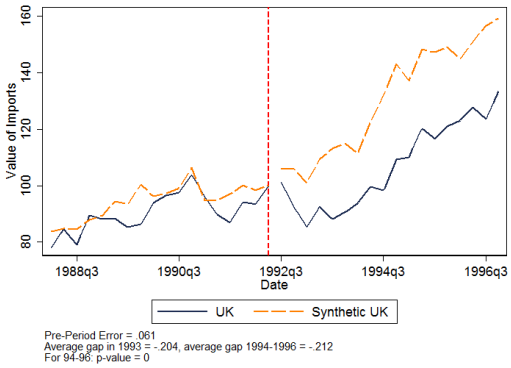
(b) Monthly Imports of Goods



(c) Quarterly Exports of Goods



(d) Quarterly Imports of Goods



Notes: These graphs compare the actual indicated outcomes for the U.K. relative to their respective synthetic counterparts. Other than the U.K., the sample consists of OECD countries outside of Europe. Values for nominal, unitless, and high-frequency outcomes are normalized to equal 100 on the final date before the devaluation. As described in the text, the note in each figure describes four moments of the data: (i) The mean squared error between the U.K. and its synthetic counterfactual in the pre-period, (ii) the average (percent) gap between the U.K. and its synthetic counterfactual in 1993, (iii) the average (percent) gap between 1994-1996, and (iv) the p-value for the gap, which roughly corresponds to the share of countries who experienced a larger (placebo) treatment effect than the U.K.'s (and is more precisely defined in Section 2.2.1). Data from the OECD.

3

Globalization and Protectionism: AMLO's 2006 presidential run

While the decision to liberalize bilateral or multilateral trading relationships is usually made at the national level, the degree to which trade restrictions bind economic outcomes is likely to vary geographically. Cities in which economic activity is concentrated in industries facing high tariffs

or other barriers to exports or protections from potential import competition are likely to be disproportionately affected by trade integration. The divergent relevance of a common shock given nationally fixed factors can help assess the true effects of trade liberalization on economic, political, and social outcomes. In this paper we study how globalization's local effects play a role on the electoral outcomes of national economic platforms. Specifically, we look at the Mexican presidential election of 2006, and find that Andrés Manuel López Obrador's (AMLO) decision to pursue a protectionist campaign platform was consequential for his narrow electoral loss.

The workhorse models of international trade have well-defined implications of the distributive consequences over trade integration, and hence, for individual preferences over integration (Rodrik, 1995). These predictions have been confirmed in the field's broad empirical literature[1]. Interestingly, more recent evidence suggests that preferences can diverge from the expectations of these same workhorse models. For instance, Blonigen (2011) finds that relationships between US labor market attributes and trade policy preferences are not consistent with leading theories for what drives policy preferences over trade integration. Pavcnik (2017) reviews the recent evidence on how international trade shapes inequality and poverty, discussing the perceptions about international trade in over 40 countries. She finds that the majority of the public in low and high-income countries accept that trade has overall benefits for the economy, even though people in low-income countries view trade as more beneficial for their livelihoods in their own country –in terms of higher wages and job creation– than do people in high-income countries.

In recent years, the literature on economic effects of trade integration has grown notoriously by

[1] Mayda and Rodrik (2005) illustrate this empirical literature. They find that pro-trade preferences are significantly and robustly correlated with an individual's level of human capital, in the manner predicted by the factor endowments model. Individuals with higher levels of human capital (proxied by educational attainment) oppose trade restrictions, but only in countries that are well endowed with human capital. They also find that preferences over trade are correlated with the trade exposure of the sector in which an individual is employed: individuals in non-traded sectors tend to be the most pro-trade, while individuals in sectors with a revealed comparative disadvantage are the most protectionist. Other relevant papers on these questions are Goldberg and Maggi (1999), Scheve and Slaughter (2001), Mayda (2006), Hainmueller and Hiscox (2007, 2010) and Ottaviano and Peri (2012).

studying its sub-national dimension, especially by exploiting the industrial composition of local labor markets. Autor et al. (2013) study how China's accession into the WTO affected American localities concentrating in industries receiving import-competing pressures. Kovak (2013) study how Brazilian integration into Mercosur affected local labor markets with higher baseline import barriers. Topalova (2007) finds that liberalization in 1991 undermined poverty reduction of Indian municipalities relatively exposed to foreign competition. Chiquiar (2008) shows that Mexico's globalization process results support the presence of Stolper-Samuelson type of responses, since regions more exposed to international markets appear to have exhibited an increase in wage levels, but a decrease in returns to schooling, relative to other regions of the country. Atkin (2016) provides further evidence of Stolper-Samuelson effects exacerbating initial skill differences by raising the return to the abundant skill. He finds that for Mexico during the period 1986 to 2000, the massive expansion of export manufacturing altered the distribution of education. In particular, the influx of new export-manufacturing jobs generated an abundance of new low-skill formal job opportunities which substantially raised the opportunity cost of schooling for youths on the drop-out margin. On the other side of the border, Hakobyan and McLaren (2016) find that trade integration with Mexico led to wage drops for blue-collar workers in US cities most exposed to import competition.

Interestingly, analyses on the local implications of trade liberalization instrumenting by the industrial structure of cities seem to have focused on the negative responses to import competition. To the authors' knowledge, no study has addressed how increasing economic opportunities from export market access for local industries due to trade liberalization impact local economic and political outcomes. This paper addresses this question by studying the effects of tariff reductions for Mexican exports into the US due to the implementation of the North American Free Trade Agreement (NAFTA) in the mid-1990's. Leveraging from the methodology proposed by Kovak (2013), and using data from Feenstra et al. (2002) and from the Mexican Economic Census[2], we observe that

[2] The Mexican Economic Census captures economic information about industries outside the agriculture

the implementation of NAFTA in 1994 led to local export tariff reductions that unevenly affected the industrial composition of different Mexican cities[3] in 1993, and find that municipalities facing higher market access gains had stronger employment growth between 1993 and 2003.

A corresponding literature has addressed the political consequences of the local economic effects of trade liberalization. David Autor et al. (2016) find that additional exposure to import competition from China associates with the election of polarized representatives to the US congress. Feigenbaum and Hall (2015) find that these representatives had more protectionist votes for trade related bills. A related literature addresses the incumbency effects of trade integration: Margalit (2011) and Jensen et al. (2017) find that higher job losses due to import competition and the presence of sectors intensive on relatively scarce inputs associate with worse electoral outcomes for incumbent presidents in the US.

We hypothesize that economic benefits due to increased export access to the US market undermines the local electoral support of economic platforms that threaten trade integration. We test this hypothesis using the local electoral turnout for Andrés Manuel López Obrador (AMLO) during the 2006's Mexican Presidential Elections. The front-runners in these tightly competed elections were AMLO and Felipe Calderón. Given the high polarization, mobilization of the respective political bases was seen as key. Regarding NAFTA, the 2006 elections were special because the last set of tariff exemptions under the agreement – Mexican imports of corn and beans from the US – were scheduled to be removed by the end of 2008. In an attempt to rally his relatively rural base, AMLO called for unilaterally rescinding the expiration of these tariff exemptions. Calderón's response advocated for rural development policies that did not threaten the NAFTA accords, and attacked AMLO's proposal as radical left-wing protectionism. The imminent expiration of the tariffs pro-

sector.

[3] Following Atkin (2016), we define cities as either official metropolitan areas defined by the Mexican government, or groups of municipalities forming commuting zones by using data on workers commuting patterns.

tecting Mexico's corn and bean sector made debates over globalization and protectionism specially salient for the 2006 elections.

For all these reasons, the 2006 election provides a proper setting for assessing our main political hypothesis: that market access gains due to globalization undermine local preferences for national protectionist platforms. Consistent with our expectations, our empirical tests suggest that local tariffs drops led to a decrease in AMLO's 2006 local vote share gains relative to the baseline vote for the left in the 1994 or 2000 presidential elections.

We argue that tariff reductions for Mexican exports into the US are exogenous and determined almost entirely by pre-NAFTA tariff protection levels. Still, results could plausibly be driven by factors other than a backlash against AMLO in localities that gained more export access to US markets. For instance, economic gains due to NAFTA tariff drops may undermine AMLO's support through a party incumbency channel, or if improving economic conditions led to a continuous shift of political preferences towards the right. However, we show that the effects disappear for the left's presidential bid in 2000, and for AMLO's 2012 and 2018 bids. These elections occurred under similar incumbency environments, and we continue to find positive economic effects of local tariff reductions. Trade integration, however, was not a salient economic policy issue in these elections, as the removal of tariff exemptions was either not imminent (for the 2000 elections) or had already occurred (for the 2012 and 2018 elections). Finding no effects of local tariff drops on electoral outcomes in elections other than 2006 suggests that the results are indeed driven by a pro-integration backlash against AMLO in areas most benefiting from NAFTA.

Given that AMLO proposed to prevent the expiration of import tariff exemptions on corn and beans, it's important to assess whether the local relevance of corn and bean growing played a role in AMLO's electoral gains in 2006. Nevertheless, we find that our results are robust to controls for local employment and local agro-ecological suitability in these sectors, and that these controls themselves were not relevant independent determinants of AMLO's vote gains in 2006. This result is

consistent with voters framing their stance on protectionism according to their past economic experience with trade liberalization: While light manufacturing regions had materially benefited from NAFTA by 2006 and wanted to defend such gains, corn and bean growing regions had been isolated from potential import competing pressures, and were not stimulated by a promise of continued protection against prospective losses.

As NAFTA tariff reductions were being rolled out, China was growing into a manufacturing powerhouse with relevant presence in world markets. The economic effects of the "China Shock" on US and Mexican labor markets have been documented in Autor et al. (2013) and Blyde et al. (2017). Nevertheless, we find that our estimates of the local political effects of NAFTA tariff drops on protectionism are not affected by relevant controls for Chinese competition in the US and Mexico, and by Chinese and Mexican competitiveness gains in non-NAFTA markets. Moreover, we find that these variables do not play an independent role in affecting AMLO's vote gains in 2006.

A key question raised by our study is whether our results are driven by the evolving preferences of voters that link NAFTA to improving economic conditions, or by the response of local organized interests and groups reacting to the threat of protectionism. We partially explore this question in assessing the heterogeneity of the effect of NAFTA on AMLO's 2006 vote gains around the party identity of the local governors and mayors at the time of the election. While we find that the identity of mayors does not affect our results, we also find evidence that results are contingent to states with PAN governors at the time of the election. We speculate that the effect of local tariff drops on AMLO's vote may have been elicited by the actions of PAN governors.

Aggregating our effects to the national level suggests that, had NAFTA not been a politically salient issue, AMLO would have obtained an extra 8% of the vote[4]. While the linearity assumption under this projection needs to be considered carefully, its size is so large versus such a razor-thin

[4] To obtain this estimate, we assume that the change in employment explained by the tariff reduction would have had no effect on AMLO's vote in 2006 with respect to previous benchmarks for the left.

outcome, that we are comfortable arguing that the decision to pursue a protectionist platform cost AMLO the 2006 election. We find that his media campaign decisions in 2012 are consistent with this realization, as the intensity of ads and the prevalence of media ads mentioning reconciliation and forgiveness was significantly higher in areas of the country with higher export access gains due to NAFTA. The same pattern is not detected when looking at ads aimed at attacking the credibility of the PRI party, which was his main competitor, and eventual winner, of the 2012 elections.

Our findings contribute to the trade, development and political economy literature. We formally document positive sub-national economic effects of export access gains for local industries due to trade integration. We do this for the case of Mexico, a developing country that entered into a Free-Trade Agreement (FTA) with two developed economies with higher productivity levels across the board. In trying to rally his rural base, AMLO's call for maintaining the remaining tariff exemptions led areas of the country benefiting from NAFTA to -pivotally- rally behind Calderón. These effects suggest that improved access to foreign markets undermines local preferences over protectionist platforms.

The paper continues as follows: Section 2 discusses AMLO's electoral platform and campaign dynamics during his 2006 and later presidential bids. Section 3 presents our hypotheses and empirical strategy. Section 4 describes the data we use and presents descriptive statistics and visualizations. Section 5 presents our regression results, and section 6 concludes.

3.1 NAFTA and AMLO's 2006, 2012 and 2018 presidential bids

The 2006 Mexican presidential election took place one term after the country's transition from seven decades of one party rule by the Partido Revoluciónario Institucional (PRI). Vicente Fox, the sitting president from the Partido de Acción Nacional (PAN), had pursued liberal economic policies. Despite showing favorable results in terms of economic growth, concerns with regards to

sluggish job creation, security and agricultural development undermined his popularity towards the end of his tenure. Importantly, there were growing concerns in the agricultural sector with regards to trade integration, as national production of corn and beans was considered vulnerable to foreign competition in general, and to the subsidized US agricultural sector in particular.[5].

NAFTA was signed in 1992 by PRI's president Carlos Salinas de Gortari, and went into effect on January 1, 1994, immediately eliminating tariffs for over 70% of Mexican exports to the US, 50% of US exports to Mexico, and removing all remaining tariffs over a period of 15 years (Villarreal and Cid, 2008). The political sensitivity around the issue of agricultural integration with the US played a role in NAFTA negotiations, and led to the establishment of longer tariff face-out periods. The last of these tariff exemptions would account for Mexican imports of corn and beans, to be removed by the end of 2008 - 15 years after the agreement went into effect.

In this context, two main candidates were contesting the country's leadership in the presidential elections; Felipe Calderón, PAN's candidate and former Secretary of Energy, and AMLO, candidate of the Partido de la Revolución Democratica (PRD), former Head of Government of the Federal District and front runner for most of year prior to this election. AMLO ran on a protectionist economic platform. Among his policy proposals, he called for preventing the lift of tariff exemptions for Mexican imports of corn and beans, a protection that was scheduled to end by 2008.[6] Debates over NAFTA became a contentious political issue during the campaign. In a bid to mobilize his rural base in what polls already predicted to be a very narrow election, AMLO pledged not to honor Mexico's commitment to eliminate tariffs on US corn and beans[7]. In response, Calderón's rural development proposal focused on compensating agriculture producers by creating rural protection policies and expanding PROCAMPO –the government's ongoing rural development program–

[5] For a thorough discussion on the effects of NAFTA on Mexico's agricultural sector, see Rosenzweig (2005).

[6] AMLO's 2006 government platform is available at https://bit.ly/2HIv16h. For complementary analysis, see https://bit.ly/2JKk6K2

[7] See https://wapo.st/2HFVzsU

without failing to comply with NAFTA agreements[8]. Unilaterally forcing a break with NAFTA's tariff schedules posed the threat of reciprocity on the manufacturing export front. AMLO's strategy to rally his base in the context of the imminent expiration of tariff exemptions raised the salience of NAFTA as a contentious policy topic during the campaign, and Mexican businesses tended to side with Calderón[9].

Calderón was declared winner by a difference of about 0.6% of the vote. AMLO challenged Calderón's razor-thin victory, leading to massive and protracted protests in Mexico City. The situation escalated to the point that AMLO symbolically sworn himself in as "legitimate president" of Mexico in a protest four months after the elections were held. Such a move was widely rejected by Mexicans and hampered his credibility as protests gradually faded.

Calderón's 2006-2012 administration was marked by the war on drugs, which led to drastic increases in the levels of violence and insecurity in different parts of the country[10]. AMLO ran as PRD's candidate once more in 2012. His campaign struck a much more conciliatory tone as means to address the public concerns on his figure after the protests of 2006, and as a way to compete with Enrique Peña Nieto, the popular front-runner from PRI[11]. As part of his strategy, AMLO moderated his economic proposals, focusing on job creation, austerity and competition. Chiefly, specific NAFTA revisions were not part of his policy platform, and former concerns with trade integration had subsided after the tariff exceptions expired.

AMLO lost in again 2012. Peña Nieto's term was marked by corrosive corruption scandals and violent events that left the public disappointed with Mexico's political establishment. In this context, AMLO broke with PRD and formed the Movement for the National Regeneration (MORENA),

[8] For instance, Calderón makes this proposal explicitly during the nationally televised presidential debate. See https://youtu.be/9W0vWxLGVBM

[9] See Méndez Soto (2014) and http://elcotidianoenlinea.com.mx/pdf/14510.pdf.

[10] Dell (2015) documents how the implementation of the Mexican drug war led to increased levels of violence.

[11] Josefina Vásquez Mota was PAN's candidate for the 2012 elections.

building his 2018 candidacy around justice ideals centered on anti-corruption efforts. President Trump's goal for a NAFTA revision led to a FTA renegotiation towards the end of Peña Nieto's term. While negotiations got derailed after the US imposed tariffs on US metal imports, all candidates were supportive of a new NAFTA deal -AMLO relied on pragmatic economic stances to prevent any game-changing events that could alter his comfortable lead[12].

In his third attempt, AMLO won the 2018 presidential election by a landslide, and Peña Nieto signed the USMCA FTA –a revised NAFTA accord– one day before AMLO was sworn in as Mexico's president. Revisions to the former agreement were limited to labor and environmental provisions; a raise in local content requirements for automobiles; and some changes to the protection of intellectual property rights[13].

3.2 Empirical strategy

We claim that market access gains due to the globalization of the Mexican economy had, through an economic channel, a negative effect in the support of AMLO in 2006. This effect was driven by a backlash against AMLO's protectionist platform, which called to avoid the looming expiration of import tariffs on corn an beans. While hoping to rally the rural vote with this policy appeal, his proposal also threatened US reciprocity against Mexican manufacturers. Fernandez and Rodrik (1991) provide a theory that helps explain why uncertainty on the distribution of gains and losses may drive status quo bias against policy reforms. Analyzing the situation from this perspective, it's easy to see the exceptional nature of the 2006 elections. Uncertainty over the consequences of non-compliance with NAFTA's agreed schedule on Mexican import tariffs that hoped to rally rural voters inadvertently alienated voters elsewhere. These uncertainties were all removed from the public agenda after

[12] See https://www.reuters.com/article/us-mexico-election/in-final-debate-mexican-presidential-favorite-says-a-nafta-fail-not-fatal-idUSKBN1J90B0.

[13] See https://www.ft.com/content/92e9ce0a-c55f-11e8-bc21-54264d1c4647

tariffs were effectively lifted, so that trade integration was not a salient issue in later electoral cycles. Similarly, the non-imminence of tariff exemptions in earlier elections would have led candidates to avoid proposing uncertainty-inducing reforms, so that NAFTA revisions were also a low salience issue in the 2000 presidential election.

We test our hypothesis with the regression specifications below:

$$\text{OLS} \quad \Rightarrow \quad \Delta\text{AMLO}_c = \alpha_0 + \alpha_1 \Delta\text{E}_c + X'\theta_c + \varepsilon_c \tag{3.1}$$

$$\text{Reduced Form} \quad \Rightarrow \quad \Delta\text{AMLO}_c = \gamma_0 + \gamma_1 \text{LTD}_c + X'\Psi_c + \mu_c \tag{3.2}$$

$$\text{First stage} \quad \Rightarrow \quad \Delta\text{E}_c = \beta_0 + \beta_1 \text{LTD}_c + X'\Upsilon_c + \eta_c \tag{3.3}$$

$$\text{Inst. Variable} \quad \Rightarrow \quad \Delta\text{AMLO}_c = \delta_0 + \delta_1 \Delta\hat{\text{E}}_c + X'\chi_c + \kappa_c \tag{3.4}$$

where ΔAMLO_c stands for AMLO's vote share in city c in the 2006 election minus PRD's local vote share in previous elections[14]; ΔE_c is the increase in employment since the year before NAFTA's implementation as a share of the population in the initial period; LTD_c stands for a weighted measure of the local tariff drops due to NAFTA between 1993 and 2001 in each city; $\Delta\hat{\text{E}}_c$ is the predicted employment change as a function of local tariff drops in the first stage; X_c includes baseline control variables; and ε_c, η_c, μ_c and κ_c stand for error terms uncorrelated with independent variables. The statistical significance of all coefficients is assessed using robust standard errors clustered at the state level. We weight each city by the total votes in the presidential election in order to make estimates representative of the national results.

Given our hypothesis, we expect to observe a positive estimate of β_1 and a negative estimate of γ_1 and δ_1. That is, we expect cities experiencing higher tariff drops to grow faster as a consequence of export market access gains, and we expect these cities to disproportionately reduce their support for

[14] We compare the vote in 2006 with respect to PRD's vote share in 1994 and 2000. The idea is to control for the inertia in the vote leaning towards PRD's regardless of the candidate running

AMLO in the 2006 elections.

We evaluate placebo specifications, assessing the effects of local tariff drops on the presidential electoral outcomes of PRD's Cuauhtémoc Cárdenas in 2000, and of AMLO in 2012 and 2018, relative to the baseline vote for Cardenas in the 1994 presidential elections[15]. PAN held the incumbency for the 2006 and 2012 elections, while PRI did so for the 2000 and 2018 elections. If incumbency drove results, we would expect a prevalent negative effect in all elections. Similarly, given how Cárdenas in 2000 and AMLO thereafter represented the candidacies furthest to the left in the Mexican political landscape, a general rightward shift of preferences in cities growing faster as a result of NAFTA would show up through prevalent negative effects in all the elections. For this reasons, if placebo estimates yield null results and the hypothesized political effects were indeed contingent to the 2006 elections, we would argue that they are most likely driven by NAFTA's effects specifically on preferences over protectionism, and not by incumbency effects or general effects of wealth on political preferences.

One possible challenge against the validity of local tariff drop as an instrument is that interest groups of different regions and economic sectors could have lobbied in favor of better access to the US for their products and, therefore, the local tariff drop instrument would not be exogenous. However, NAFTA lowered the tariffs for Mexican exports to the US almost to zero for the majority of products by 2001, regardless the tariff charged before NAFTA. Support for exogeneity comes from an examination of the nature of the tariff cuts during the liberalization, following the approach of Goldberg and Pavcnik (2005) and Kovak (2013). Figure 3.1 shows that industries with high tariffs before liberalization experienced the greatest cuts, with the correlation between the pre-liberalization tariff level and change in tariff equaling -0.99. As it can be seen in the figure, there is only a few sectors in which the final tariff was above zero. Since the liberalization policy imposed

[15] Cuauhtémoc Cárdenas was one of the main figures from the left in Mexican politics between the late 80's and the early 2000's. He ran for the presidency of Mexico in 1988, 1994 and 2000.

cuts based on a protective structure that was set decades earlier, it is unlikely that the tariff cuts were manipulated to induce correlation with counterfactual industry performance or with industrial political influence.

3.3 Data

In order to test the effect of the globalization of the Mexican economy on the electoral results, we collected data from different sources. Since our argument states an explicit link between economic outcomes and electoral outcomes, its important to use an appropriate definition of local economic markets. For this purpose, we group municipalities into commuting zones – which we will refer often to as cities – by combining municipalities in the same Metropolitan Zones (as classified by INEGI) or where a significant number of commuters moved between them, following Atkin (2016).[16]

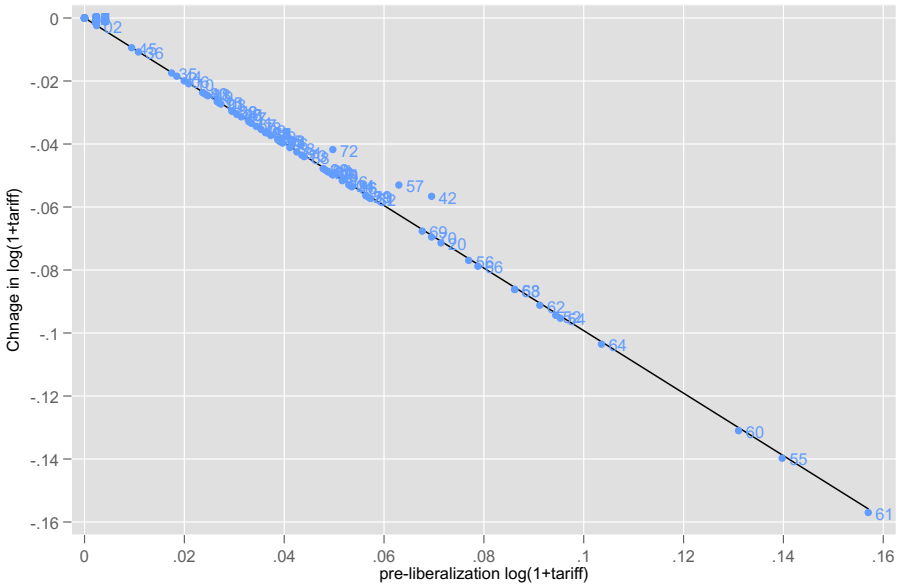
3.3.1 Employment and demographic data

We use the Economic Census data from INEGI of 1988, 1993, 2003, 2008 and 2013, to assess the employment in each Mexican city and industry following the NAICS classification.[17] We capture baseline socio-demographic variables from INEGI's Population Census. We compute ΔE_c as the difference in production workers between the census of 2003 and 1993, over the population of the city in the initial period, calculated as the average population reported in the Population Censuses of 1990 and 1995. An employment estimate closer to the presidential election of 2006 is unfortunately not available. We conduct robustness checks using employment estimates from the Economic Census of 2008, and obtain similar results.

[16] Atkin (2016) classifies commuting zones as groups of municipalities with more than 10 percent of their working population reported commuting between municipality lines but within the grouped set of localities.

[17] The Economic Census data used for this paper was provided by the Ministry of Finance of Mexico. This version of the data contains estimates following the NAICS industry classification of 2002.

Figure 3.1: Relationship between tariff drop and pre-liberalization tariff Levels



Notes: Figure shows the relation between pre-liberalization tariff ($log(1 + \text{tariff})$) and the change in tariffs before (year 1993) after NAFTA (year 2001). Tariffs correspond to those charged by the US to Mexican imports following the Harmonized Tariff System (HTS) at 8 digits. The product tariffs used for the figure correspond to the simple average at the 2-digit level. The line shows the fitted line of a regression with coefficient -0.99; standard error: 0.0052, and t-statistic: 190.0.

For the construction of other variables explained below we use estimates of employment at the industry-city level tabulated by INEGI using the micro-data from the Economic Census of each year. These tabulations are similar to what the US Census does with the well known County Business Patterns (CBP).

3.3.2 Local tariff drops

US import tariffs by product between 1989 and 2001 are obtained from Feenstra et al. (2002). Given the phased roll-out of tariff cuts under NAFTA, we capture the difference between a product's import tariff in 1993 and the NAFTA-determined Mexican import tariffs from 2001.

We transform this data from the Harmonized Tariff System (HTS8) to the US version of the North American Industry Classification System (NAICS 07). The concordance tables used come from Pierce and Schott (2012). These transformations are done by simple averaging of the tariff drops observed by products that share industry classifications[18].

In order to calculate the relevant local tariff drop for each city we combine the industry specific tariff drops with municipality-industry economic data from the Mexican Economic Censuses. We use data on the distribution of labor across industries in each city before the onset of NAFTA to produce our metric of local tariff drop (LTD), calculated as:

$$LTD_c = \sum_i s_{c,i} * \Delta \text{Tariff}_i \tag{3.5}$$

where $s_{c,i}$ represents the share of labor in industry i in city c just before the signing of NAFTA.

[18] Table 3.8 in the appendix list as an illustration of the 40 sectors that observed the larger tariff drops (out of 96), which concentrate in textiles and light manufacturing.

3.3.3 Electoral Data

Electoral data at the municipality level for all presidential elections between 1994 and 2018 was obtained from the Instituto Nacional Electoral (INE). The data provides party specific vote tallies as well as the size of the registry per municipality. The share of AMLO's vote in each municipality is the main dependent variable in our study. It is calculated as the total number of AMLO's votes as a share of all valid votes - that is, voting abstention is not considered. Data on local elections determining the parties of mayors and governors at the time of the 2006 elections was collected from the electoral tribunals of each state[19].

3.3.4 Media advertisements in the 2012 elections

In order to assess whether AMLO's strategies to appease voters concerned with his radical platform and actions of 2006 were intensified for areas with NAFTA induced economic gains, we look at the geographical distribution of AMLO's media campaign ads in the 2012 election. The Mexican electoral authority (INE), started collecting this information as part of the electoral reforms of 2007 [20]. The data accounts for the use of each ad in each TV and radio outlet in the country during the 2012 electoral campaign. Leveraging from a mapping of the geographic reach of each outlet's signal, we were able to assess the relative use of different ads in different municipalities during the campaign. The political aim in each of these ads can be captured from their scripts. In the case of AMLO, there are specific ads that focus on a message of forgiveness and reconciliation, while other ads are negative in nature[21].

[19] Data on local elections was collected and prepared by Gorrín et al. (2019).

[20] Sadly, this kind of information is not available for the 2006 election.

[21] Ads can be downloaded from http://pautas.ife.org.mx/transparencia/proceso_2012/camp/. The use of each ad in each media outlet during the campaign can be found at http://pautas.ife.org.mx/transparencia/ot/pef_2012/index.html. The geographic reach of each Radio and TV station can be found at https://portalanterior.ine.mx/archivos3/portal/historico/contenido/Mapa_de_Coberturas_de_Radio_Television/. These data sources were prepared and integrated for Larreguy et al. (2014) and

3.3.5 Covariates

Our estimates control for the levels of formal agricultural employment as a share of local formal employment in 2006. These estimates come from the Mexican Atlas of Economic Complexity[22]. We believe this control is important because voters in areas heavily dependent on the production of corn and beans may have been appealed by AMLO's proposal to sustain tariff exemptions. If the local intensities in agriculture and in the sectors that benefited most from tariff drops (concentrating in textiles and light manufacturing) are inversely correlated, then failing to control for agricultural intensity may yield a negative effect of local tariff drops on AMLO's vote due to omitted variable bias.

Finally, we include the baseline population size and area of a city as covariates, which helps us control for demographic determinants of political preferences which may correlate with local tariff drops.

3.4 Results

3.4.1 The geography of economic and electoral outcomes

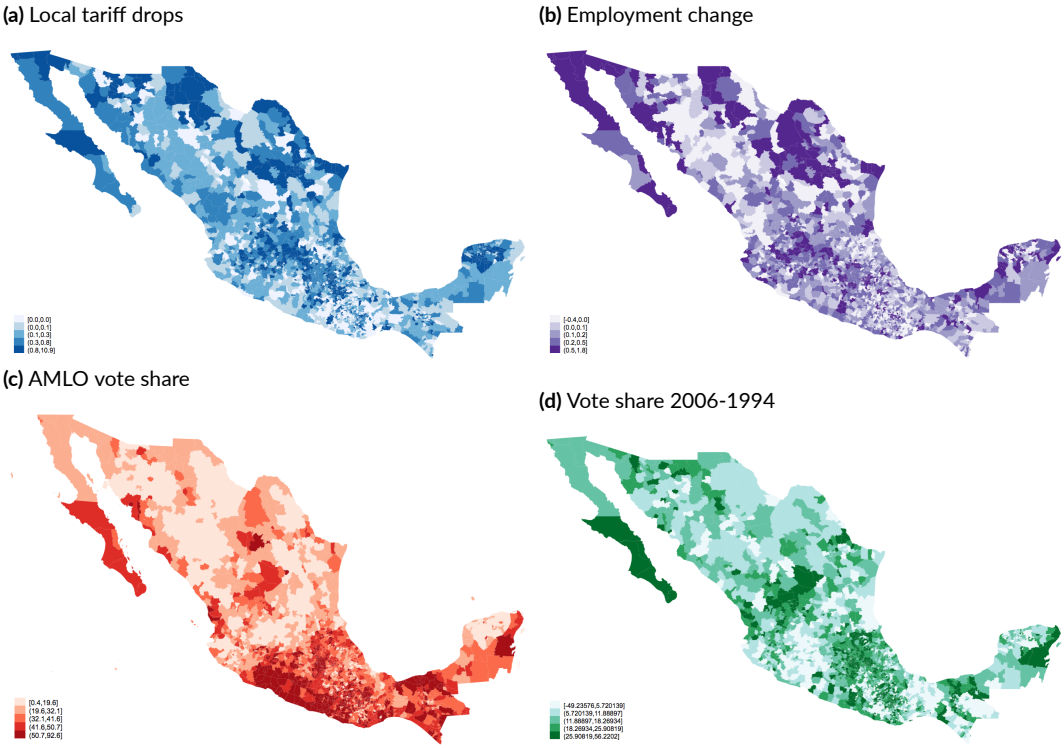
There is a large geographical heterogeneity of economic conditions and electoral outcomes. In order to provide a visual illustration of the heterogeneity, Figure 3.2 shows the map of Mexico colouring commuting zones according the local tariff drop, the employment change between just before the approval of NAFTA and the latest measurement before the election, the share of votes that AMLO got in 2006, and the share of votes as a difference with respect to PRD's vote share in 1994. Figure 3.2a shows how gains in US market access for local industries and economic gains were more broadly distributed throughout the country than AMLO's vote share, but still relatively concen-

Larreguy et al. (2018). We are very thankful to Horacio Larreguy for sharing this data with us.

[22] This data can be downloaded from https://datos.gob.mx/complejidad/

trated in the north. AMLO's political support in 2006 was much stronger in the south and center of the country, while it was much weaker towards the north of the country. This concentration, however, is not as strong when assessing the growth in AMLO's 2006 vote in comparison to the baseline vote for PRD in the 1994 elections.

Figure 3.2: The geography of economic and electoral outcomes



Notes: This figure shows four different versions of the map of Mexico according to outcomes defined in the main text. Panel (a) shows with darker shade of blue commuting zones that had a larger tariff drop from NAFTA to access the US market; panel (b) shows with darker shade of purple commuting zones that experienced a larger increase in annual employment as a share of total population; and panel (c) shows with a darker shade of red commuting zones where AMLO had a higher share of votes; panel (d) shows with a darker shade of green the vote share of AMLO in 2006 minus the share of PRD in 1994.

3.4.2 Regression estimates

To be precise, our claim is that there is a positive association between local trade integration preferences and (export) market access gains. We use AMLO's vote share increase in 2006 with respect to PRD's 1994 baseline vote share, as our main outcome variable. We take this as a measure of preferences against integration elicited by his NAFTA-threatening proposals after taking into account the vote that would usually lean towards left wing candidates[23]. Before discussing the regression results in table 3.1, it may be helpful to provide a graphical description of our empirical strategy. In figure 3.3 we show the partial correlation of the instrumental variable estimation of equation (3.4), following the Frisch-Waugh-Lovell decomposition; panel (a) shows the partial correlation of the first stage regression, while panel (b) shows the partial correlation in the second stage estimation.[24] Our first stage regression confirms our economic hypothesis: panel (a) shows that employment grew more in cities where the local tariff drop was larger. Turning now to the second stage estimator, our political hypothesis is also validated: Panel (b) of figure 3.3 shows that in cities where employment growth was larger as a consequence of NAFTA, AMLO's vote in 2006 relative to the baseline 1994 vote for the left was smaller.

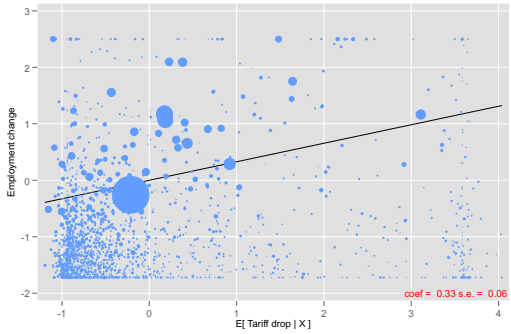
Our main estimates are shown in Table 3.1. We find that after controlling for baseline agriculture and socio-demographic variables, a one standard deviation increase in the local tariff drop metric associates with about a 0.33 standard deviation increase in local employment (column 1). The reduced form equation, shown in column2, indicates that the same local tariff drop is associated with

[23] Tables 3.9 and 3.11 show that results using levels and not changes in voting yield significant coefficients for all elections after 2000. This makes sense, as areas benefiting most from NAFTA were concentrated in the north of the country and AMLO's support was stronger in the south. To address this concern, our main specification uses the change in AMLO's vote relative to PRD's 1994 baseline as main variable of interest. As we observed above, this variable is not as geographically concentrated towards the south, suggesting that AMLO's southern dominance was due to baseline left-wing preferences in that region.

[24] The first stage estimation in panel (a) corresponds to the coefficient shown in column 2 of table 3.1, while the second stage estimation shown in panel (b) is equivalent to the column 4 of table 3.1.

Figure 3.3: Graphical representation of the instrumental variables regression

(a) Δ employment vs tariff drop



(b) AMLO vote share vs Δ employment

Notes: This figure shows in panel (a) the partial correlation between the change in employment and the local tariff drop, while figure (b) shows the vote share of AMLO in year 2006 minus PRD's vote share in 1994, with respect to the employment change instrumented and after controlling for the covariates use in table 3.1. Bubbles represent commuting zones and its size is proportional to their share in the total number of votes in 2006's election.

a 0.16 s.d. drop in AMLO's local vote share in 2006 relative to the left's 1994 baseline. The OLS estimations shown in columns 3 and 6, indicate that a 1 s.d. increase in employment reduced the vote for AMLO by almost 0.3 and 0.22 standard deviations, depending the whether the comparison baseline is 1994 or 2000. The OLS estimates are likely to be biased as approximations of the political effects of NAFTA induced economic growth. This is likely to be the case as the effects of growth on AMLO's support in areas that did not benefit from NAFTA was probably lower in magnitude. In columns 4 and 7 we show the IV estimates, where employment change is instrumented by the local tariff drop from NAFTA. The point estimates, depending on the comparison baseline used, suggest a between a 0.47 and 0.59 standard deviation drop in AMLO's vote share as a consequence of a 1 standard deviation increase in employment growth. These effects are between 1.6 and 2.6 times bigger than the OLS effects. We test for the statistical inference of whether our IV strategy is valid, using the Kleibergen-Paap LM test and find that we reject the null of underidentification with a p-value of 0.001.

While the results shown so far are consistent with the hypothesized mechanism, they could plau-

Table 3.1: AMLO's result in the 2006 election

		Vote share of year 2006					
	Employment change	with respect to 1994			with respect to 2000		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employment change			-0.29***	-0.47**		-0.22**	-0.59**
			(0.10)	(0.24)		(0.09)	(0.24)
Local tariff drop	0.33***	-0.16*			-0.20**		
	(0.06)	(0.08)			(0.07)		
Initial pop, log	0.17	0.65***	0.68***	0.73***	0.78***	0.78***	0.88***
	(0.25)	(0.21)	(0.17)	(0.12)	(0.14)	(0.12)	(0.11)
Area, log	0.06	-0.14	-0.12	-0.12	-0.25**	-0.22**	-0.21*
	(0.09)	(0.11)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)
Agriculture emp. share	-0.04	-0.05	-0.05	-0.07	-0.02	-0.01	-0.04
	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Observations	2,132	2,132	2,132	2,132	2,132	2,132	2,132
R-squared	0.21	0.29	0.34	0.31	0.35	0.36	0.24
Method	1S	RF	OLS	IV	RF	OLS	IV
Weights	yes	yes	yes	yes	yes	yes	yes
K-P LM p-value		-	-	.001	-	-	.001

Robust standard errors in parentheses clustered at the state level
*** p<0.01, ** p<0.05, * p<0.1

Notes: The estimates of column 1 correspond to the first stage estimates of the Instrumental Variables estimates of columns 4 and 7.

sibly be driven by other factors affecting the preferences for other candidates. For instance, we may expect that municipalities with greater increases in their access to the US market may have done better economically, so that our results are due to a relative increase in PAN's incumbent party support. Moreover, the result may be driven by structural pro-market positions in municipalities that happened to have gained relative US market access. However, if this was the case, we would expect the political effects to hold for other elections between 2000 and 2018. Thus, the idea is to provide a placebo of the same specification as columns 4 and 7 shown in table 3.1, where we expect to find that the employment growth explained by tariff drops from NAFTA not to be a significative predic-

tor of electoral outcomes. We explore this in table 3.2, where the dependent variable is the differential vote share of each election since 2000. In columns 1 to 4 the difference is with respect to PRD's share in 1994, while in columns 5 to 7 we use PRD's share in the election of year 2000. All columns of the table present IV estimates, and the corresponding first stage estimates, which are all valid, are shown in the appendix. We find that variation in local tariff drops, and its respective economic effects, does not associate with the growth in the local voting performance for the left in any election other than in 2006. This implies the NAFTA was relevant only in 2006, playing an important role on AMLO not being elected.

Table 3.2: AMLO's results in three elections

	Vote share of year:						
	2000	2006	2012	2018	2006	2012	2018
	with respect to 1994				with respect to 2000		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employment change 93-03	0.05	-0.47**			-0.59**		
	(0.17)	(0.24)			(0.24)		
Employment change 93-08			-0.08			0.04	
			(0.26)			(0.27)	
Employment change 93-13				-0.09			0.02
				(0.27)			(0.31)
Agriculture emp. share	-0.07	-0.07	-0.01	0.06	-0.04	0.03	0.08
	(0.05)	(0.05)	(0.07)	(0.07)	(0.05)	(0.06)	(0.06)
Initial pop, log	-0.05	0.73***	0.45***	0.08	0.88***	0.53***	0.17
	(0.22)	(0.12)	(0.14)	(0.16)	(0.11)	(0.10)	(0.11)
Area, log	0.13	-0.12	-0.14	-0.02	-0.21*	-0.19**	-0.07
	(0.13)	(0.10)	(0.12)	(0.17)	(0.11)	(0.08)	(0.12)
Observations	2,132	2,132	2,132	2,152	2,135	2,135	2,155
Method	IV	IV	IV	IV	IV	IV	IV
Weights	yes	yes	yes	yes	yes	yes	yes
K-P LM p-value	.001	.001	.001	.009	.001	.001	.009

Robust standard errors in parentheses clustered at the state level
*** p<0.01, ** p<0.05, * p<0.1

Given that the effects disappear outside of the 2006 election, we interpret our results as evidence

that preferences shifted away from that year's protectionist platform -not necessarily away from AMLO as a politician, or from left leaning platforms in general. Doing a back of the envelope calculation using the results in columns 4 and 7 of table 3.1, we find that AMLO would have about an extra 8% in the national vote for the 2006 Mexican presidential election. While this calculation relies on a linear projection which demands cautious interpretation, we find this effect to be sufficiently high for us to safely assume it was pivotal in a razor-thin election. By appealing to his rural base with a protectionist stance, AMLO alienated voters elsewhere and lost the election as a consequence[25].

3.4.3 Local economic relevance of corn and beans

Thus far, we have assessed the negative political effects of AMLO's 2006 protectionist stance on his electoral gains relative to past benchmarks of local support for the left. However, the decision to pursue a protectionist platform hinged on his bet to rally his supposed relatively strong agricultural base. So far, in the two previous tables, we control for the local formal employment share in agriculture in 2006, and find no significant effects on the growth of AMLO's support.

However, there are a number of reasons why this may not be the optimal metric to test for an effect of protectionism in areas that might have benefited from sustaining import tariff exemptions on corn and beans. While these sectors are indeed key to Mexico's agriculture sector, they do not capture the totality of agriculture output in the country. Other salient agriculture products –like avocados, bananas and tomatoes– show strong export performance to the US, and benefited from NAFTA. Consequently, we would like to test for proxies of agriculture production that restrict

[25] Dell et al. (ming) find positive effects of trade-induced labor displacements in Mexico on violence and drug-trafficking activities. The authors restrict their sample to urban labor markets, where the local effects from competition in manufactures should concentrate. Tables 3.15 and 3.15 in our appendix replicate tables 3.1 and 3.2 while mimicking their approach. We limit our sample to urban municipalities and metropolitan areas with over 50% of their population residing in urban areas. The main coefficients grow substantively (between 30% and 40%), and the overall interpretation of results -that negative effects of NAFTA induced employment growth on AMLO's vote gains are only observed in the 2006 election- remains unaltered.

to the production of corn and beans, which were the only import items being protected by tariff exemptions.

Table 3.3 shows IV estimates of the political effect of employment change instrumented by NAFTA tariff drops, controlling for different measures of agriculture intensity. The baseline estimates are provided in columns 1 and 5, which use AMLO's 2006 vote gains with respect to the vote for PRD in 1994 and 2000, respectively. These baseline estimates do not control for agricultural employment. Columns 2 and 6 include the formal share of agricultural employment in 2006 as in regression 4 of table 3.1. In columns 3 and 7 we introduce a control for the local formal employment share in corn and bean growing[26], while columns 4 and 8 control for a proxy of the suitability of corn and bean crops at the commuting zone level[27]. Our results underscore the robustness of our IV estimates of the economic effects of NAFTA in both magnitude and significance. Moreover, we find mostly insignificant and negative associations between the exposure to agriculture and corn and bean growing at the time of the election and AMLO's vote gains.

Considered jointly, these results suggest that while areas benefiting from NAFTA responded negatively to the protectionist outlook, AMLO's bet to elicit additional support and turnout from corn and bean growing regions did not yield the expected results. This is consistent with voters framing their stance on protectionism according to their past economic experience with trade liberalization. While light manufacturing regions had materially benefited from NAFTA and wanted to defend such gains, corn and bean growing regions had been isolated from potential import competing pressures, and were not stimulated by a promise of continued protection against prospective losses.

[26] This is the employment associated to NAICS industry code 1111, "Oilseed, legume and cereal growing".

[27] We take this data from the Global Agro-Ecological Zones program from the FAO, which provide potential agro-climatic yields (kilograms of dry matter per hectare) of maize and phaleous beans. The data is provided in separate rasters of 5 arc-minutes and 30 arc-second grid-cells for each crop. We take agro-climatic potentials of rain-fed and intermediate input yields. We use ArcGIS geo-spatial software to produce average yields for the polygon of each city. Finally, we average each city's potential yield for maize and beans into a single score.

Table 3.3: AMLO's result, NAFTA and corn and bean growing

	AMLO vote share							
	with respect to 1994				with respect to 2000			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Employment change	-0.45**	-0.47**	-0.46**	-0.48*	-0.58**	-0.59**	-0.58**	-0.58**
	(0.23)	(0.23)	(0.23)	(0.28)	(0.24)	(0.24)	(0.24)	(0.29)
Agriculture employment share (2006)		-0.06				-0.03		
		(0.05)				(0.04)		
Corn and bean employment share (2006)			-0.09**				-0.01	
			(0.04)				(0.06)	
Corn and bean suitability				-0.04				-0.00
				(0.09)				(0.09)
Area, log	-0.16*	-0.13	-0.13	-0.17*	-0.24**	-0.22**	-0.24**	-0.24**
	(0.09)	(0.10)	(0.09)	(0.09)	(0.10)	(0.11)	(0.11)	(0.11)
Initial pop, log	0.79***	0.75***	0.75***	0.80***	0.92***	0.90***	0.91***	0.92***
	(0.12)	(0.12)	(0.11)	(0.13)	(0.10)	(0.11)	(0.10)	(0.13)
Observations	2,129	2,129	2,129	2,129	2,129	2,129	2,129	2,129
R-squared	0.33	0.33	0.33	0.32	0.25	0.25	0.25	0.25
Method	IV	IV	IV	IV	IV	IV	IV	IV

Robust standard errors in parentheses clustered at the state level
*** p<0.01, ** p<0.05, * p<0.1

Notes: Estimates in all columns show IV estimates for Employment change instrumented by NAFTA tariff drops, along with the coefficient of different metrics of local relevance of corn and beans production.

3.4.4 Chinese competition

In tandem with NAFTA, Mexico was being affected by an additional globalization shock: China's rise as a manufacturing powerhouse, hastily capturing international markets. The economic effects of the China shock in the US economy and in the Mexican economy have been studied by Autor et al. (2013) and Blyde et al. (2017). These shocks are relevant since they may affect how local labor markets perceive the most salient aspect of globalization in the Mexican political debate (NAFTA), as either beneficial of detrimental for their welfare. Some Mexican regions benefiting from improved access to the US market may have not been able to seize economic gains due to Chinese competi-

tion in the US market. Hence, voters in regions more affected by import competing pressures from China could assign the responsibility of such pressures on NAFTA, seeking protection. Finally, an important question is to assess whether the effects of NAFTA tariff drops on AMLO's 2006 gains were driven or not by general productivity improvements in Mexico, which would be observed in the country's export performance to non-NAFTA markets.

For studying these questions, we use a similar empirical strategy as used in table 3.1 were we analyzed the political effect of employment change instrumented by NAFTA tariff drops, but now controlling for different dimensions of trade competition. Following Autor et al. (2013), the specific expression[28] we use to proxy trade exposure in each city is:

$$\Delta \text{ trade exposure }_c = \sum_i \left(\frac{L_{c,i}}{L_c}\right) \times \frac{\Delta \text{trade}_{i,m}}{L_i}$$

were $L_{c,i}/L_c$ is the share of industry i in city c, L_i is the total employment of industry i in the country, and $\Delta\text{trade}_{i,m}$ is the change of trade in market m.[29] In our analysis m could refer to the exports of China to the US market, or other non-NAFTA countries, exports from China to Mexico, or Mexican exports to other non-NAFTA countries.[30]

Table 3.4 shows the results of assessing the importance trade competition. Baseline estimates are provided in columns 1 and 6, which use AMLO's 2006 vote gains with respect to the vote for PRD in 1994 and with respect to 2000, respectively. Regressions 2 and 7 control for the local relevance of Chinese product export growth to the US Market, while regressions 3 and 8 control for Chinese exports growth to Mexico. As Autor et al. (2013) explains, these trade shocks may be explained by China's increased capacity to supply World markets, but also by demand driven factors. In this con-

[28] This expression is derived from a trade model with monopolistic competition in which each region is treated as a small open economy. See the appendix of Autor et al. (2013).

[29] Bilateral trade used in this section is the cleaned trade dataset by Bustos and Yildirim (2020).

[30] We decided not to include Mexican exports to the US, as a control variable, since its effect is already captured and it is endogenous to the employment change, our main explanatory variable.

text, Chinese exports to the US may have also been affected by NAFTA, and therefore having an impact over the intensity and composition of Mexican exports to the US. To address this, regressions 4 and 9 consider Chinese product exports growth to its top 10 non-NAFTA destinations, which is likely unaffected by NAFTA demand factors, and it is intended to capture China's supply productivity increase over the period. Finally, regressions 5 and 10 control for Mexican product exports growth to non-NAFTA destinations as a way to capture overall Mexican productivity gains in different products. Overall, the estimates of trade shocks do not appear to have a significant impact over the vote of AMLO, since none of the estimates is significant at the conventional 5% confidence level. The result indicates that the economic effect of NAFTA tariff drops on AMLO's 2006 vote gains are robust to controlling for trade shocks included in the analysis. Moreover, we find that these channels show no apparent independent effect on AMLO's 2006 vote gains.

3.4.5 Political alignment of governors and mayors

The observed effects of export access gains on the support for protectionism may be driven by the evolving preferences of voters that recognize globalization as a determinant of their improving economic welfare. An alternative view would point towards the agency and behavior of local elites (authorities, politicians, firms, unions, media, guilds, etc.) in bolstering local support for pro-globalization platforms and eroding that of protectionist ones. For example, the negative effect of local tariff drops on AMLO's vote gains may have been determined by the actions of governors or mayors from PAN, who were trying to get Felipe Calderón elected.

Table 3.5 shows the reduced form effect of a municipality's local tariff drop on AMLO's vote gain relative to PRD's 1994 benchmark[31]. Regression 1 provides a baseline estimate for all munic-

[31] In this section, we work with data at the municipality level and not at the city level because some cities cross state lines and have mayors from different parties for the different municipalities that shape them. We also provide reduced form effects of the local tariff drops and not IV effects of the instrumented change in employment so as to interpret the relevant interaction terms most intuitively.

Table 3.4: AMLO's result, NAFTA and Chinese competition

	AMLO vote share									
	with respect to 1994					with respect to 2000				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Employment change	-0.47**	-0.50*	-0.51*	-0.51*	-0.47*	-0.59**	-0.67**	-0.70**	-0.72**	-0.62**
	(0.24)	(0.29)	(0.30)	(0.31)	(0.26)	(0.24)	(0.30)	(0.29)	(0.30)	(0.25)
China to US		0.04					0.10			
		(0.08)					(0.10)			
China to Mexico			0.05					0.15		
			(0.10)					(0.12)		
China to other				0.05					0.15	
				(0.10)					(0.12)	
Mexico to other					-0.02					0.08*
					(0.06)					(0.05)
Initial pop, log	0.73***	0.75***	0.75***	0.75***	0.73***	0.88***	0.92***	0.93***	0.94***	0.88***
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.12)	(0.13)	(0.10)
Area, log	-0.12	-0.13	-0.14	-0.13	-0.12	-0.22*	-0.25**	-0.27**	-0.27**	-0.23**
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.12)	(0.12)	(0.11)
Agriculture emp. share	-0.06	-0.06	-0.06	-0.06	-0.06	-0.04	-0.04	-0.04	-0.04	-0.03
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)
Observations	2,132	2,132	2,132	2,132	2,132	2,132	2,132	2,132	2,132	2,132
R-squared	0.31	0.30	0.30	0.30	0.32	0.24	0.19	0.17	0.16	0.22
Method	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV
Weights	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
K-P LM p-value	.001	.005	.008	.008	.001	.001	.005	.008	.008	.001

Robust standard errors in parentheses clustered at the state level
*** p<0.01, ** p<0.05, * p<0.1

Notes: Estimates in all columns show IV estimates for Employment change instrumented by NAFTA tariff drops, along with the coefficient of different metrics of Chinese competition into the US market, into the Mexican market and into other markets non-NAFTA markets.

ipalities, while regression 2 and 3 condition for municipalities that had a PAN or a Non-PAN governor at the time of the election in 2006. Regression 4 operates on all municipalities and includes a binary term for PAN governors and an interaction term between the PAN governor indicator and the local tariff drop.

Table 3.5: AMLO's result, NAFTA and PAN Governors

	AMLO's vote share of year 2006 with respect to 1994			
	(1)	(2)	(3)	(4)
Local Tariff Drop	-0.09*	-0.09**	-0.01	0.02
	(0.05)	(0.04)	(0.05)	(0.06)
PAN Governor				-0.45**
				(0.18)
PAN Governor * LTD				-0.15*
				(0.08)
Observations	2,395	439	1,956	2,395
R-squared	0.24	0.13	0.27	0.28
Governors	All	PAN	Non-PAN	All

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Estimates in all columns show reduced form estimates of the effect of the local NAFTA tariff drop at the municipality level on AMLO's vote gains relative to 1994. Regression 1 provides the baseline estimate. Regression 2 conditions for municipalities under a PAN governor, and regression 3 conditions for the rest of the municipalities. Regression 4 provides estimates for the effect of the local tariff drop, the event of a PAN governor and their interaction. All regressions control for initial population, area and agricultural employment (coefficients not shown). Standard errors are clustered at the city level.

A first result worth noting is that the reduced form estimate of regression 1 is substantially lower than the estimate from regression 2 in Table 3.1. We attribute this change to attenuation bias due to noisier measurement of local tariff drops when working at the municipality level. More importantly, results in table 3.5 suggest that the connection between improvements in export market access and protectionism in 2006 were contingent to states under PAN governors at the time of the election. This means that differences in local tariff drops between municipalities seem to only make a difference for AMLO's vote gains under the rule of pro-Calderón governors.

It is difficult to interpret this finding causally, as the chance of having a PAN governor is not randomly assigned and is likely endogenous to local economic events such as the improvement in export market access for local industries. Still, the heterogeneity along this dimension allows us to speculate that part of the political effects documented in the study may have been induced by the actions of governors.

Similarly, table 3.6 addresses the question of how the effect of local tariff drops on AMLO's 2006 vote gains is affected by the party alignment of a municipality's Mayor with Felipe Calder'on's PAN. Again, regression 1 provides a reference estimate, while regressions 2 and 3 provide estimates conditioning to PAN and Non-PAN mayors respectively. Regression 4 provides an estimate with all municipalities, controlling for an indicator for a PAN mayor and its interaction with the local tariff drop. Regressions 5 - 7 condition to municipalities with mayors elected in close local elections – that is, where the mayor was elected with an electoral difference under 5 percentage points. Regression 5 only controls by the local tariff drop, while regression 6 provides a linear regression discontinuity estimate of the effect of a marginal PAN mayor on AMLO's vote gains in 2006[32]. Finally, regression 7 provides the same regression discontinuity setting, and includes the local tariff drop and its interaction with a marginally elected PAN mayor.

While the results from regressions 2 and 3 would suggest that the observed effect of LTD on AMLO's 2006 vote gains are contingent to municipalities with Non-PAN mayors, regression 4 does not yield clear estimates of this heterogeneity. Now again, as was the case with PAN governors, we cannot clearly interpret these results because of the non-randomness and endogeneity of PAN mayors. The regression discontinuity approach helps identify plausibly exogenous variation in the political alignment of mayors. Regression 5 confirms that the effect of local tariff drops is robust to the subsample of municipalities with mayors elected in close elections. Regression 6 suggests that, by itself, a marginally elected PAN mayor did not meaningfully affect AMLO's vote gains. Finally,

[32] The effect of linear controls around the electoral discontinuity are omitted

Table 3.6: AMLO's result, NAFTA and PAN Mayors

	AMLO's vote share of year 2006 with respect to 1994						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Local Tariff Drop	-0.09*	-0.03	-0.08*	-0.05	-0.11**		-0.14*
	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)		(0.08)
PAN mayor				-0.64***		-0.13	-0.16
				(0.15)		(0.16)	(0.16)
PAN mayor * LTD				-0.03			0.09
				(0.07)			(0.10)
Observations	2,395	559	1,421	1,980	356	356	356
R-squared	0.24	0.15	0.31	0.33	0.08	0.07	0.10
Mayors	All	PAN	Non-PAN	All	All	All	All
Bandwidth	Full	Full	Full	Full	5pp	5pp	5pp
RD	No	No	No	No	No	Linear	Linear

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Estimates in all columns show reduced form estimates of the effect of the local NAFTA tariff drop at the municipality level on AMLO's vote gains relative to 1994. Regression 1 provides the baseline estimate. Regression 2 conditions for municipalities under a PAN mayor, and regression 3 conditions for the rest of the municipalities. Regression 4 provides estimates for the effect of the local tariff drop, the event of a PAN mayor and their interaction. Regressions 5 provides a baseline estimate for a sub-sample of municipalities with mayors at the time of the 2006 presidential elections that were elected with relatively narrow margins (5 percentage point difference with the runner-up in the local election). Regression 6 provides a linear regression discontinuity estimate of the effect of a close PAN mayor - coefficients of the linear controls around the discontinuity are omitted. Regression 7 provides the same specification, adding the effect of the local tariff drop and its interaction with the event of a marginal PAN mayor. All regressions control for initial population, area and agricultural employment (coefficients not shown). Standard errors are clustered at the city level.

regression 7 finds that the effect of the local tariff drop is robust to the inclusion of regression discontinuity controls and its interaction with the indicator for a marginally elected PAN mayor, but that the effects of this interaction are not significant. Overall, these results suggest that the main effects in the study are not determined by mayors' party alignment.

3.4.6 Reconciling with those who gain from NAFTA: AMLO's media strategy in 2012

As we mentioned in the introduction, aggregating our main effects across Mexican cities suggests that AMLO's 2006 decision to pursue a protectionist platform cost him about 8% of the vote. If the effects of his economic platform over voting was as large and pivotal as our results suggest, AMLO may have detected them and responded accordingly in his presidential campaign in 2012. That is, if voters in regions benefiting from NAFTA reacted negatively to AMLO's 2006 platform, it would be expected of him to prioritize these regions for efforts geared at appeasing and reconciling with voters concerned over his 2006 economic platform, and his radical decisions after losing the election.

For AMLO in particular we look at the intensity of ads used in different locations, and the prevalence of ads with a conciliatory or confrontational tones. We expect a more intense media presence of AMLO in locations that benefited more from NAFTA and where he had and adverse result in 2006. We measure ad intensity as the ratio of the number of ads to the number of total votes of that location in the previous election. Regarding the message, we hypothesize that the share of conciliatory ads should be higher in municipalities that experienced larger tariff drops due to NAFTA, but the prevalence of negative ads should not be affected these tariff drops. We leverage the fact that only some of his ads mention the reconciliation after his radical 2006 stances. The shared heading in the script of the ads talking about reconciliation reads: "I candidly offer my hand as signal of reconciliation, of friendship, to those that I may have affected in my struggle for democracy and peace". These are the only ads that include the word "reconciliation". We benchmark these outcomes against the relative use of ads aimed at undermining the credibility of the PRI party, which was AMLO's main competitor (and eventual winner) in the 2012 election. The shared script heading in these ads reads: "Do you really think that voting for PRI will help this country? Do you realy think there's anyone better than AMLO?". These were the only ads from AMLO that referred to

other parties directly[33].

Results of our analysis is shown in table 3.7, were we run regressions similar to those of table 1, now using the ads as the dependent variables and focusing on the results of the reduced form and instrumental variable regressions. Consistent with our hypothesis, we find that places with a larger tariff drop or a larger increase in employment were places that AMLOs campaign chose to expose to a higher intensity of ads (columns 1 and 2): A one standard deviation drop on tariffs is correlated with a 9% higher intensity of ads, while a one standard deviation in employment (instrumented by tariff drop) is found to increase ads by 0.4 st. deviation (both results are significant at the 10% level). Regarding the use of conciliatory ads, results in columns 3 and 4 show that a 1 standard deviation increase in the local tariff drop associates with a 0.29 standard deviation increase in the share of conciliatory ads. The estimates of the effect of employment change is even more steep: a one standard deviation of employment change is found to have increased conciliatory ads in 1.4 standard deviations. On the other hand we find no meaningful relationship between local tariff drops or employment change on the prevalence of more frontal ads targeting his opponents of PRI. Probably this later result is consistent with the decision to run a less controversial electoral campaign. These results suggest that, While benefits from NAFTA informed AMLO's deployment of ads intensity and conciliatory messages in 2012, they did not inform his deployment of negative messages against PRI.

3.5 Conclusions

The goal of this paper was to study the sub-national political effects of export tariff reductions on local economic outcomes and political preferences over trade integration. The question is innovative

[33] The "reconciliation" ad can be downloaded and viewed at http://pautas.ife.org.mx/materiales/pef_2012/RV00231-12.mp4. The ad attacking PRI can be found at http://pautas.ife.org.mx/materiales/pef_2012/RV00959-12.mp4.

Table 3.7: AMLO's 2012 media ads

	Ads intensity		Reconciliation		PRI	
	(1)	(2)	(3)	(4)	(5)	(6)
Employment change		0.44*		1.39***		0.08
		(0.23)		(0.39)		(0.23)
Local tariff drop	0.09*		0.29***		0.02	
	(0.05)		(0.05)		(0.05)	
Area, log	-0.18***	-0.14**	-0.08	0.06	0.20*	0.21*
	(0.05)	(0.06)	(0.09)	(0.19)	(0.12)	(0.11)
Initial population, log	-0.54***	-0.74***	0.10	-0.54*	-0.09	-0.13
	(0.10)	(0.14)	(0.09)	(0.32)	(0.09)	(0.13)
Agriculture emp. share	-0.06	-0.03	-0.04	0.06	0.02	0.03
	(0.04)	(0.05)	(0.03)	(0.08)	(0.06)	(0.06)
Observations	2,183	2,183	2,183	2,183	2,183	2,183
R-squared	0.38	0.26	0.12	-1.30	0.03	0.03
Method	OLS	IV	OLS	IV	OLS	IV
Weights	yes	yes	yes	yes	yes	yes

Robust standard errors in parentheses clustered at the state level
*** p<0.01, ** p<0.05, * p<0.1

in both economic and political grounds.

Economically, we find that regions with higher export tariff drops faced faster employment growth. The result is innovative given how the standing literature instrumenting the local relevance of national trade agreements by the industrial structure of labor markets focuses on the effects of import-competing pressures from globalization. These positive economic effects of integration are consistent with McCaig and Pavcnik (2018) and Trefler (2004), which employ alternative methodologies to assess the export effects of trade integration of Vietnam and Canada with the US.

More importantly, our political results suggest material negative effects of NAFTA-induced economic gains on AMLO's 2006's presidential bid, but not for other elections between 2000 and 2018. Given the special salience of NAFTA in the 2006 elections, we interpret this result as suggesting that export market access gains undermine preferences for protectionism, while not generally

undermining non-incumbent candidacies, left-wing candidacies, or AMLO's other candidacies. The overall effect of our estimates on the 2006 election were large, and most likely pivotal for the election's final result. Our findings suggest that local polities do tend to vote rationally in defending policies that have materially benefited them in the past. This is opposed, for instance, to Blonigen (2011)'s finding that US voters tend to set preferences on trade policies in manners that are inconsistent with theories of international trade, such as the Stolper-Samuelson theorem[34].

We extend our analysis in four directions. First, we assess the relevance of local corn and bean growing – the main sectors protected by the expiring tariff exemptions. We find that our results are robust to controls for local employment and local agro-ecological suitability in these sectors, and that these controls themselves were not relevant determinants of AMLO's vote gains. Second, we assess the relevance of Chinese competition in US and Mexican markets, and of Chinese and Mexican general competitiveness gains, and find that these do not affect the effects of NAFTA tariff drops on AMLO's vote gains, and that they did not induce independent political effects. Third, we studied whether these effect were heterogeneous along the party identity of the governor or the mayor at the time of the election, finding that reduced form effects are contingent to municipalities in states that had PAN governors in July, 2006. Finally, we evaluate how NAFTA tariff drops associated with AMLO's deployment of conciliatory or negative ads in 2012, finding reduced form evidence that benefiting from NAFTA led to more conciliatory ads but did not affect the distribution of negative ads. Our findings suggest that export access gains due to globalization undermine local political preferences over national protectionist platforms.

[34] The workhorse models of international trade have well-defined implications for the distributive consequences of trade and hence for individual preferences (Rodrik, 1995). Under the factor-endowments model, which assumes cost-less inter-sectoral mobility of productive factors, the Stolper-Samuelson theorem states that trade benefits individuals who own the factors with which the economy is relatively well endowed, and hurts the others. Under the specific-factors model, trade benefits individuals who are employed in the export-oriented sectors and hurts those who are employed in the import competing sectors.

3.6 Appendix

3.6.1 Tariffs before and after NAFTA

Table 3.8 shows the average tariffs before NAFTA and the estimated (weighted) tariff reduction, using the HS classification at 2-digit. The table lists the top 40 groups of products (out of 96), sorted by tariff reduction.

3.6.2 Alternative table: Vote shares in levels

Table 3.9 shows results equivalent to those of table 3.1 used in the main text, but using the AMLO's vote share in 2006 in columns 2 to 4. The results in the table indicate that a 1 standard deviation of employment change decrease the vote against AMLO by 0.49 standard deviations, when using OLS (column 3). When performing the estimation using the IV strategy, we find that the size of the effect more than doubles; a one standard deviation of change in employment leads to a 1.19 st. deviation drop in AMLO's vote share. This result confirm the results of table 3.1 discussed in the main text.

3.6.3 First Stage estimates for table 3.2

In this section we present the first stage estimations used for the IV estimates shown in Table 3.2 in the main text. In table 3.2 below, the estimates of column 1 correspond to the first stage used for columns 1, 2 and 5 in table 3.2, while column 2 correspond to the estimates used for columns 3 and 6 in table 3.2. Finally, the estimates of column 3 correspond to the estimates used for columns 4 and 7 in table 3.2.

3.6.4 Equivalent to table 1 for other elections

Table 3.8: Tariff drop

HS code	Description	Initial tariff	reduction
61	articles of apparel and clothing accessories-knitted or crocheted	17.0	-17.0
55	man-made staple fibers, inc. yarns etc.	15.0	-15.0
60	knitted or crocheted fabrics	14.0	-14.0
64	footwear, gaiters, and the like	10.9	-10.9
54	man-made filaments, inc. yarns and woven etc.	10.0	-10.0
52	cotton, inc. yarns and woven fabrics thereof	9.9	-9.9
62	articles of apparel and clothing accessories-not knitted or crocheted	9.6	-9.6
58	special woven fabrics, tufted textiles, lace	9.0	-9.0
63	made-up textile articles nesoi, needlecraft sets, worn clothing, rags	9.0	-9.0
66	umbrellas, sun umbrellas, walking-sticks, whips, riding-crops and parts	8.2	-8.2
56	wadding, felt and nonwovens, special yarns, twine, cordage, ropes and cables and articles	8.0	-8.0
20	preps of vegs, fruits, nuts, etc.	7.4	-7.4
70	glass and glassware	7.2	-7.2
69	ceramic products	7.0	-7.0
32	tanning or dyeing extracts, dyes, pigments, paints and varnishes, putty, and inks	5.9	-5.9
42	articles of leather, saddlery and harness, travel goods, handbags, articles of gut	7.2	-5.9
51	wool and fine or coarse animal hair, inc. yarns and woven fabrics thereof	5.9	-5.9
29	organic chemicals	5.8	-5.8
59	impregnated, coated, covered, or laminated textile prod, textile prod for industrial use	5.8	-5.8
71	pearls, stones, prec. metals, imitation jewelry, coins	5.8	-5.8
57	carpets and other textile floor coverings	6.5	-5.5
86	railway or tramway locomotives, rolling stock, track fixtures and fittings, signals	5.5	-5.5
16	ed. prep. of meat, fish, crustaceans, etc	5.5	-5.5
24	tobacco and manuf. tobacco substitutes	5.5	-5.5
04	dairy, eggs, honey, and ed. products	5.4	-5.4
46	manu. of straw, esparto, or other plaiting materials, basketware and wickerwork	5.3	-5.3
96	miscellaneous manufactured articles	5.1	-5.1
83	miscellaneous articles of base metal	5.1	-5.1
39	plastics and articles thereof	5.1	-5.1
07	edible vegetables	5.1	-5.1
50	silk, inc. yarns and woven fabrics thereof	5.0	-5.0
21	misc. edible preparations	5.0	-5.0
92	musical instruments, parts and accessories	5.0	-5.0
95	toys, games and sports equip, parts and acces.	4.9	-4.9
90	optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and accessories	4.9	-4.9
33	oils and resinoids, perfumery, cosmetic or toilet preparations	4.9	-4.9
88	aircraft, spacecraft, and parts thereof	4.5	-4.5
73	rticles of iron or steel	4.5	-4.5
81	base metals nesoi, cermets, articles etc.	4.3	-4.3
72	iron and steel	5.1	-4.3

Table 3.9: AMLO's result in the 2006 election

	Employment change	Vote share of year 2006		
VARIABLES	(1)	(2)	(3)	(4)
Employment change			-0.49***	-1.19***
			(0.10)	(0.28)
Local tariff drop	0.33***	-0.39***		
	(0.06)	(0.07)		
Initial pop, log	0.17	0.58**	0.59***	0.79***
	(0.25)	(0.23)	(0.16)	(0.13)
Area, log	0.06	-0.23**	-0.18	-0.16
	(0.09)	(0.11)	(0.11)	(0.11)
Agriculture emp. share	-0.04	-0.12**	-0.11**	-0.16**
	(0.05)	(0.06)	(0.05)	(0.06)
Observations	2,132	2,132	2,132	2,132
R-squared	0.21	0.28	0.36	-0.08
Method	1S	RF	OLS	IV
Weights	yes	yes	yes	yes
K-P LM p-value		-	-	.001

Robust standard errors in parentheses clustered at the state level.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.10: First stage estimations for table 3.2

VARIABLES	Employment change		
	1993-2003	1993-2008	1993-2013
	(1)	(2)	(3)
Local tariff drop	0.33***	0.30***	0.32***
	(0.06)	(0.05)	(0.08)
Agriculture employment share	-0.04	-0.04	0.04
	(0.05)	(0.04)	(0.06)
Initial pop, log	0.17	0.31	-0.21
	(0.25)	(0.22)	(0.29)
Area, log	0.06	-0.03	0.18*
	(0.09)	(0.07)	(0.09)
Observations	2,132	2,132	2,152
R-squared	0.21	0.24	0.10

Robust standard errors in parentheses clustered at the state level.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.11: PRD's and AMLO's vote levels

	vote share in year:			
	2000	2006	2012	2018
	(1)	(2)	(3)	(4)
Employment change 93-03	-1.12***	-1.19***		
	(0.22)	(0.28)		
Employment change 93-08			-1.09***	
			(0.34)	
Employment change 93-13				-0.94***
				(0.33)
Agriculture employment share	-0.19***	-0.16**	-0.19**	-0.04
	(0.07)	(0.06)	(0.08)	(0.11)
Initial population, log	0.35***	0.79***	1.01***	0.12
	(0.11)	(0.13)	(0.18)	(0.25)
Area, log	-0.05	-0.16	-0.36***	-0.04
	(0.09)	(0.11)	(0.10)	(0.15)
Observations	2,132	2,132	2,132	2,152
Method	IV	IV	IV	IV
Weights	yes	yes	yes	yes
K-P LM p-value	.001	.001	.001	.009

Robust standard errors in parentheses clustered at the state level.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.12: Result in the 2000 election

	Employment change	Vote share of year 2000 with respect to 1994		
	(1)	(2)	(3)	(4)
Employment change			-0.17**	0.05
			(0.07)	(0.17)
Local tariff drop	0.34***	0.02		
	(0.06)	(0.06)		
Initial pop, log	0.19	-0.04	0.02	-0.05
	(0.24)	(0.19)	(0.17)	(0.22)
Area, log	0.05	0.13	0.13	0.13
	(0.09)	(0.13)	(0.12)	(0.13)
Agriculture emp. share	-0.03	-0.07	-0.08	-0.06
	(0.05)	(0.05)	(0.05)	(0.05)
Observations	2,132	2,132	2,132	2,132
R-squared	0.22	0.01	0.04	-0.00
Method	OLS	OLS	OLS	IV
Weights	yes	yes	yes	yes
K-P LM p-value		-	-	.001

Robust standard errors in parentheses clustered at the state level.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.13: Result in the 2012 election

		Vote share of year 2012					
	Employment change	with respect to 1994			with respect to 2000		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employment change			0.05	-0.05		0.17**	0.07
			(0.10)	(0.28)		(0.06)	(0.28)
Local tariff drop	0.28***	-0.01			0.02		
	(0.05)	(0.08)			(0.08)		
Initial pop, log	0.29	0.37**	0.34*	0.38**	0.47***	0.41***	0.45***
	(0.19)	(0.17)	(0.20)	(0.17)	(0.09)	(0.12)	(0.12)
Area, log	0.06	-0.10	-0.10	-0.10	-0.14	-0.15	-0.14
	(0.09)	(0.13)	(0.13)	(0.13)	(0.09)	(0.09)	(0.09)
Agriculture emp. share	-0.02	0.00	0.01	0.00	0.02	0.02	0.02
	(0.04)	(0.06)	(0.06)	(0.06)	(0.04)	(0.05)	(0.05)
Observations	2,132	2,132	2,132	2,132	2,132	2,132	2,132
R-squared	0.27	0.09	0.09	0.08	0.14	0.16	0.16
Method	OLS	OLS	OLS	IV	OLS	OLS	IV
Weights	yes	yes	yes	yes	yes	yes	yes
K-P LM p-value		-	-	.002	-	-	.002

Robust standard errors in parentheses clustered at the state level.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.14: Result in the 2018 election

		Vote share of year 2018					
	Employment change	with respect to 1994			with respect to 2000		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employment change			0.18*	-0.09		0.26***	0.02
			(0.09)	(0.32)		(0.07)	(0.35)
Local tariff drop	0.28***	-0.02			0.01		
	(0.06)	(0.09)			(0.10)		
Initial pop, log	0.26	0.07	-0.01	0.09	0.12	0.03	0.12
	(0.19)	(0.15)	(0.16)	(0.16)	(0.12)	(0.10)	(0.18)
Area, log	0.07	-0.02	-0.03	-0.01	-0.04	-0.06	-0.04
	(0.08)	(0.15)	(0.16)	(0.15)	(0.10)	(0.11)	(0.11)
Agriculture emp. share	-0.03	0.06	0.07	0.05	0.06	0.08	0.06
	(0.04)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)
Observations	2,132	2,132	2,132	2,132	2,132	2,132	2,132
R-squared	0.25	0.00	0.03	-0.03	0.01	0.07	0.02
Method	OLS	OLS	OLS	IV	OLS	OLS	IV
Weights	yes	yes	yes	yes	yes	yes	yes
K-P LM p-value		-	-	.002	-	-	.002

Robust standard errors in parentheses clustered at the state level.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.15: Equivalent to table 1, excluding rural localities

		Vote share of year 2006					
	Employment change	with respect to 1994			with respect to 2000		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employment change			-0.31***	-0.61**		-0.28***	-0.82***
			(0.10)	(0.29)		(0.09)	(0.31)
Local tariff drop	0.32***	-0.20**			-0.27***		
	(0.07)	(0.08)			(0.08)		
Initial pop, log	-0.22	0.67***	0.59***	0.54***	0.75***	0.66***	0.57***
	(0.25)	(0.22)	(0.16)	(0.13)	(0.18)	(0.14)	(0.13)
Area, log	0.17*	-0.13	-0.08	-0.03	-0.24*	-0.19	-0.10
	(0.10)	(0.12)	(0.12)	(0.13)	(0.12)	(0.13)	(0.14)
Agriculture emp. share	-0.14**	-0.04	-0.06	-0.13	-0.01	-0.02	-0.13
	(0.06)	(0.06)	(0.06)	(0.10)	(0.07)	(0.07)	(0.09)
Observations	773	773	773	773	773	773	773
R-squared	0.13	0.35	0.40	0.32	0.36	0.37	0.09
Method	OLS	OLS	OLS	IV	OLS	OLS	IV
Weights	yes	yes	yes	yes	yes	yes	yes
K-P LM p-value		-	-	.002	-	-	.002

Robust standard errors in parentheses clustered at the state level
*** p<0.01, ** p<0.05, * p<0.1

Table 3.16: Equivalent to table 2, excluding rural localities

	Vote share of year:						
	2000	2006	2012	2018	2006	2012	2018
		with respect to 1994			with respect to 2000		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employment change 93-03	0.14	-0.61**			-0.82***		
	(0.22)	(0.29)			(0.31)		
Employment change 93-08			-0.39			-0.34	
			(0.36)			(0.35)	
Employment change 93-13				-0.38			-0.27
				(0.42)			(0.40)
Agriculture emp. share	-0.05	-0.13	-0.04	0.17*	-0.13	-0.02	0.18*
	(0.10)	(0.10)	(0.13)	(0.10)	(0.09)	(0.11)	(0.10)
Initial pop, log	0.09	0.54***	0.62***	-0.12	0.57***	0.61***	-0.17
	(0.23)	(0.13)	(0.15)	(0.34)	(0.13)	(0.16)	(0.30)
Area, log	0.13	-0.03	-0.23	0.10	-0.10	-0.17	0.16
	(0.16)	(0.13)	(0.14)	(0.22)	(0.14)	(0.12)	(0.20)
Observations	773	773	773	779	773	773	779
Method	IV	IV	IV	IV	IV	IV	IV
Weights	yes	yes	yes	yes	yes	yes	yes
K-P LM p-value	.002	.002	.01	.051	.002	.01	.051

Robust standard errors in parentheses clustered at the state level
*** p<0.01, ** p<0.05, * p<0.1

4

Challenges of Multinational Firms' Tax Compliance: Evidence from Chile

International tax avoidance by multinational firms has been at the forefront of policy debates and news coverage in recent years. This chapter provides a brief overview of the challenges and policy debates regarding taxation of multinational corporations and provides novel descriptive

evidence on the case of Chile.

With growing globalization of ownership structures and financial flows, multinational enterprises account for an increasingly large share of the global economy (Narula and Dunning, 2010; Clausing, 2018). A growing body of evidence, building on Hines Jr and Rice (1994), suggests that multinationals artificially shift a large fraction of their profits to low-tax locales (see Dharmapala (2014) for a review of the empirical literature). More than half of the foreign profits of US firms, for example, are booked in Bermuda, Luxembourg, Switzerland, the Netherlands, Singapore, Ireland, and Caribbean islands (e.g., Clausing (2016)). By one estimate (Wright and Zucman, 2018), this shifting is on the rise and has reduced the effective corporate tax rate paid by U.S. multinationals on their foreign profits by more than 6 percentage points in 2015. Multinationals from other regions have similar incentives, suggesting that global revenue losses due to multinational corporate tax avoidance may be sizable.

Profit shifting is particularly concerning for developing countries and emerging economies, where building tax capacity is a key policy goal, both to finance public infrastructure and services and to reduce distortions in the economy (see Pomeranz and Vila-Belda (2019) for an overview of recent economics research with tax authorities). As economies grow, their number of multinationals tends to increase, and the question of how to monitor profit shifting becomes important (Johannesen et al., 2016). Developing countries face a fundamental trade-off in dealing with multinationals. On the one hand, multinational firms are often believed to be an important vehicle to bring managerial best practices, innovation, investment, and increased productivity, and there are important debates about whether governments should therefore subsidize such firms' investments ((Spencer, 2008; Harrison and Rodríguez-Clare, 2010; Kose et al., 2010; Alfaro and Chen, 2018). On the other hand, multinationals often have more avenues and resources to avoid or evade taxation, compared to domestic firms that cannot rely on international networks. International tax arbitrage and tax havens can also affect the location of real economic activities (De Mooij and Liu,

2020; Suárez Serrato, 2018). Against this backdrop, how can governments improve their ability to attract investment by multinational firms without compromising their capacity to collect taxes?

There is a lively debate on how to curb multinational tax avoidance. The OECD encourages governments to spend more resources enforcing the rules that currently govern the taxation of multinationals. However, as discussed below, critics argue that the OECD framework is not ideally suited to today's globalized world (e.g. Independent Commission for the Reform of International Corporate Taxation 2015) and question its effectiveness to prevent profit shifting. In order to shed light on this debate, in ongoing work we study the recent experience of Chile in tackling profit shifting through transfer pricing legislation based on OECD recommendations.

4.1 Common ways for multinational firms to shift profits

The key challenge of taxing multinational firms stems from the fact that profits are produced jointly by subsidiaries located in different countries but taxation is applied by each jurisdiction at the national level. The question then emerges, which parts of the global corporation's profit should be taxed by which country. Profits can be shifted from one country to another by manipulating prices of intra-firm transactions (so called "transfer-prices"). When a subsidiary in a high-tax country sells goods or services at artificially low prices to a subsidiary in a low-tax jurisdiction, this leads to a decrease in profits and a reduction in the taxes paid in the high-tax location, as well as in the total amount of taxes paid. Multinational firms can exploit discrepancies in tax rates and tax rules of different jurisdictions by strategically choosing the location of their affiliates and the transactions between them. The economics literature provides substantial evidence for the presence of tax-motivated transfer pricing (Bartelsman and Beetsma, 2003; Clausing, 2003; Bernard et al., 2006; Hebous and Johannesen, 2016; Davies et al., 2018).

To counteract this tendency, many countries have agreed to use the so-called arm's-length prin-

ciple to regulate intra-firm transactions (see Zucman (2014) for a description of the history and implications of these rules). This principle, established in the 1920s, stipulates that subsidiaries of a multinational firm in different countries have to set prices on transactions between each other as if they belonged to separate firms, i.e. as if they were market prices.

In practice, however, the arm's length principle can be hard to implement. Many goods and especially services involved in intra-firm trade can be firm-specific and may not be traded outside a given multinational group, therefore lacking a clear market price. It is often hard to determine, for example, what the market price would be for the right to use intellectual property, if the patent is only used by other subsidiaries of the same multinational firm, or how much should be charged for marketing services provided internally between subsidiaries of a multinational corporation. Empirical evidence shows that the location of intangible assets is systematically distorted towards low-tax locations (Dischinger and Riedel, 2011; Karkinsky and Riedel, 2012; Griffith et al., 2014; Alstadsæter et al., 2018).

Another method used by multinational firms to shift profits involves intra-group loans (also known as "debt shifting"). Debt and equity are treated differently for tax purposes, as interest payments are deductible. This creates an incentive for financing with debt rather than equity. Multinationals can exploit this for profit shifting purposes without affecting the group's overall debt exposure by routing equity into low-tax affiliates, which then lend to high-tax affiliates, which in turn deduct their interest payments, thus reducing the group's overall tax liability. Several empirical studies provide evidence of debt shifting, e.g. Desai et al. (2007) or Weichenrieder and Mintz (2010). A meta-analysis by Heckemeyer and Overesch (2017)estimates that around 30% of overall income shifting can be attributed to debt shifting.

As companies have developed increasingly intricate ways to shift profits, the corresponding regulations have also grown more complex. In that context, devoting extra resources to enforcing the arm's length principle could potentially lead to a bad equilibrium: growing monitoring costs for tax

authorities and compliance costs for corporations, with little increase in tax collection, resulting in possibly lower welfare. So far there exists relatively limited causal evidence on the impact of reforms to enforce arm's length pricing rules on compliance and tax collection. Measuring their impact is key to evaluate whether alternative approaches to international taxation should be favored.

Indeed, some fundamentally different approaches for international corporate taxation have been proposed (Devereux and Vella, 2014). One prominent such approach would treat multinationals as a single entity for tax purposes. Avi-Yonah and Clausing (2007), Avi-Yonah et al. (2008), Zucman (2015), and the Independent Commission for the Reform of International Corporate Taxation (2015), among others, propose starting from the consolidated profits of multinationals and apportioning them across countries using an apportionment formula. This formula intends to reflect the real economic activity of multinational groups, for example based on how much of the corporations' sales are made to different countries, or how much of its payroll or assets are located in different jurisdictions.

A similar approach is currently already in place within the United States for the taxation of corporations by different states. Proponents argue this unitary approach could better reflect how multinationals operate today, and would prevent them from shifting profits to tax havens where no real economic activity takes place (e.g. Janskỳ and Prats (2015)). Whether and to what extent firms would respond to factors in the apportionment formula is still debated (Altshuler and Grubert, 2010; Clausing, 2006).

4.2 The Chilean Setting

In 2010, Chile became the first South American country to join the OECD. As part of this process, it committed to OECD transfer pricing rules. Starting in 2011, Chile made a number of changes to its tax enforcement policy regarding multinational firms. The reform was designed to address all

forms of profit shifting, whether through financial or real transactions. Prior to the reform, the tax authority had only limited information on the activities of multinational companies. The reform strongly increased the reporting requirements on intra-group transactions, changed the burden of proof for the correct valuation of these transactions from the tax authority to the firms and boosted the monitoring of international transactions by increasing the number of specialized tax auditors devoted to these tasks. Chile is an ideal laboratory to study the impact of such changes, as it illustrates the challenges of taxation of multinational corporations for an emerging economy, and because the Chilean tax authority is known for having high implementation capacities and low corruption rates (Adimark-GfK 2006). While Chile has a long track-record of using effective and innovative enforcement methods for domestic taxes such as the VAT (Pomeranz, 2015), international profit shifting by multinational firms presents important and growing challenges for tax collection.

In order to study the extent of profit shifting and evaluate the impact of the new rules, we partnered with the Chilean tax authority to combine several administrative datasets, including corporate tax filings, filings on international transactions, and customs data. This data allows us to provide novel descriptions of multinational firms operating in Chile, discussed below. In ongoing work, we also analyze the reform's impact on tax collection and firm behavior.

Out of approximately 300,000 incorporated firms in Chile in 2010 , only around 5,300 had foreign affiliates, and around 630 had affiliates in countries that the tax authority classifies as tax havens. However, these firms account for a large share of total sales by Chilean firms. The firms with foreign affiliates account for around 40% of total sales by incorporated firms in the country, and firms with affiliates in tax havens make up around 13%.

Many of the firms with foreign affiliates have a network of affiliates in multiple countries. The mean number of countries in which they have affiliates is 4.1, with a median of 2 and a maximum of 96. Among firms with affiliates in tax havens, these numbers are even larger, with a mean of 8.6 countries with affiliates, and a median of 4. Such large and complex web of relationships may lead

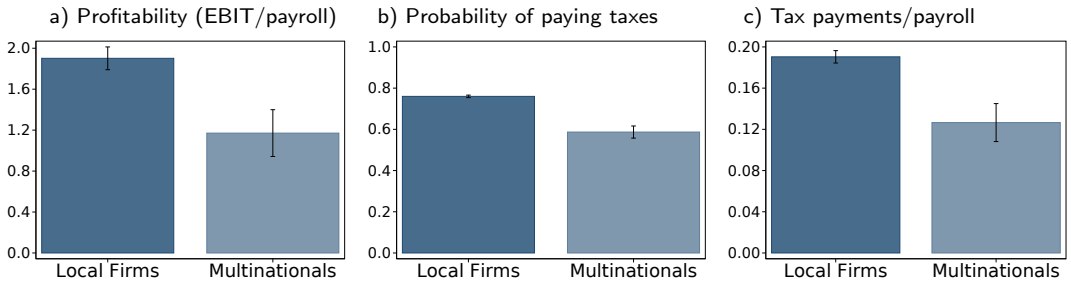
to both high monitoring costs for the tax authority and high compliance costs for the multinational firms.

In addition, the ownership structures of many of these relationships are complex and hard to track for the tax authority. Firms indicate in their tax forms whether the relationship with a given foreign affiliate is one in which a) the Chilean firm owns the foreign affiliate, b) the foreign firm owns the Chilean affiliate, or c) both are owned by the same third party. 50% of multinational firms list affiliates with relationships of type (a), 59% of type (b), and 45% of type (c). 13% have foreign affiliates of all three types.

Our descriptive analysis provides suggestive evidence consistent with profit shifting by multinational firms in Chile (See Figure 1). Their tax filings indicate that multinational firms have lower profit rates (as a ratio of EBIT /wages) compared to local firms similar in size, industry and region. This is consistent with the notion that they shift part of their profits to lower tax countries, and in line with the findings of Tørsløv et al. (2018) who show that multinational firms in higher-tax jurisdictions tend to have lower profit rates, and those in low-tax countries tend to have higher profit rates compared to purely domestic firms. This lower profitability leads to a lower probability of paying corporate income tax in Chile, and a lower rate of taxes/payroll.

In ongoing work, we investigate the channels used by multinationals to lower their tax payments in Chile, and analyze whether the reform had an impact on profit shifting and tax collection. It is clear that the reform increased both monitoring costs for the Chilean tax authority and compliance costs of firms with foreign affiliates, boosting demand for tax advisory services. We conducted interviews with tax advisors of the four largest tax consulting firms in Chile, which revealed that their number of employees dedicated to supporting firms on "tax planning strategies" to comply with transfer pricing regulation increased about 15-fold.

Figure 4.1: Profit Rates and Tax Payments of Multinationals vs Local Firms



Note: OLS estimates from the pre-reform period (2007-2010) on a dummy for whether a firm has foreign affiliates. To compare firms with similar characteristics, observations are weighted by the inverse propensity score for being a multinational using firms' size category, region and industry. Outcomes in panels a and c winsorized at the 99th percentile. Vertical bars show 95% confidence intervals. Sample restricted to firms with positive costs and wages, excluding firms in the first and last percentiles of the propensity score.

4.3 Conclusion: Open Questions for Research

In an increasingly globalized corporate world, the debate on how to effectively tax multinational corporation has become of first order importance for many governments around the world. The magnitudes involved are large. In Chile, about 40% of sales come from the 2% of corporations that have affiliates in foreign countries. Many countries try to attract investment by multinational firms, as this is often thought to bring positive spillovers for economic development. However, multinationals often have more avenues to avoid taxes, which can undermine countries' goal of building tax capacity. Guidance by the OECD on how to reduce international profit shifting has been subject to controversial debate, but empirical evidence on its effectiveness is limited.

In 2011, Chile implemented an OECD-inspired reform that strongly increased reporting requirements for multinational firms and created a specialized unit to monitor transfer pricing. This led to higher monitoring costs and higher compliance costs for firms, and increased demand for tax consulting services. It is, however, unknown so far whether it led to more tax collection. The growing

number of collaborations between researchers and tax authorities, leveraging administrative tax data, has the potential to shed empirical light on this type of pressing questions and to help improve international tax policy.

References

Abadie, A., Diamond, A., and Hainmueller, J. (2010). Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program. *Journal of the American Statistical Association*, 105(490):493–505.

Abadie, A., Diamond, A., and Hainmueller, J. (2015). Comparative Politics and the Synthetic Control Method. *American Journal of Political Science*, 59(2):495–510.

Abadie, A. and Gardeazabal, J. (2003). The economic costs of conflict: A case study of the Basque country. *American Economic Review*, 93(1):113–132.

Alessandria, G., Kaboski, J. P., and Midrigan, V. (2010). Inventories, lumpy trade, and large devaluations. *American Economic Review*, 100(5):2304–2339.

Alessandria, G., Pratap, S., and Yue, V. (2015). Export Growth and Aggregate Dynamics in Large Devaluations. *Working Paper*.

Alfaro, L. and Chen, M. X. (2018). Selection and market reallocation: Productivity gains from multinational production. *American Economic Journal: Economic Policy*, 10(2):1–38.

Alstadsæter, A., Barrios, S., Nicodème, G., Skonieczna, A. M., and Vezzani, A. (2018). Patent boxes design, patents location, and local r&d. *Economic Policy*, 33(93):131–177.

Altshuler, R. and Grubert, H. (2010). Formula apportionment: is it better than the current system and are there better alternatives? *National Tax Journal, December*, 63(4):1145–1184.

Amiti, M., Itskhoki, O., and Konings, J. (2014). Importers, exporters, and exchange rate disconnect. *American Economic Review*, 104(7):1942–1978.

Amiti, M. and Weinstein, D. E. (2011). Export and Financial Shocks. *The Quarterly Journal of Economics*, 126(4):1841–1877.

Antràs, P., Chor, D., Fally, T., and Hillberry, R. (2012). Measuring the upstreamness of production and trade flows. *American Economic Review*, 102(3):412–16.

Archibugi, D. and Coco, A. (2005). Measuring technological capabilities at the country level: A survey and a menu for choice. *Research Policy*, 34(2):175–194.

Artus, J. (1975). The 1967 Devaluation of the Pound Sterling. *Staff Papers (International Monetary Fund)*, 22(3):595–640.

Asprilla, A., Berman, N., Cadot, O., and Jaud, M. (2015). Pricing-to-market, Trade Policy, and Market Power. *Working Paper*.

Athey, S. and Imbens, G. (2016). The State of Applied Econometrics - Causality and Policy Evaluation. *Working Paper*.

Atkin, D. (2016). Endogenous skill acquisition and export manufacturing in mexico. *American Economic Review*, 106(8):2046–85.

Autor, D. H., Dorn, D., and Hanson, G. H. (2013). The China Syndrome: Local Labor Market Effects of Import Competition in the United States. *American Economic Review*, 103(6):2121–68.

Avi-Yonah, R. S. and Clausing, K. A. (2007). *Reforming corporate taxation in a global economy: a proposal to adopt formulary apportionment*. Brookings Institution Washington, DC.

Avi-Yonah, R. S., Clausing, K. A., and Durst, M. C. (2008). Allocating business profits for tax purposes: A proposal to adopt a formulary profit split. *Fla. Tax Rev.*, 9:497.

Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1994). Dynamics of the trade balance and the terms of trade: the J-curve? *American Economic Review*, 84(1):84–103.

Balassa, B. (1965). Trade liberalisation and "revealed" comparative advantage. *The manchester school*, 33(2):99–123.

Balland, P.-A., Boschma, R., Crespo, J., and Rigby, D. L. (2018). Smart specialization policy in the european union: relatedness, knowledge complexity and regional diversification. *Regional Studies*, pages 1–17.

Balland, P.-A., Jara-Figueroa, C., Petralia, S. G., Steijn, M. P. A., Rigby, D. L., and Hidalgo, C. A. (2020). Complex economic activities concentrate in large cities. *Nature Human Behaviour*, 4(3):248–254.

Balland, P.-A. and Rigby, D. (2017). The geography of complex knowledge. *Economic Geography*, 93(1):1–23.

Bank of England (1993). *Report and accounts 1993*.

Barro, R. J. (1991). Economic growth in a cross section of countries. *The Quarterly Journal of Economics*, 106(2):407–443.

Bartelsman, E. J. and Beetsma, R. M. (2003). Why pay more? corporate tax avoidance through transfer pricing in oecd countries. *Journal of public economics*, 87(9-10):2225–2252.

Bean, C. (2004). Inflation targeting: the uk experience. *Perspektiven der Wirtschaftspolitik*, 5(4):405–421.

Beaudry, C. and Schiffauerova, A. (2009). Who's right, marshall or jacobs? the localization versus urbanization debate. *Research Policy*, 38(2):318–337.

Beck, T., Demirgüç-Kunt, A., Laeven, L., and Levine, R. (2008). Finance, Firm Size, and Growth. *Journal of Money, Credit and Banking*, 40(7):1379–1405.

Berman, N., Martin, P., and Mayer, T. (2012). How do different exporters react to exchange rate changes? *Quarterly Journal of Economics*, 127(1):437–492.

Bernard, A. B., Jensen, J. B., Redding, S. J., and Schott, P. K. (2009). The margins of u.s. trade. Working Paper 14662, National Bureau of Economic Research.

Bernard, A. B., Jensen, J. B., and Schott, P. K. (2006). Transfer pricing by us-based multinational firms. Technical report, National Bureau of Economic Research.

Bettencourt, L. M., Samaniego, H., and Youn, H. (2014). Professional diversity and the productivity of cities. *Scientific Reports*, 4:5393.

Birnbaum, A. (1968). Some latent trait models and their use in inferring an examinee's ability. In Lord, F. M. and Novick, M. R., editors, *Statistical Theories of Mental Test Scores*, chapter 17-20, pages 397–479. Addison-Wesley, Reading, Massachusetts.

Blonigen, B. A. (2011). Revisiting the evidence on trade policy preferences. *Journal of International Economics*, 85(1):129–135.

Blyde, J., Busso, M., Faggioni, V., and Romero, D. (2017). The impact of chinese competition on mexican labor outcomes. *Banco Interamericano de Desarrollo, Washington, DC. Documento inédito*.

Bonefeld, W. and Burnham, P. (1996). Britain and the Politics of the European Exchange Rate Mechanism 1990 - 1992. *Capital & Class*, 20:5–38.

Boschma, R. (2017). Relatedness as driver of regional diversification: A research agenda. *Regional Studies*, 51(3):351–364.

Boschma, R. and Capone, G. (2015). Institutions and diversification: Related versus unrelated diversification in a varieties of capitalism framework. *Research Policy*, 44(10):1902–1914.

Brahmakulam, I., Jackson, B., Wagner, C., Wong, A., and Yoda, T. (2001). Science and technology collaboration: Building capacity in developing countries. RAND Science and Technology. Santa Monica, CA-2001.

Branson, W. H. (1972). The Trade Effects of the 1971 Currency Realignments. *Brookings Papers on Economic Activity*, 1(1972):15–58.

Broda, C. and Weinstein, D. E. (2006). Globalization and the Gains From Variety. *The Quarterly Journal of Economics*, 121(2):541–585.

Budd, A. (2004). Black Wednesday: A Re-examination of Britain's Experience in the Exchange Rate Mechanism. In *Thirty-Fourth Wincott Lecture*.

Burstein, A., Eichenbaum, M., and Rebelo, S. (2005). Large Devaluations and the Real Exchange Rate. *Journal of Political Economy*, 113(4):742–784.

Burstein, A., Eichenbaum, M., and Rebelo, S. (2007). Modeling exchange rate passthrough after large devaluations. *Journal of Monetary Economics*, 54(2):346–368.

Burstein, A. and Gopinath, G. (2014). International prices level and exchange rates. *Handbook of International Economics*, 4:391–451.

Burstein, A. and Jaimovich, N. (2012). Understanding Movements in Aggregate and Product-Level Real Exchange Rates. *Working Paper*.

Bussière, M., Saxena, S. C., and Tovar, C. E. (2010). Chronicle of large currency devaluations: re-examining the effects on output. *BIS Working Paper*, 314.

Bustos, S., Gomez, C., Hausmann, R., and Hidalgo, C. A. (2012). The dynamics of nestedness predicts the evolution of industrial ecosystems. *PloS one*, 7(11):e49393.

Bustos, S. and Yildirim, M. A. (2020). Uncovering trade flows. Unpublished mimeo, available upon request.

Cadot, O., Carrère, C., and Strauss-Kahn, V. (2011). Export diversification: what's behind the hump? *Review of Economics and Statistics*, 93(2):590–605.

Caliendo, L. and Parro, F. (2015). Estimates of the Trade and Welfare Effects of NAFTA. *The Review of Economic Studies*, 82(1):1–44.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary Economics*, 12(3):383–398.

Campa, J. M. and Goldberg, L. S. (2005). Exchange Rate Pass-Through into Import Prices. *Review of Economics and Statistics*, 87(4):679–690.

Campbell, D. L. (2016). Relative Prices, Hysteresis, and the Decline of American Manufacturing. *Working Paper*, page 51723.

Campos, N., Coricelli, F., and Moretti, L. (2014). Economic growth and political integration: Estimating the benefits from membership in the european union. Technical report, CEPR Discussion Paper 9968.

Casas, C., Díez, F. J., Gopinath, G., and Gourinchas, P.-O. (2016). Dominant currency paradigm. Working Paper 22943, National Bureau of Economic Research.

Chen, S.-S. and Engel, C. (2005). Does 'aggregation bias' explain the ppp puzzle? *Pacific Economic Review*, 10(1):49–72.

Chinn, M. D. (2006). A primer on real effective exchange rates: Determinants, overvaluation, trade flows and competitive devaluation. *Open Economies Review*, 17(1):115–143.

Chiquiar, D. (2008). Globalization, regional wage differentials and the stolper–samuelson theorem: Evidence from mexico. *Journal of International Economics*, 74(1):70–93.

Clausing, K. A. (2003). Tax-motivated transfer pricing and us intrafirm trade prices. *Journal of Public Economics*, 87(9-10):2207–2223.

Clausing, K. A. (2006). International tax avoidance us international trade. *National Tax Journal*, pages 269–287.

Clausing, K. A. (2016). The effect of profit shifting on the corporate tax base in the united states and beyond. *Available at SSRN 2685442*.

Clausing, K. A. (2018). Does tax drive the headquarters locations of the world's biggest companies? *Available at SSRN 3232887*.

Colacelli, M. (2010). Intensive and Extensive Margins of Exports and Real Exchange Rates. *Working Paper*.

Cooper, R. N. (1971). Currency Devaluation in Developing Countries. *Essays in International Finance*, 86(86).

Couharde, C., Delatte, A.-L., Grekou, C., Mignon, V., and Morvillier, F. (2017). Eqchange: A world database on actual and equilibrium effective exchange rates. Working Papers 2017-14, CEPII.

Cravino, J. and Levchenko, A. (2015). The Distributional Consequences of Large Devaluations. *NBER Working Paper*.

Cristelli, M., Tacchella, A., and Pietronero, L. (2015). The heterogeneous dynamics of economic complexity. *PloS one*, 10(2):e0117174.

Darvas, Z. (2012). Real Effective Exchange Rates for 178 Countries : a New Database. *Bruegel Working Paper*, 06:1–35.

David Autor, Dorn, D., Hanson, G., and Majlesi, K. (2016). Importing political polarization? the electoral consequences of rising trade exposure. Technical report, National Bureau of Economic Research.

Davies, R. B., Martin, J., Parenti, M., and Toubal, F. (2018). Knocking on tax haven's door: Multinational firms and transfer pricing. *Review of Economics and Statistics*, 100(1):120–134.

De Mooij, R. and Liu, L. (2020). At a cost: The real effects of transfer pricing regulations. *IMF Economic Review*, 68(1):268–306.

Dell, M. (2015). Trafficking networks and the mexican drug war. *American Economic Review*, 105(6):1738–79.

Dell, M., Feigenberg, B., and Teshima, K. (2018 forthcoming). The violent consequences of trade-induced worker displacement in mexico. *American Economic Review: Insights*.

Desai, M., Fukuda-Parr, S., Johansson, C., and Sagasti, F. (2002). Measuring the technology achievement of nations and the capacity to participate in the network age. *Journal of Human Development*, 3(1):95–122.

Desai, M. A., Foley, C. F., and Hines Jr, J. R. (2007). Dividend policy inside the multinational firm. *Financial management*, pages 5–26.

Devereux, M. P. and Vella, J. (2014). Are we heading towards a corporate tax system fit for the 21st century? *Fiscal studies*, 35(4):449–475.

Dharmapala, D. (2014). What do we know about base erosion and profit shifting? a review of the empirical literature. *Fiscal Studies*, 35(4):421–448.

Diodato, D., Neffke, F., and O'Clery, N. (2018). Why do industries coagglomerate? how marshallian externalities differ by industry and have evolved over time. *Journal of Urban Economics*, 106:1–26.

Dischinger, M. and Riedel, N. (2011). Corporate taxes and the location of intangible assets within multinational firms. *Journal of Public Economics*, 95(7-8):691–707.

Drozd, L. A., Kolbin, S., and Nosal, J. B. (2014). Long-Run Price Elasticity of Trade and the Trade-Comovement Puzzle. *Working Paper*.

Eaton, J., Kortum, S. S., and Neiman, B. (2015). Obstfeld and Rogoff'S International Macro Puzzles: a Quantitative Assessment. *NBER Working Paper Series*, 1.

Eckert, F., Fort, T. C., Schott, P. K., and Yang, N. J. (2020). Imputing missing values in the us census bureau's county business patterns. National Bureau of Economic Research (NBER) Working Paper 26632.

Economist", T. (2017). To err is human; so is the failure to admit it.

Eichengreen, B., Rose, A. K., and Wyplosz, C. (1995). Exchange Market Mayhem: The Antecedents and Aftermath of Speculative Attacks. *Economic Policy*, 10(21):249–312.

Eichengreen, B. and Wyplosz, C. (1993). The unstable EMS. *Brookings Papers on Economic Activity*, 1:51–143.

Fan, J. (1992). Design-adaptive nonparametric regression. *Journal of the American statistical Association*, 87(420):998–1004.

Feenstra, R. C. (1994). New Product Varieties and the Measurement of International Prices. *American Economic Review*, 84(1):157–177.

Feenstra, R. C., Inklaar, R., and Timmer, M. P. (2015). The Next Generation of the Penn World Table. *American Economic Review*, 105(10):3150–3182.

Feenstra, R. C., Obstfeld, M., and Russ, K. N. (2014). In search of the Armington elasticity. *Nber*, pages 1–44.

Feenstra, R. C., Romalis, J., and Schott, P. K. (2002). Us imports, exports, and tariff data, 1989-2001. Technical report, National Bureau of Economic Research.

Feigenbaum, J. J. and Hall, A. B. (2015). How legislators respond to localized economic shocks: Evidence from chinese import competition. *The Journal of Politics*, 77(4):1012–1030.

Felipe, J., Kumar, U., Usui, N., and Abdon, A. (2012). Why has china succeeded? and why it will continue to do so. *Cambridge Journal of Economics*, 37(4):791–818.

Ferguson, N. and Schlefer, J. (2009). Who Broke the Bank of England ? *Harvard Business School BGIE Unit Case*, 9(709-026).

Fernández, C. and García Perea, P. (2015). The Impact of the Euro on Euro Area GDP per capita. *Banco de Espana Working Paper*, No. 1530.

Fernandez, R. and Rodrik, D. (1991). Resistance to reform: Status quo bias in the presence of individual-specific uncertainty. *The American economic review*, pages 1146–1155.

Firpo, S. and Possebom, V. (2016). Synthetic Control Estimator: A Generalized Inference Procedure and Confidence Sets. *Working Paper*.

Fitzgerald, D. (2008). Can trade costs explain why exchange rate volatility does not feed into consumer prices? *Journal of monetary Economics*, 55(3):606–628.

Fitzgerald, D. and Haller, S. (2014). Exporters and Shocks: Dissecting the International Elasticity Puzzle. *NBER Working Paper 19968*, pages 1–36.

Fleming, L. and Sorenson, O. (2001). Technology as a complex adaptive system: evidence from patent data. *Research Policy*, 30(7):1019–1039.

Forbes, K., Hjortsoe, I., and Nenova, T. (2016). The Shocks Matter: Improving our Estimates of Exchange Rate Pass-Through. *Bank of England Discussion Paper*.

Fort, T. C. (2017). Technology and production fragmentation: Domestic versus foreign sourcing. *The Review of Economic Studies*, 84(2):650–687.

Fort, T. C., Pierce, J. R., and Schott, P. K. (2018). New perspectives on the decline of us manufacturing employment. *Journal of Economic Perspectives*, 32(2):47–72.

Frankel, J. (2004). Contractionary Currency Crashes In Developing Countries. *Fifth Annual Research Conference of the International Monetary Fund*, pages 1–54.

Fritz, B. S. and Manduca, R. A. (2019). The economic complexity of us metropolitan areas. arXiv preprint arXiv:1901.08112.

Glaeser, E. L., Kallal, H. D., Scheinkman, J. A., and Shleifer, A. (1992). Growth in cities. *Journal of Political Economy*, 100(6):1126–1152.

Goldberg, L. S. and Campa, J. M. (2010). The Sensitivity of the CPI to Exchange Rates: Distribution Margins, Imported Inputs, and Trade Exposure. *Review of Economics and Statistics*, 92(2):392–407.

Goldberg, L. S. and Tille, C. (2008). Vehicle currency use in international trade. *Journal of international Economics*, 76(2):177–192.

Goldberg, P. K. and Maggi, G. (1999). Protection for sale: An empirical investigation. *American Economic Review*, 89(5):1135–1155.

Goldberg, P. K. and Pavcnik, N. (2005). Trade, wages, and the political economy of trade protection: evidence from the colombian trade reforms. *Journal of International Economics*, 66(1):75–105.

Gomis-Porqueras, P. and Puzzello, L. (2014). Winners and Losers from the Euro. *Working Paper*.

Gopinath, G. (2015). The International price system. In *Jackson Hole Symposium*, volume 1, pages 1–7.

Gopinath, G. and Rigobon, R. (2008). Sticky Borders. *The Quarterly Journal of Economics*, 123(2):531–575.

Gordon, R. J. (2000). The aftermath of the 1992 erm breakup: was there a macroeconomic free lunch? In *Currency crises*, pages 241–282. University of Chicago Press.

Gorrín, J., Morales, J., and Ricca, B. (2019). The impact of the mexican drug war on trade.

Griffith, R., Miller, H., and O'Connell, M. (2014). Ownership of intellectual property and corporate taxation. *Journal of Public Economics*, 112:12–23.

Guzman, M., Ocampo, J. A., and Stiglitz, J. E. (2017). Real exchange rate policies for economic development. Working Paper 23868, National Bureau of Economic Research.

Hainmueller, J. and Hiscox, M. J. (2007). Educated preferences: Explaining attitudes toward immigration in europe. *International organization*, 61(2):399–442.

Hainmueller, J. and Hiscox, M. J. (2010). Attitudes toward highly skilled and low-skilled immigration: Evidence from a survey experiment. *American political science review*, 104(1):61–84.

Hakobyan, S. and McLaren, J. (2016). Looking for local labor market effects of nafta. *Review of Economics and Statistics*, 98(4):728–741.

Hallak, J. C. (2010). A product-quality view of the linder hypothesis. *The Review of Economics and Statistics*, 92(3):453–466.

Hardie, M., Jowett, A., Marshall, T., Wales, P., et al. (2013). Explanation beyond exchange rates: Trends in uk trade since 2007. *Office of National Statistics Working Paper*.

Harrison, A. and Rodríguez-Clare, A. (2010). Trade, foreign investment, and industrial policy for developing countries. In *Handbook of development economics*, volume 5, pages 4039–4214. Elsevier.

Hausmann, R. and Hidalgo, C. A. (2011). The network structure of economic output. *Journal of Economic Growth*, 16(4):309–342.

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes, A., and Yıldırım, M. A. (2014). *The Atlas of Economic Complexity: Mapping Paths to Prosperity*. The MIT Press.

Hausmann, R., Hidalgo, C. A., Stock, D., and Yildirim, M. A. (2019). Implied comparative advantage. CID Working Paper No. 276.

Hausmann, R., Hwang, J., and Rodrik, D. (2007). What you export matters. *Journal of Economic Growth*, 12(1):1–25.

Hebous, S. and Johannesen, N. (2016). At your service! the role of tax havens in international trade with services. In *Proceedings. Annual Conference on Taxation and Minutes of the Annual Meeting of the National Tax Association*, volume 109, pages 1–24. JSTOR.

Heckemeyer, J. H. and Overesch, M. (2017). Multinationals' profit response to tax differentials: Effect size and shifting channels. *Canadian Journal of Economics/Revue canadienne d'économique*, 50(4):965–994.

Hidalgo, C. A., Balland, P.-A., Boschma, R., Delgado, M., Feldman, M., Frenken, K., Glaeser, E., He, C., Kogler, D. F., Morrison, A., et al. (2018). The principle of relatedness. In *International Conference on Complex Systems*, pages 451–457. Springer.

Hidalgo, C. A. and Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the National Academy of Sciences of the United States of America*, 106(26):10570–10575.

Hidalgo, C. A., Klinger, B., Barabási, A.-L., and Hausmann, R. (2007). The product space conditions the development of nations. *Science*, 317(5837):482–487.

Hines Jr, J. R. and Rice, E. M. (1994). Fiscal paradise: Foreign tax havens and american business. *The Quarterly Journal of Economics*, 109(1):149–182.

Hooper, P., Johnson, K., and Marquez, J. R. (2000). Trade elasticities for the g-7 countries. *Princeton International Economics Section Working Paper*.

Hughes-Hallett, A. J. and Wren-Lewis, S. (1995). Is There Life Outside the ERM? An Evaluation of the Effects of Sterling's Devaluation on the UK Economy. *International Journal of Financial Economics*, 2:199–216.

Imbs, J. and Mejean, I. (2015). Elasticity Optimism. *American Economic Journal: Macroeconomics*, 7(3):43–83.

Imbs, J., Mumtaz, H., Ravn, M. O., and Rey, H. (2005). Ppp strikes back: Aggregation and the real exchange rate. *The Quarterly Journal of Economics*, pages 1–43.

Imbs, J. and Wacziarg, R. (2003). Stages of diversification. *American Economic Review*, 93(1):63–86.

Itskhoki, O. and Mukhin, D. (2016). Exchange Rate Disconnect in General Equilibrium. *Working Paper*, page 800.

Jacobs, J. (1969). *The economy of cities*. Random House, New York.

Janskỳ, P. and Prats, A. (2015). International profit-shifting out of developing countries and the role of tax havens. *Development policy review*, 33(3):271–292.

Javorcik, B. S., Lo Turco, A., and Maggioni, D. (2018). New and improved: Does fdi boost production complexity in host countries? *The Economic Journal*, 128(614):2507–2537.

Jensen, J. B., Quinn, D. P., and Weymouth, S. (2017). Winners and losers in international trade: The effects on us presidential voting. *International Organization*, 71(3):423–457.

Johannesen, N., Tørsløv, T., and Wier, L. (2016). Are less developed countries more exposed to multinational tax avoidance? method and evidence from micro-data. Technical report, WIDER Working Paper.

Junz, H. B. and Rhomberg, R. R. (1973). Price Competitiveness in Export Trade Among Industrial Countries. *The American Economic Review, Papers and Proceedings*, 63(2):412–418.

Karkinsky, T. and Riedel, N. (2012). Corporate taxation and the choice of patent location within multinational firms. *Journal of international Economics*, 88(1):176–185.

Kehoe, T. and Ruhl, K. (2013). How Important Is the New Goods Margin in International Trade? *Journal of Political Economy*, 121(2):358–392.

Khandelwal, A. (2010). The long and short (of) quality ladders. *The Review of Economic Studies*, 77(4):1450–1476.

King, M. (1997a). Changes in uk monetary policy: Rules and discretion in practice. *Journal of Monetary Economics*, 39(1):81–97.

King, M. (1997b). The inflation target five years on. *Bank of England. Quarterly Bulletin*, 37(4):434.

Kose, M. A., Prasad, E., Rogoff, K., and Wei, S.-J. (2010). Financial globalization and economic policies. In *Handbook of development economics*, volume 5, pages 4283–4359. Elsevier.

Kovak, B. K. (2013). Regional effects of trade reform: What is the correct measure of liberalization? *American Economic Review*, 103(5):1960–76.

Krugman, P. (1986). Pricing to Market When the Exchange Rate Changes. *NBER Working Paper Series*, pages 1–43.

Lall, S. (2003). Indicators of the relative importance of iprs in developing countries. *Research Policy*, 32(9):1657–1680.

Lane, P. and Shambaugh, J. C. (2010). Financial Exchange Rates and International Currency Exposures. *American Economic Review*, 100(1):518–540.

Larreguy, H. A., Marshall, J., and Snyder, James M, J. (2014). Revealing malfeasance: How local media facilitates electoral sanctioning of mayors in mexico. Working Paper 20697, National Bureau of Economic Research.

Larreguy, H. A., Marshall, J., and Snyder Jr, J. M. (2018). Leveling the playing field: How campaign advertising can help non-dominant parties. *Journal of the European Economic Association*, 16(6):1812–1849.

Lazarsfeld, P. F. (1950). The logical and mathematical foundation of latent structure analysis. *Studies in Social Psychology in World War II Vol. IV: Measurement and Prediction*, pages 362–412.

Lee, C.-Y. (2018). Geographical clustering and firm growth: Differential growth performance among clustered firms. *Research Policy*, 47(6):1173–1184.

Leigh, D., Lian, W., Poplawski-Ribeiro, M., Szymanski, R., Tsyrennikov, V., and Yang, H. (2017). Exchange rates and trade: A disconnect? *IMF Working Paper*, 17(58).

Lewis, L. T. (2017). How Important are Trade Prices for Trade Flows? *IMF Economic Review*, 65:471––497.

Lord, F. M. (1952). A theory of test scores. *Psychometrika Monographs. No. 7*.

Lord, F. M. (2012). *Applications of item response theory to practical testing problems*. Routledge.

Love, P. and Stockdale-Otárola, J., editors (2017). *OECD Insights Debate the Issues: Complexity and Policy making*, Paris. OECD Publishing.

Magee, S. P. (1973). Currency Contracts, Pass-through, and Devaluation. *Brookings Papers on Economic Activity*, 1:303–325.

Mankiw, N. G., Romer, D., and Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 107(2):407–437.

Margalit, Y. (2011). Costly jobs: Trade-related layoffs, government compensation, and voting in us elections. *American Political Science Review*, 105(1):166–188.

Marshall, A. (1890). *Principles of economics*. Macmillan and Company.

Mayda, A. M. (2006). Who is against immigration? a cross-country investigation of individual attitudes toward immigrants. *The review of Economics and Statistics*, 88(3):510–530.

Mayda, A. M. and Rodrik, D. (2005). Why are some people (and countries) more protectionist than others? *European Economic Review*, 49(6):1393–1430.

McCaig, B. and Pavcnik, N. (2018). Export markets and labor allocation in a low-income country. *American Economic Review*, 108(7):1899–1941.

Mealy, P., Farmer, J. D., and Teytelboym, A. (2019). Interpreting economic complexity. *Science Advances*, 5(1):eaau1705.

Méndez Soto, P. M. (2014). Los empresarios en el marco de la comunicación política durante procesos electorales. *Revista Mexicana de Opinión Pública*, 17:134–160.

Morrison, G., Buldyrev, S. V., Imbruno, M., Arrieta, O. A. D., Rungi, A., Riccaboni, M., and Pammolli, F. (2017). On economic complexity and the fitness of nations. *Scientific Reports*, 7(1):15332.

Nakamura, E. and Steinsson, J. (2017). Identification in macroeconomics. *Working Paper*.

Narula, R. and Dunning, J. H. (2010). Multinational enterprises, development and globalization: Some clarifications and a research agenda. *Oxford Development Studies*, 38(3):263–287.

Obstfeld, M. and Rogoff, K. (2000). *The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?*, volume 15.

Ottaviano, G. I. and Peri, G. (2012). Rethinking the effect of immigration on wages. *Journal of the European economic association*, 10(1):152–197.

Paravisini, D., Rappoport, V., Schnabl, P., and Wolfenzon, D. (2015). Dissecting the Effect of Credit Supply on Trade: Evidence from Matched Credit-Export Data. *Review of Economic Studies*, 82(1):333–359.

Pavcnik, N. (2017). The impact of trade on inequality in developing countries. Technical report, National Bureau of Economic Research.

Petralia, S., Balland, P.-A., and Morrison, A. (2017). Climbing the ladder of technological development. *Research Policy*, 46(5):956–969.

Pierce, J. R. and Schott, P. K. (2012). A concordance between ten-digit us harmonized system codes and sic/naics product classes and industries. *Journal of Economic and Social Measurement*, 37(1, 2):61–96.

Pomeranz, D. (2015). No taxation without information: Deterrence and self-enforcement in the value added tax. *American Economic Review*, 105(8):2539–69.

Pomeranz, D. and Vila-Belda, J. (2019). Taking state-capacity research to the field: Insights from collaborations with tax authorities. *Annual Review of Economics*, 11:755–781.

Porter, M. (2003). The economic performance of regions. *Regional Studies*, 37(6-7):545–546.

Rajan, R. G. and Zingales, L. (1998). Financial dependence and growth. *American Economic Review*, 88(3):559–586.

Rasch, G. (1960). *Studies in mathematical psychology: I. Probabilistic models for some intelligence and attainment tests.* Nielsen & Lydiche.

Rauch, J. E. (1999). Networks versus markets in international trade. *Journal of international Economics*, 48:7–35.

Robitzsch, A., Kiefer, T., and Wu, M. (2018). *TAM: Test analysis modules*. R package version 3.0-21.

Rodnyansky, A. (2016). (Un)Competitive Devaluations and Firm Dynamics: Evidence from Abenomics. *Working Paper*.

Rodrik, D. (1995). Political economy of trade policy. *Handbook of International Economics*, 3:1457–1494.

Rose, A. K. and Yellen, J. L. (1989). Is there a J-curve? *Journal of Monetary Economics*, 24(1):53–68.

Rosenzweig, A. (2005). El debate sobre el sector agropecuario en el tratado de libre comercio. *CEPAL, LC/MEX/L*, 650.

Rubin, D. P. (1974). Estimating Causal Effects of Treatments in Randomized and Nonrandomized Studies. *Journal of Educational Psychology*, 66(5):688–701.

Ruhl, K. J. (2008). The International Elasticity Puzzle. *Working Paper*.

Saia, A. (2014). Choosing the Open Sea: The Cost to the UK of Staying Out of the Euro. *Working Paper*.

Salas, J. (2015). A Tale of Two Sectors: Product Differentiation and Heterogeneity in Price Stickiness in a General Equilibrium Model. *Working Paper*.

Scheve, K. F. and Slaughter, M. J. (2001). What determines individual trade-policy preferences? *Journal of International Economics*, 54(2):267–292.

Shambaugh, J. (2008). A new look at pass-through. *Journal of International Money and Finance*, 27(4):560–591.

Spencer, J. W. (2008). The impact of multinational enterprise strategy on indigenous enterprises: Horizontal spillovers and crowding out in developing countries. *Academy of Management Review*, 33(2):341–361.

Suárez Serrato, J. C. (2018). Unintended consequences of eliminating tax havens. Technical report, National Bureau of Economic Research.

Sumner, S. (2016). The pound depreciated by 10%. What does that mean? *The Library of Economics and Liberty Blog*.

Svensson, L. E. (2010). Inflation targeting. Working Paper 16654, National Bureau of Economic Research.

Tacchella, A., Cristelli, M., Caldarelli, G., Gabrielli, A., and Pietronero, L. (2012). A new metrics for countries' fitness and products' complexity. *Scientific Reports*, 2:723.

Topalova, P. (2007). Trade liberalization, poverty and inequality: Evidence from indian districts. In *Globalization and Poverty*, pages 291–336. University of Chicago Press.

Tørsløv, T. R., Wier, L. S., and Zucman, G. (2018). The missing profits of nations. Technical report, National Bureau of Economic Research.

Trefler, D. (2004). The long and short of the canada-us free trade agreement. *American Economic Review*, 94(4):870–895.

Verhoogen, E. (2008). Trade, quality upgrading, and wage inequality in the mexican manufacturing sector. *The Quarterly Journal of Economics*, 123(2):489–530.

Villarreal, M. and Cid, M. (2008). Nafta and the mexican economy. *Congressional Research Service, Report for Congress*, page 565.

Weichenrieder, A. J. and Mintz, J. (2010). The indirect side of direct investment: Multinational company finance and taxation.

Wright, T. and Zucman, G. (2018). The exorbitant tax privilege. Technical report, National Bureau of Economic Research.

Xu, Y. (2015). Generalized Synthetic Control Method for Causal Inference with Time-Series Cross-Sectional Data. *Working paper*.

Zucman, G. (2014). Taxing across borders: Tracking personal wealth and corporate profits. *The Journal of Economic Perspectives*, pages 121–148.

Zucman, G. (2015). *The hidden wealth of nations: The scourge of tax havens*. University of Chicago Press.

Zudel, B. and Melioris, L. (2016). Five Years in a Balloon Estimating The Effects of Euro Adoption in Slovakia Using The Synthetic Control Method. *OECD Working Paper*.