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Preface

In the past 30 years the world has witnessed an era of extraordinary globalization. In addition to a strong increase in goods trade, two important features of this period are the international fragmentation of production creating complex value chains organized by multinational firms as well as an increase in the international mobility of labor. Political and regulatory decision-making, however, has not kept up with economic integration. Its reference point remains the nation-state, creating substantial problems in an integrated world economy.

Chapters I and II investigate responses to these novel challenges by firms, consumers, governments and civil society actors. Chapter I contributes to a better understanding of the international organization of production in the absence of global regulation and the presence of externalities in the production process as well as the possibility of consumer boycotts.[1] Chapter II analyzes how increased international labor mobility and decision-making at the national level can generate instability in arrangements of deep economic integration like the EU. Chapter III takes a broader perspective and contributes to one of the most important questions in the field of international economics: How large are the gains from trade?

Civil society organizations and the media have long accused multinational companies of exploiting regulatory differences between their home markets and the location of production to cut costs at the expense of workers and the environment. The accusations mostly concern the actions of independent suppliers. These accusations have triggered a large number of NGO campaigns and consumer boycotts.

In joint work with Sebastian Krautheim, Chapter I addresses the following question: How do firms organize international production when the global regulatory void allows for cost savings at the expense of workers and the environment, but when this may also induce consumer boycotts and advocacy NGO campaigns, threatening reputation and sales? We introduce North-South differences in regulation, a cost-saving 'unethical' technology and consumer boycotts into a standard property rights model of international

[1] This chapter is also available as CESifo Working Paper No. 6922.

production following Antràs (2003). While a firm's headquarter is located in the 'Global North', more lenient regulation and lower enforcement capacity in the 'Global South' allows suppliers there to choose a cost-saving technology. The use of this technology also generates an externality like local pollution or worker rights infringements. Northern consumers care about these externalities so that an 'unethical' firm may face a consumer boycott and lose demand. Contracts are incomplete, limiting the headquarter's control over both investments and (un)ethical technology choices of suppliers along the value chain.

We show that international outsourcing and 'unethical' production are linked through a novel *unethical outsourcing incentive*: a high cost advantage of 'unethical' production in an industry and a low regulatory stringency in the supplier's country favor international outsourcing (as opposed to vertical FDI).

We test this prediction using U.S. intrafirm trade data at the industry level from the U.S. Census Bureau and proxy for the incentive to produce unethically with sectoral data on the importance of expenditure on water treatment and hazardous waste removal in the production process taken from the U.S. Annual Survey of Manufactures. We find robust evidence in support of the model's prediction.

Following the Brexit vote and recent electoral successes of right-wing populist parties with anti-immigration and anti-EU agendas, the European integration framework is under severe strain. Immigration from Eastern Europe was a much debated topic in the U.K. prior to the referendum and political tensions within the EU over immigration concern refugee reallocation in Eastern Europe as well as pressures from economic migrants from Africa in Italy and Spain. The danger of a break-up of the European Union is a common theme in the public debate.

Chapter II studies how international labor market integration can lead to disintegrative political pressures in a deep regional integration framework. In particular, I ask: Considering welfare-maximizing decisions of governments, is international labor market integration able to cause a country's endogenous exit from the EU? I combine the Ricardian multi-country trade model from Eaton and Kortum (2002) with quantitative modeling of worker migration using individual preference draws from Redding (2016). I add bilateral utility costs of migration and keep track of worker nationalities. Starting from an equilibrium with costly trade, I show that falling migration costs and subsequent worker flows induce a redistribution of the gains from trade towards the net sending countries through a terms of trade effect. If the integrating countries are sufficiently dissimilar in their levels of technology, the redistributive effect can dominate the direct utility gains from falling migration frictions. While aggregate utility increases, labor market integration can generate welfare losses for workers of net receiving countries.

These countries then face a *disintegration trade-off*. Because of the indivisibility of the free movement of labor and goods inside the EU Single Market, unilateral migration policies designed to restrict immigration are only possible outside of it. Exit, however, entails a rise in mutual tariff levels between the exiting country and the remaining EU countries, hindering trade.

I assess the quantitative importance of this trade-off by matching the model to data on trade and migration from before the EU Eastern Enlargement. I confront it with actual tariff changes and estimated changes in migration costs for the period 2004 to 2007 and find that aggregate EU welfare rises. However, there is substantial heterogeneity across countries: workers from Eastern Europe benefit strongly from the accession, while some Western European workers lose, among them the British. In a counterfactual exercise I consider the exit decision of the U.K. government involving mutual tariff increases with the remaining EU countries and a reset of migration costs to pre-Enlargement levels. I find that U.K. workers are better off outside the EU, but worse off than inside the EU before the Eastern Enlargement.

In the public debate, the Brexit decision and the government's determination to follow through with it have often been portrayed as irrational and populist. Chapter II presents a rationalization of this decision based on the arguments outlined above which is also supported quantitatively. These results are an important reference point but need to be corroborated in future work. In particular, the inclusion of multiple sectors and factors of production as well as the consideration in the quantitative exercise of the labor market integration with big European economies like Germany that happened after 2007 is likely to affect the results.

The quantitative trade model and the techniques to study counterfactual outcomes used in Chapter II are well established in the field of international economics. Nevertheless, there is an ongoing debate - started by Arkolakis, Costinot, and Rodríguez-Clare (2012) - about the microfoundations that underlie quantitative trade models and the (identical) size of the gains from trade they predict. This debate is important because it informs the interpretation of the numbers these models produce when they are applied to answer policy questions and helps to put them into perspective.

Chapter III of this dissertation contributes to this debate. Using a simple modification of the microfoundation to the Eaton-Kortum model, I combine gains from resource reallocation to the most efficient producers with gains from access to new goods into a tractable quantitative Ricardian model of trade. In contrast to the Eaton-Kortum model, I assume that countries randomly draw a country-specific subset of goods from an exogenous continuum, which they are able to produce in autarky. Different goods are then produced by different sets of producer countries who continue to compete perfectly over market shares.

The gains from trade in this model arise from two sources. First, consumers can buy goods already available in autarky from the cheapest producer, who may be located in a foreign country. Second, consumers get access to new goods they were unable to consume in autarky because their country was not able to produce them. These can now also be sourced from the lowest-cost supplier. This interaction of specialization and new goods gains raises the overall gains from trade compared to a standard Eaton-Kortum setup. On the other hand, the number of possible sourcing locations is reduced compared to the Eaton-Kortum model because only a small fraction of goods is produced by *all* countries. This reduces the gains from specialization.

In a quantitative exercise I determine the net effect of these two forces. I calibrate the model to match aggregate bilateral trade flows between 26 OECD economies. In the preferred specification, I find that the gains from trade increase by 43% on average relative to the Eaton-Kortum model.

The chapters of this dissertation constitute three independent contributions to the field of international economics. While they are linked by topic or by method as outlined above, each contribution may be read independently.

Chapter I

The International Organization of Production in the Regulatory Void

I.1 Introduction

The past three decades have been characterized by an unprecedented fragmentation and geographical dispersion of production. Value chains span all over the globe and even firms with a strong national branding have highly segmented international supply chains. The fact that low trade and information costs allow firms to exploit cross-country differences in factor prices is well established in the economics literature. But this profound change in the locus and organization of production also allows firms to exploit differences in environmental and labor regulation as well as enforcement capacity across countries. With national regulatory regimes and multinational production, these firms operate in a regulatory void (Short, 2013).

In this context, multinational firms and their suppliers are frequently accused of using the regulatory void to cut costs at the expense of the environment, local workers and future generations. The large number of cases in which allegations of 'unethical' or 'immoral' practices have led to consumer boycotts and NGO campaigns against global industry leaders highlights the relevance of this phenomenon. Examples include Nike for

This chapter is joint work with Sebastian Krautheim.

sweatshops in Indonesia (Harrison and Scorse, 2010); Apple and Samsung for abusive work conditions and environmental pollution in their supplier factories in China (China Labor Watch, 2018, Bloomberg, 2018, and China Labor Watch, 2012); McDonalds, Pepsico, Nestlé, Unilever and Procter and Gamble for rainforest destruction by their palm oil suppliers in Indonesia (Rainforest Action Network, 2017, Guardian, 2017); Coca-Cola for child labor at sugar cane suppliers in El Salvador (Human Rights Watch, 2004, Guardian, 2014); Abercrombie&Fitch, Benetton, C&A, Columbia, Decathlon, Old Navy, Banana Republic, H&M, Levi's, Marks&Spencer, Hilfiger and Calvin Klein for abusive work conditions at Indian supplier factories (Clean Clothes Campaign, 2017) and toy producers Hasbro and Mattel for labor abuse by their suppliers in China (China Labor Watch, 2015, Fortune, 2015). Responding to NGO pressure, the top five apparel brands Nike, Zara, H&M, Adidas, and Uniqlo have - among many others - agreed to remove hazardous chemicals from their entire supply chain by 2020 (Greenpeace, 2016).[1]

These are just a few examples to illustrate that the value chains of leading firms in a diverse set of industries have come under heavy criticism for reducing costs at the expense of workers or the environment. That is, in ways that some civil society actors and consumers consider 'unethical'. Baron (2012) and Krautheim and Verdier (2016) provide additional examples. While the benefits for firms on the cost side are obvious, also the damage on sales, reputation and stock market valuation can be sizable.[2]

Even the most casual observation of these examples suggests that most criticism concerns 'unethical' practices by *independent suppliers* rather than subsidiaries of multinational firms (although both cases exist). This raises the following questions: Does the choice between 'ethical' and 'unethical' production interact with the international organization of production? Are independent suppliers more likely to implement 'unethical' technologies than affiliates of multinational firms? How does this interact with the established views on the international integration vs. outsourcing decision?

Within the field of economics, the literature on the international organization of production based on the seminal contribution by Antràs (2003) appears to be the natural framework to address these questions. It applies the property rights theory of the firm by Grossman and Hart (1986) and Hart and Moore (1990) to international value chains in

[1] We take the ranking from KantarMillwardBrown (2017).

[2] An instructive example is the case of Nike. In 1997, Nike was hit by large-scale protests against work conditions in supplier factories in Indonesia. The Nike Annual Report for the fiscal year 1998 reports a 49.8% drop in profits, the stock price on May 31st, 1998, was 20% below its mark one year earlier and revenue grew only by 4% compared to 42% and 36% in the two years before. In March 1998, Nike CEO Phil Knight made the following statement: "The Nike product has become synonymous with slave wages, forced overtime, and arbitrary abuse. I truly believe the American consumer doesn't want to buy products made under abusive conditions" (New York Times, 1998). While this is an instructive case, several studies provide more systematic evidence that activist campaigns against firms negatively impact their stock market valuation (e.g. King and Soule, 2007, and Flammer, 2013).

a North-South context. Several determinants of the choice between vertical integration and international outsourcing have been analyzed both theoretically and empirically, e.g. capital/headquarter intensity in Antràs (2003), firm heterogeneity in Antràs and Helpman (2004), contractibility of inputs in Antràs and Helpman (2008), task routineness in Costinot, Oldenski, and Rauch (2011), and downstreamness of the supplier in the value chain in Antràs and Chor (2013).

In this paper we introduce North-South differences in regulation, a cost-saving 'unethical' technology and consumer boycotts into this literature. We seek to better understand how the boundaries of the firm respond when the implementation of possibly legal but supposedly 'unethical' practices in one country can have repercussions on sales and profits in another country. We find an additional outsourcing incentive that is absent in the previous literature: the cost savings of 'unethical' production alter optimal investments along the value chain and thereby make outsourcing more attractive. This effect is strongest in supplier-intensive sectors and implies that sectors with high potential cost savings of 'unethical' production are more prone to keeping their suppliers at arm's length. We also provide evidence for the empirical relevance of this effect.

We place our analysis in a context where the internationalization of production lets firms locate parts of their value chain in a jurisdiction (the 'Global South') with a more lenient regulation and/or lower enforcement capacity. This allows firms to implement a technology, forbidden in the Global North, which saves costs, but generates an externality on a third party (e.g. local pollution, unsustainable extraction of renewable resources or poor labor, safety and health standards). The first premise of our analysis is that these externalities raise ethical concerns on the side of consumers in the Global North potentially resulting in a consumer boycott of the final product.[3] As the production technology cannot be inferred from the final product, and is difficult or impossible to be verified by final consumers, it constitutes a credence attribute of the final product (Feddersen and Gilligan, 2001, and Baron, 2011). In the absence of international regulation addressing the market failures associated to credence goods, social activists can respond to this international governance deficit (Gereffi and Mayer, 2006) by initiating consumer boycotts to influence the production technology of firms along the value chain.[4]

[3]We do not take any normative stand on what 'ethical' or 'unethical' practices are. In our analysis, the defining feature of an 'unethical' technology is simply that it saves costs but may trigger a consumer boycott. There is ample empirical evidence both from surveys (O'Rourke, 2005, and Loureiro and Lotade, 2005) and from field experiments with real purchasing decisions (e.g. Hiscox and Smyth, 2011, and Hainmueller and Hiscox, 2012) that consumers do care about such issues and have a higher willingness to pay for ethical products. Moreover, Basu and Tzannatos (2003) and Cone (2013) provide evidence that this awareness has increased over the last decades.

[4]While most evidence on NGO campaigns rests on case studies, very recently, more systematic evidence is provided by Hatte and Koenig (2018). They use unique data from Sigwatch, a for-profit consultancy that provides firms with daily processed information on how NGOs comment on them. For a period

The second premise of our analysis is that production along international value chains is characterized by incomplete contracts. This is the central assumption of the property rights theory of international production introduced by Antràs (2003) and appears very natural for production in a North-South context. Issues concerning dispute settlement, place of jurisdiction as well as questions of enforcement across borders arise in this context. Moreover, relationship-specificity of investments along the value chain aggravates these problems as it adds dimensions to the product that are hard to specify ex-ante and difficult to verify by a third party ex-post. In our context, this contractual incompleteness naturally extends to the implementation of technology: no contract effectively binds the supplier to implement the ethical or unethical technology type. The massive difficulties of internationally active firms trying to implement codes of conduct for their suppliers largely backs this assumption.[5]

One central result of our analysis is that the headquarter intensity (and therefore also its counterpart, the supplier intensity) of the production technology is a key determinant both for the organization of production *and* for the choice between the unethical and the ethical technology. We find that, just like in Antràs (2003), a *high supplier intensity favors international outsourcing* over vertical integration. In addition, we find that a *high supplier intensity favors unethical production*. This implies that in sectors where the supplier provides an important contribution to the production process one should observe both more outsourcing *and* more unethical production.[6] Our model therefore implies an association between international outsourcing and unethical production.

Further analysis of the mechanics of our model reveals a more sophisticated relation between the two. In our model, outsourcing is an instrument for the headquarter to alleviate the underinvestment of the supplier. Unethical production increases the gap between the optimal and the actual investment. This aggravated underinvestment under unethical production magnifies the incentive of the headquarter to choose outsourcing compared to the ethical (i.e. the Antràs, 2003) case. We label this the *unethical outsourcing incentive*.

This generates a range of factor intensities for which outsourcing is only chosen because

from 2010–2014, their raw data contain campaigns of 2949 activists, campaigning against a total of 6893 firms headquartered in 130 countries. Using data on the location of the firm's headquarter, the NGO's headquarter as well as the country in which the criticized action takes place, they show that the international fragmentation of production is also reflected in the activity of advocacy NGO campaigns. On the one hand, they find a strong international dimension of this activity. On the other hand, their triadic gravity analysis shows a strong bias for NGOs to campaign against domestic firms. This pattern is consistent with our modeling approach where a firm from the Global North is confronted by an NGO from the Global North about an action taking place in the Global South.

[5]Nike is a well documented case in point (e.g. Locke, Qin, and Brause, 2007). Other research documenting difficulties of implementing codes of conduct with independent suppliers includes Egels-Zandén (2007), Ruwanpura and Wrigley (2011), and Bird, Short, and Toffel (2017).

[6]Despite this link, our model is rich enough to also feature *ethical outsourcing* and *unethical integration* as equilibrium outcomes.

the headquarter anticipates unethical production by the supplier. The supplier's option to implement the unethical technology therefore biases the organizational decision of the firm towards outsourcing. This effect is more pronounced for sectors with stronger incentives for unethical production. Our model therefore implies that sectoral variation in the incentives for unethical production - in terms of model parameters: high unethical cost advantage and a low probability of a boycott - is associated with sectoral variation in the organizational form even *after* controlling for factor intensities. In Section I.4.6 we provide empirical evidence for this conditional correlation: controlling for all standard proxies of headquarter intensity, we find that high cost savings from unethical production in an industry are associated with more outsourcing relative to vertical integration.

The unethical outsourcing incentive also implies an interesting tension between aspirations and reality when it comes to the headquarter's actions. In the public debate firms are frequently accused of 'greenwashing', i.e. claiming to be in favor of ethical production but acting differently. We find that the combination of actually *wishing* to source ethically but *expanding* unethical production can be an equilibrium outcome. This is the case when the headquarter would *prefer* the ethical technology (which it cannot impose on the supplier) but *anticipates* unethical production. The headquarter then has an incentive to maximize cost savings from unethical production, which is achieved by keeping the supplier at arm's length and thereby scaling up unethical production.[7]

With consumers willing to boycott certain products on ethical grounds, information about the implemented production technology is crucial. We assume that technology is a credence attribute of a product - it cannot be inferred from the final product even after consumption. That said, observable firm choices (like investments, quantities and prices) may nevertheless contain information about the underlying technology. A deviation from those investments, quantities or prices that are optimal under ethical production may then indicate that the unethical technology has been implemented. In the baseline model we simply impose that any deviation from these observables is interpreted as proof of unethical production and directly triggers a consumer boycott, leading firms to set observables like under ethical production. This allows us to focus on the implications of our model for the international organization of production in the baseline model in Section I.2. In Section I.3 we provide a microfoundation in which we introduce an activist NGO screening firms for signs of unethical behavior and organizing consumer boycotts in response. We find that - as in the baseline model - in equilibrium unethical firms hide their type by pooling with ethical firms. We show that both the microfounded and the baseline model yield qualitatively identical results.

[7]The model also features cases where the interests of the headquarter and the supplier are aligned and both prefer the ethical or, notably, both prefer the unethical technology.

The need to pool with ethical firms implies that in equilibrium unethical firms set the same investment levels as ethical firms. Given that an unethical supplier faces lower variable costs, the deviation of the *actual* from the *optimal* investment increases. As outsourcing is the only instrument to mitigate the underinvestment by the supplier, outsourcing becomes more attractive under unethical production, generating the unethical outsourcing incentive.

While the (un)ethical technology choice of the supplier depends on the factor intensity of production (and, quite intuitively, the cost advantage of unethical production and the risk of a boycott), it turns out to be *independent* of the organization of production. The reason for this is that the organization of production has two countervailing effects on the attractiveness of unethical production for the supplier, which exactly offset one another. On the one hand, outsourcing scales up cost savings from unethical production through increased investments, on the other, it makes the supplier more vulnerable to a boycott by increasing its share of final revenues. This implies that the headquarter has no instrument to affect the supplier's technology choice. Our model therefore remains very close to the setting in Antràs (2003) and allows us to focus on the prevalent question in this literature: how can one instrument (organization of production) be used to affect one variable (investment incentives) under incomplete contracts? Our setting allows us to analyze how the potentially unethical technology choice of the supplier distorts the use of the instrument by the headquarter, linking unethical production to outsourcing in equilibrium.

As outlined above, our model predicts a link between the incentives for unethical production and outsourcing. To support this prediction empirically, we follow the established literature, e.g. Nunn and Trefler (2013), Antràs and Chor (2013) and Antràs and Yeaple (2014), in using U.S. Census Bureau data on intrafirm trade. We use the standard measure of vertical integration at the industry level: the share of U.S. intrafirm imports in total U.S. imports for the years $2007 - 2014$. We correlate this variable with the cost advantage of unethical production and analyze if this relation differs systematically across levels of regulatory stringency of the exporting country.

We suggest a measure of cost savings at the expense of the environment, for which we draw on data from the Annual Survey of Manufactures provided by the U.S. Census Bureau. Since 2007 the survey has recorded the industry-level expenditure on water, sewer, refuse removal, and other non-electric utility payments including the cost of hazardous waste removal. These expenditures are highly sensitive to regulation. We use their share in total costs to proxy for potential cost savings from operating under more lenient regulation (with the U.S. as the benchmark). To measure the level of regulation (and enforcement) in different countries, we use the Environmental Policy Stringency Index computed by the OECD for 33 countries for the years 2007 to 2012, including the six non-member countries Brazil, China, India, Indonesia, Russia, and South Africa. The index combines information on 14 environmental policy instruments that are mainly related to air and climate pollution and is suitable for comparisons across countries.

As predicted by our model, we find a statistically and economically significant negative relationship between our measure of the unethical cost advantage and the share of intrafirm imports in an industry. The relationship is stronger in countries with more lenient regulation. These findings are robust to the inclusion of country-year fixed effects as well as a large number of control variables that the previous literature has found - and our theory predicts - to affect the prevalence of vertical integration.

Our paper contributes to the large literature on the international organization of production pioneered by Antràs (2003). Some of the major contributions are highlighted above and a recent survey is provided by Antràs and Yeaple (2014). Differences in regulation and institutions are not alien to this literature. Antràs and Helpman (2004) assume that integration improves the outside option of the headquarter more in the North than in the South. In Antràs and Helpman (2008), the share of contractible inputs may differ between production locations. In contrast to those papers, we do not consider institutions like rule of law and the protection of property rights, but instead consider differences in environmental regulation and labor rights and their enforcement.

By introducing consumer boycotts and an advocacy NGO into a model of the international organization of production, our paper contributes to bridging the gap between the international economics literature and the literature on private politics started by Baron (2001, 2003). The latter focuses on activists attempting to affect firm behavior not through lobbying for regulation (*public politics*) but through campaigns and boycotts of firms (*private politics*). This literature takes an industrial organization perspective and analyzes the interaction of activists, firms and possibly a regulator under different market structures and allowing for strategic interactions between all parties.[8]

Brooks (2002) considers the possibility that a loss of control in case of outsourcing also limits liability in case of infringement (in our wording: unethical production). Fu, Gong, and Png (2018) extend this approach to continuous production and infringement levels. They take an industrial organization perspective and focus their analysis on the trade-off between full control and full liability under integration and limited control and limited liability under outsourcing. While they do not introduce this trade-off into established

[8]Some of the main contributions include Innes (2006), Baron and Diermeier (2007), Lyon and Salant (2013), Baron (2010), as well as Baron (2016), and Egorov and Harstad (2017). Closely related to the private politics literature, but with a different focus, are works on the private provision of public goods and corporate social responsibility (CSR) surveyed by Kitzmuller and Shimshack (2012).

frameworks in international economics, their modeling is consistent with the transaction cost approach (e.g. Grossman and Helpman, 2002), where integration provides the headquarter with full control over the supplier (see Footnote 18 for details). In contrast, we follow the predominant paradigm in the international economics literature: the property rights theory of the firm used in Antràs (2003). On the one hand, this allows us to analyze how the established theoretical insights change when the novel elements and trade-offs are introduced. On the other hand, we can derive testable implications that can be brought to the data and neatly tie into the established empirical approaches in the international economics literature.

Several papers have introduced elements of private politics into international economics. Aldashev and Verdier (2009) analyze the international competition for funds among development-oriented NGOs. Aldashev, Limardi, and Verdier (2015) consider the impact of NGO campaigns on industry structure in a setting with endogenous mark-ups and monopolistic competition. Krautheim and Verdier (2016) analyze the endogenous emergence of a consumer-financed NGO in response to the offshoring decision of a firm. Kitzmuller (2012) takes the model of Besley and Ghatak (2007), who explicitly model an NGO as a potential provider of a public good, to the international level.

Issues related to private regulation, social activism and NGO-firm interactions in global value chains have received much more attention in political sciences and management studies. This literature finds that social activism is instrumental in the establishment of codes of conduct in multinational supply chains and analyzes further determinants of their success in case studies and more recently in large firm-level datasets.[9]

Our work has some relation to several strands of the international trade literature. First and foremost, Copeland and Taylor (1994) formalize the idea that differences in environmental regulation affect the international location of production. This triggered a large literature on trade (FDI) and the environment which is surveyed in Copeland and Taylor (2004).[10] Our approach has in common with this literature that we view regulatory differences as a driving force of the internationalization of production. This literature, however, does not analyze the international organization of production and, importantly, ignores the feedback effects the implementation of unethical technologies can have on demand when consumer boycotts are possible.[11]

[9]See e.g. Locke, Kochan, Romis, and Qin (2007), Distelhorst, Hainmueller, and Locke (2017), Ouellet, Short, and Toffel (2015), Distelhorst and Locke (2018) and references therein.

[10]See Aichele and Felbermayr (2015) and references therein for more recent contributions.

[11]We identified two other strands of the literature that resonate with some dimension of our analysis. First, the 'protection for sale' literature based on Grossman and Helpman (1994), which considers the influence of a special interest group on trade policy outcomes. The focus is therefore on *public politics* rather than on *private politics* and on *trade policy* rather than on the *international organization of production*. Second, Eckel and Egger (2009) study the role of trade unions for international investment and production decisions of firms. There are several important differences between advocacy NGOs and

The remainder of this paper is structured as follows. In Section I.2, we present our baseline model of unethical production and consumer boycotts and analyze the optimal international organization of production. In Section I.3, we analyze an extension of the model featuring advocacy NGOs and asymmetric information, thereby microfounding the relation between consumer boycotts and observables like the organization of production, investments, quantities, and prices. We describe the empirical specification along with the data sources and the results of our empirical analysis in Section I.4. Section I.5 concludes.

I.2 A Model of (Un)ethical Sourcing with Incomplete Contracts

In this section, we outline a property-rights model of the boundaries of the firm in the context of international differences in labor or environmental regulation and the risk of consumer boycotts. To facilitate the comparison to the existing literature, we closely follow Antràs (2003) in our baseline setting.[12] Similar to Antràs and Chor (2013), we focus on the analysis of the organizational choice of the headquarter-supplier pair and abstract from an analysis of the industry equilibrium.

I.2.1 Baseline Model

We first outline our baseline model.

I.2.1.1 Preferences, Consumer Boycotts and Demand

All consumers are located in the Global North. Their preferences are summarized by the following CES aggregate over a large number of symmetric varieties indexed by ω,

$$U = \left(\int_{\omega \in \Omega} y(\omega)^{\alpha} I(\omega) d\omega \right)^{\frac{1}{\alpha}}, \tag{I.1}$$

trade unions. The former affect firms through demand, tend to be indifferent to survival of the firm and address externalities that usually concern third parties. The latter in turn affect firms on the cost side, vitally depend on firm survival and maximize the utility of their (nationally segmented) members.

[12]We do not include firm heterogeneity like in Antràs and Helpman (2004) in our model, but rather take the original model in Antràs (2003) as a reference point. The reason is that to our knowledge there are no stylized facts concerning correlations of firm size, productivity or quality to the implementation of unethical production, that could guide our modeling. We argue that our mechanism is equally general as the mechanism in Antràs (2003). It should therefore carry over to *any* extension of the original Antràs model, but possibly at the expense of tractability. The attentive reader of our microfoundation spelled out in Section I.3 might think that in a model with heterogeneous firms the link between investment choices and boycotts may break down. We argue in Footnote 28 that this is not the case in particular if heterogeneity is modeled as differences in quality rather than productivity.

with $\alpha \in (0,1)$, Ω being the set of available varieties and $y(\omega)$ representing the quantity consumed of variety ω. These preferences are standard with the exception of the indicator variable $I(\omega)$. It reflects the fact that a firm (and its variety) can be hit by a consumer boycott. In this case the indicator variable takes a value of zero implying that the representative consumer does not derive any utility from its consumption.

Consumers maximize their utility subject to the budget constraint

$$E \leq \int_{\omega \in \Omega} p(\omega) y(\omega) d\omega.$$

Therefore, in general, demand for each variety ω is given by

$$y(\omega) = Ap(\omega)^{-\frac{1}{1-\alpha}} I(\omega)^{\frac{1}{1-\alpha}}, \tag{I.2}$$

where $A = E\left(\int_{\omega \in \Omega} p(\omega)^{-\frac{\alpha}{1-\alpha}} I(\omega)^{\frac{1}{1-\alpha}} d\omega\right)^{-1}$.

From equation (I.2) we can see how demand responds to a boycott. In this case the indicator variable takes the value of zero and there is no demand for the product.[13] The value of the preference shifter depends on the choice of the firm and nature (in the baseline model) or the activity of an advocacy NGO (in the microfounded model). This stylized assumption allows us to generate the risk of losing final revenues as a consequence of unethical production in a simple way that preserves tractability of the model.[14]

I.2.1.2 Production of the Final Good and the Intermediate Input

The final good is produced by the headquarter located in the Global North using an intermediate good provided by the supplier located in the Global South. The headquarter can costlessly transform one unit of an intermediate good into final output:

$$y(\omega) = x(\omega). \tag{I.3}$$

The quantity $y(\omega)$ produced of the final good is therefore simply given by the quantity $x(\omega)$ of the intermediate good the headquarter has at its disposal. The intermediate good

[13] Technically, this modeling is a variation of the standard approach in the literature on quality and international trade with CES preferences, where firms can invest into quality represented by a (usually continuous) variable which takes the place of our indicator variable. See e.g. Hummels and Klenow (2005) and Hallak (2006) for early contributions.

[14] There are interesting microeconomic and behavioral issues related to this, in particular the question to which extent consumers form expectations about (un)ethical production and adjust consumption accordingly (as in Krautheim and Verdier, 2016) and to which extent the preference for ethical consumption is endogenous to NGO activity: Nyborg (2011) shows that consumers can be willing to pay to *not* receive information in order to avoid a moral obligation to contribute voluntarily. We do not seek to contribute to answering these questions and simply model consumer preferences such that we obtain the main features relevant for our analysis maintaining tractability.

is in turn produced by a supplier combining a headquarter service and a manufacturing input according to the following production function:

$$x(\omega) = \left(\frac{h(\omega)}{\beta}\right)^{\beta} \left(\frac{m(\omega)}{1-\beta}\right)^{1-\beta} \tag{I.4}$$

where $\beta \in (0,1)$ is the headquarter intensity of production. The headquarter service $h(\omega)$ is provided to the supplier by the headquarter which then combines it with the manufacturing input $m(\omega)$ to produce $x(\omega)$ units of the intermediate good. The intermediate good produced is entirely relationship-specific. Neither can the supplier sell $x(\omega)$ to any third party nor can the headquarter produce any of the final output without the intermediate good that is in the possession of the supplier.[15] We stress that the manufacturing input $m(\omega)$ stands for a bundle of factors of production used by the supplier. Among these are labor and physical capital, as well as human capital and materials. In addition, and crucially for our model, the supplier also incurs other expenditures, such as provisions for workplace safety and the cost of compliance with local environmental regulation in the process of providing the input $m(\omega)$.

I.2.1.3 Unethical Production and Consumer Boycotts

The central innovation in this paper is that the supplier does not only choose the investment necessary to produce the manufacturing input, but can also choose between a high- and a low-cost technology. The low-cost technology produces a (higher) negative externality on a third party. We can think of such externalities as taking the form of exploitation of workers with forced overtime, low work safety standards or child labor as well as pollution of the environment, e.g. by dumping dangerous chemicals in rivers, emitting substantial quantities of carbon dioxide or harvesting old growth rainforests. Consumers consider an unnecessarily high (but cost-saving) level of this externality as unethical. We define the marginal cost of the supplier's high-cost, ethical technology as c_m^e and the low-cost, unethical technology by $c_m^u = \mu c_m^e$, with $\mu \in (0,1)$.

We do not take any *normative* stand on what an ethical or unethical technology is. This includes for example the debate on the desirability of a ban of child labor. We

[15] A setting where the headquarter provides an input to the supplier who can combine it with its own input and then take the produced output 'hostage' may seem a little artificial. The same may be the case for a final good technology that costlessly transforms the intermediate into the final product. We chose this modeling approach in order to reproduce the original Antràs (2003) setting. Later contributions consider settings where headquarter and supplier each produce an intermediate. Both intermediates are then combined to produce the final output. This setup appears more natural but delivers the same results and mechanisms as the original setting. To make the comparison to Antràs (2003) as clear as possible, we stick to the original modeling. Moreover, it is of interest to note that recent work on factoryless manufacturing points at examples like Apple or Dyson, who do not own any manufacturing establishments at all (Bernard and Fort, 2015).

simply start our modeling from the observation that consumer boycotts are triggered by the perception of (some) consumers that firms act in an unethical way. Clearly, what is considered 'unethical' may depend on the historical context, income, culture, salience of specific issues in the public debate as well as alternative technologies.

As consumers cannot infer from the final product whether the unethical technology was used in production, unethical firms can potentially prevent consumers from learning about the type of the firm. While we assume that the technology used cannot be directly observed by consumers, some firm choices are observable, potentially leading consumers to believe that the firm is of the unethical type. In the baseline version of the model we impose a simple link between observable choices (investments, quantities and prices) of the firm and the probability of facing a boycott: an unethical firm setting observables at values that are optimal for an ethical firm ('mimicking') has a chance to pass as an ethical firm and faces a boycott with probability $1 - \gamma < 1$. *Any firm deviating from the investments, quantities or prices of ethical firms faces a boycott with probability one.*[16] In fact, we only need to impose this for investments, as conditional on identical investments, the same quantities and prices maximize profits of both firm types.[17] This implies that an unethical firm faces discontinuous demand being positive in expectation if and only if it chooses investments like an ethical firm. This leads unethical firms to *mimic* ethical firms and in equilibrium the levels of investment, quantities and prices do not reveal the type of the firm.

Using this reduced-form approach in the baseline model allows us to focus on the analysis of the international organization of production with unethical technologies, to derive our main results on the integration and technology decision, their interaction as well as empirical implications. However, the reduced-form approach leaves some questions open: What is the mechanism/the agent triggering a consumer boycott? Why is it triggered by a deviation from ethical firm choices? Should ethical firms adjust their investments in order to signal their type? To address these questions, we provide a microfoundation in Section I.3, where an NGO observes firm choices (organization of production, investments, quantities, prices) and can determine the optimal choices of an ethical firm. When the NGO observes a firm that acts inconsistently with the use of the ethical technology

[16] It is merely for tractability that we consider a setting where *any* deviation of the ethical investment triggers a consumer boycott. Even if this assumption were to be relaxed, the magnification of the outsourcing incentive through unethical production presented below should remain active as long as the supplier needs to stay below the level of investment it would optimally choose in the absence of the threat of a boycott.

[17] This is because after investments are made, the 'optimization' of a firm with respect to quantities and prices is equivalent to a situation in which all costs are sunk, marginal costs are zero, and the maximum output is fixed and identical for both firm types as investments are the same. Therefore, when both firms have set the same investment levels and there is positive demand for the unethical firm, both firms will set the same quantities and market clearing prices.

it starts an investigation. If it finds the firm to be of the unethical type it initiates a boycott. We show that all the results of the baseline model remain qualitatively unchanged when the model is fully microfounded. As all the additional assumptions introduced in the microfoundation serve the sole purpose of microfounding the link between mimicking and boycotts, but do not add major insights on the role of unethical technology for the international organization of production, we keep them separated from the baseline model.

I.2.1.4 Hold-up Problem and the Organization of the Firm

We consider an environment with incomplete contracts. Neither can contracts be written contingent on choices the parties make, nor on outcomes like revenue. The only contractible items are the lump-sum transfer from the supplier to the headquarter (discussed in detail below) and the organization of production. This means that investment quantities are not contractible, but also that our new feature, the technology choice of the supplier, cannot be contracted upon.[18]

As contracts are incomplete, neither the investments nor the split of the revenues can be fixed ex-ante. The relationship-specificity of investments then implies that after investments are sunk and the intermediate input is produced, the two parties face a hold-up problem. Both parties need the partner to generate (full) revenue and therefore engage in a bargaining process over the split of final revenues. Following the literature, we model this ex-post bargaining as generalized Nash bargaining with the headquarter getting a fraction of the final revenues. This fraction is endogenous and depends on the residual rights of control, which are in turn affected by the organization of production chosen by the headquarter.

Before investments take place, the headquarter can choose between integrating the supplier into the firm or leaving it as an independent party. We index the mode of organization by $k \in \{O, V\}$, where O stands for international outsourcing and V for vertical integration. The key difference between the two is that outsourcing leaves the supplier with the residual rights of control over the produced intermediate. In this case the outside options of both parties are zero if bargaining fails: the headquarter has no input to produce the final product and the supplier cannot transform the intermediate

[18] Alternatively, one could assume that integration allows the headquarter to *impose* the technology on the supplier. This would, however, mix property rights theory (for production) and the transaction cost approach à la Grossman and Helpman (2002) or Carluccio and Bas (2015) (for technology). In the latter, all contractual incompleteness is resolved by integration. It appears hard to justify the assumption that under integration the headquarter *can* impose the type of technology but *cannot* impose the level of investment. More interesting might be the analysis of a setting that fully embraces the logic of the transaction cost approach where integration allows the headquarter to impose both the investment and the technology. We leave this alternative model for future research and focus in this paper on the predominant paradigm in the literature: the property-rights theory of the firm.

into the final product.[19] Integration in turn shifts the residual rights of control to the headquarter allowing it to recover a fraction $\delta \in (0,1)$ of the intermediates from the supplier if bargaining fails. The outside option of the headquarter under integration is therefore better than under outsourcing, implying that the bargaining results in a larger share of revenues going to the headquarter, i.e. $\phi_V > \phi_O$, where, as in Antràs (2003), $\phi_V = \phi_O + \delta^{\alpha} (1 - \phi_O)$.

We assume $\phi_k > \frac{1}{2}$. Antràs (2003) shows that this assumption is sufficient to ensure that the headquarter optimally produces the headquarter service by itself and hands it over to the supplier for production of intermediate $x(\omega)$ while the supplier produces the manufacturing input.[20]

I.2.1.5 Match Creation and Transfer Payment

We have now described the situation after a headquarter has been matched to a supplier. Ex-ante, the headquarter faces a large number of perfectly competitive suppliers available for a match. Once a match is formed, their relationship is transformed into one of bilateral monopoly (Williamson, 1985) in that investments are relationship-specific and have no outside value. Due to incomplete contracts, the production process involving bargaining over the revenues will leave the supplier with positive profits. The large number of potential suppliers compete for this profitable opportunity by offering a transfer payment to the headquarter in return for forming the match with them. Perfect competition among suppliers implies that the headquarter can set a payment that extracts the full expected surplus from the supplier. Besides the organization of production, the transfer payment is the only variable the headquarter and supplier can contract on. Both are fixed in the moment the match is formed.

I.2.1.6 Time Line

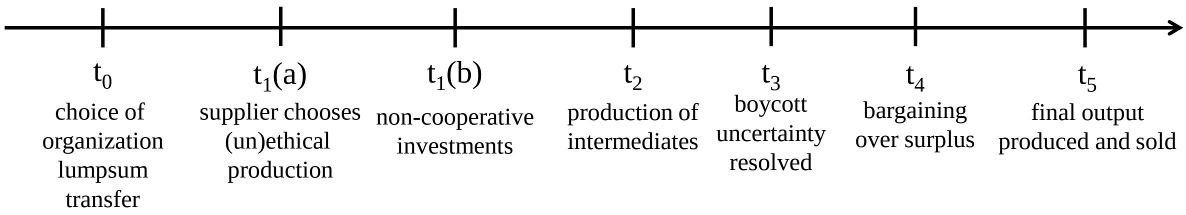
Figure I.1 gives an overview of the sequence of events. In t_0, the headquarter chooses the organizational form and the lump-sum transfer. In $t_1(a)$, the supplier chooses between ethical and unethical production. Both parties make their physical investments non-cooperatively in $t_1(b)$. The headquarter hands the headquarter service to the supplier, who in turn produces intermediate inputs in t_2 by combining the headquarter service with

[19]The assumption that the supplier cannot get anything out of its residual rights of control can easily be relaxed e.g. by allowing the supplier to sell the intermediate good at a discounted rate on a secondary market. We do not expect this to affect the results, as it does not do so in related settings either (see e.g. Antràs and Yeaple, 2014).

[20]This assumption implies that we are considering a two-sided hold-up problem, where both parties have sunk an investment in their specific factor. This assumption is therefore key to establish the qualitative equivalence to setups briefly outlined in Footnote 15 where the respective inputs are only combined after bargaining was successful.

its own manufacturing input. In t_3, nature determines whether an unethical firm will be boycotted by consumers. Period t_4 features the ex-post bargaining over the division of the surplus. In t_5, if the parties have agreed on a division, intermediates are converted to final output, sold and revenues distributed to headquarter and supplier if the firm is not boycotted. In case of a boycott, demand is zero and no final goods are produced and sold.

Figure I.1: Timing of Events.



I.2.2 Equilibrium Firm Choices

We solve the model by backward induction.

I.2.2.1 t_5: Revenues of Ethical and Unethical Firms

We denote revenue from selling variety ω as $R(\omega)_k^l$, where $k \in \{V, O\}$ indicates vertical integration and outsourcing and $l \in \{e, u\}$ indicates ethical and unethical production. An ethical firm always faces full demand as it is never targeted by a consumer boycott. Its revenues are given by $R(\omega)_k^e = p(\omega)_k^e \; y(\omega)_k^e$. $h(\omega)_k^e$ and $m(\omega)_k^e$ represent the investment quantities chosen by headquarter and supplier in the case of ethical production. Given that the quantity $x(\omega)$ of the intermediate good produced by the supplier is determined by investments and given that the headquarter costlessly transforms $x(\omega)$ into $y(\omega)$, total revenues of an ethical firm can be expressed as

$$R(\omega)_k^e = A^{1-\alpha} \left[\left(\frac{h(\omega)_k^e}{\beta} \right)^{\beta} \left(\frac{m(\omega)_k^e}{1-\beta} \right)^{1-\beta} \right]^{\alpha}. \tag{I.5}$$

An unethical firm only faces positive demand in expectation if $h(\omega)_k^u = h(\omega)_k^e$ and $m(\omega)_k^u = m(\omega)_k^e$, its revenues under mimicking and if it does not face an exogenous boycott in t_3 are also given by the above expression.

I.2.2.2 t_4: Bargaining

Headquarter and supplier bargain over the distribution of revenue. The bargaining power - and therefore also the share of revenue - of the headquarter is assumed to be $\phi_O > \frac{1}{2}$ under outsourcing. This reflects the fact that in the arm's length relationship, both parties have an outside option of zero and the payoff allocation is determined only by the exogenous assumptions about the distribution of the gains from trade. In the case of integration, the outside option of the supplier remains at zero because of the relationship-specificity of the produced intermediates. The headquarter, however, has allocated the residual rights of control to itself. It is able to continue producing $\delta y(\omega)$ in case bargaining breaks down. Using equations (I.3), (I.4), and (I.5) this translates into sales of $\delta^\alpha R(\omega)_k^l$. The gains from trade are thus reduced to $(1-\delta^\alpha)\, R(\omega)_k^l$. With integration, the headquarter receives its larger outside option plus its exogenous share from the gains from trade, which is $\phi_V R(\omega)_k^l$, with ϕ_V as defined in Section I.2.1.4.

I.2.2.3 t_3 and t_2: Consumer Boycotts and Production of Intermediates

In period t_3 nature decides whether an unethical firm faces a boycott. We assume that ethical firms never face a boycott, firms that are openly unethical always face a boycott and firms that mimic ethical firms in terms of prices, output, and investment face a boycott with a probability $1-\gamma$. Before the boycott uncertainty is resolved, a mimicking unethical firm therefore has an expected revenue of

$$E[R(\omega)_k^u] = \gamma R(\omega)_k^e. \tag{I.6}$$

In period t_2, the supplier uses the invested quantities to produce intermediate output $x(\omega)$. As outlined above, provided it mimicked in terms of investments in t_1, there is no reason for an unethical firm to deviate from the optimal quantity of an ethical firm, which is production according to equation (I.4).

I.2.2.4 $t_1(b)$: Investments

Two types of decisions are taken sequentially in period t_1. In period $t_1(a)$ the supplier chooses to implement the ethical or unethical technology. In period $t_1(b)$ supplier and headquarter take their investment decisions simultaneously. We first consider the investment choices conditional on the ethical or unethical technology being implemented.

Ethical Investments: When the supplier implements the ethical technology, the setting is isomorphic to Antràs (2003). The two parties simultaneously and non-cooperatively set investments to maximize their respective shares of final revenue. They take into account incomplete contracts and the ensuing ex-post bargaining. The headquarter maximizes

$$\max_{h(\omega)_k^e} \phi_k R(\omega)_k^e - c_h h(\omega)_k^e, \tag{I.7}$$

whereas the supplier solves

$$\max_{m(\omega)_k^e} (1-\phi_k) R(\omega)_k^e - c_m^e m(\omega)_k^e. \tag{I.8}$$

Notice the superscript in the marginal cost of the supplier. With ethical production, the supplier rewards its factor of production at the ethical rate c_m^e.

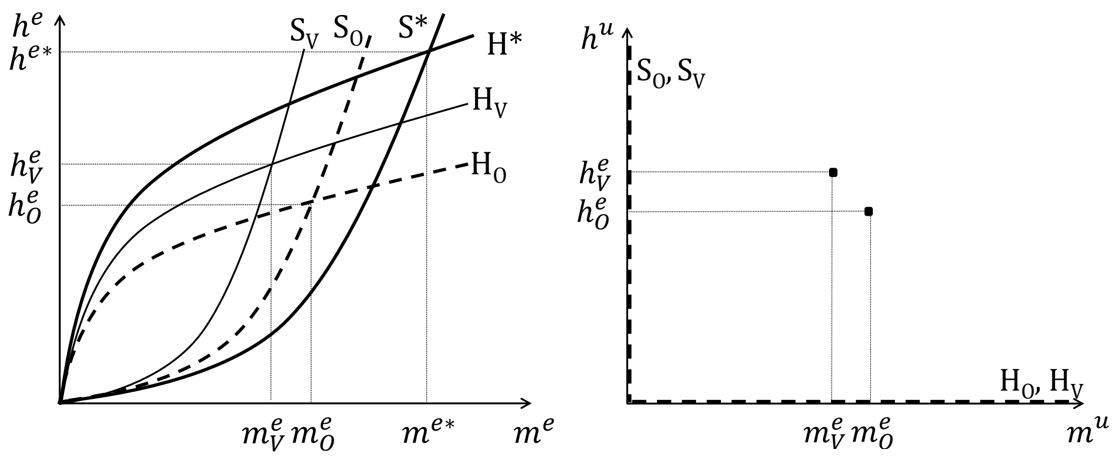
The first order conditions deliver the best response functions that give optimal investment of each party for any positive level of investment of the other party:

$$h(\omega)_k^e = \beta \left(\frac{\phi_k \alpha}{c_h}\right)^{\frac{1}{1-\beta\alpha}} A^{\frac{1-\alpha}{1-\alpha\beta}} \left(\frac{m(\omega)_k^e}{1-\beta}\right)^{\frac{(1-\beta)\alpha}{1-\beta\alpha}}$$

$$m(\omega)_k^e = (1-\beta)\left(\frac{(1-\phi_k)\,\alpha}{c_m^e}\right)^{\frac{1}{1-(1-\beta)\alpha}} A^{\frac{1-\alpha}{1-(1-\beta)\alpha}} \left(\frac{h(\omega)_k^e}{\beta}\right)^{\frac{\beta\alpha}{1-(1-\beta)\alpha}}.$$

Curve S_V in the left panel of Figure I.2 depicts the supplier's best response function, H_V the headquarter's best response function under vertical integration, S_O and H_O do the same for outsourcing. S^* and H^* show the best responses in the first best case, which is unattainable because of incomplete contracts.

Figure I.2: Best Response Functions under Ethical and Unethical Production.



Note: The left panel shows the best response functions when the ethical technology is used. The right panel shows them for the unethical technology case.

Like in Antràs (2003), the equilibrium of the investment game is at the intersection of the best response functions. The standard argument of Pareto-dominance rules out the other Nash equilibrium at zero-zero. Equilibrium investments are therefore given by

$$h(\omega)_k^e = \beta A \alpha^{\frac{1}{1-\alpha}} \frac{\phi_k}{c_h} \left[\left(\frac{c_h}{\phi_k} \right)^{\beta} \left(\frac{c_m^e}{1-\phi_k} \right)^{1-\beta} \right]^{\frac{-\alpha}{1-\alpha}} \tag{I.9}$$

$$m(\omega)_k^e = (1-\beta) A \alpha^{\frac{1}{1-\alpha}} \frac{1-\phi_k}{c_m^e} \left[\left(\frac{c_h}{\phi_k} \right)^{\beta} \left(\frac{c_m^e}{1-\phi_k} \right)^{1-\beta} \right]^{\frac{-\alpha}{1-\alpha}}. \tag{I.10}$$

We label these investments the *baseline ethical investment profile* $i(\omega)_k^* = \{h(\omega)_k^e, m(\omega)_k^e\}$. Plugging (I.9) and (I.10) into revenue from (I.5) gives equilibrium revenue generated by an ethical firm as

$$R(\omega)_k^e = A \alpha^{\frac{\alpha}{1-\alpha}} \left[\left(\frac{c_h}{\phi_k} \right)^{\beta} \left(\frac{c_m^e}{1-\phi_k} \right)^{1-\beta} \right]^{\frac{-\alpha}{1-\alpha}}. \tag{I.11}$$

Unethical Investments: We now turn to the non-cooperative investment game when the supplier has chosen the unethical technology. Demand is still given by equation (I.2), but the difference is that the indicator variable $I(\omega)$ may also take the value of zero. This is the case when the unethical firm does not mimic or if it faces an exogenous boycott in t_3. Mimicking involves setting the same price as the ethical firm. Therefore, the demand function becomes degenerate. When the unethical firm sets the ethical investment and price, $I(\omega) = 1$ and it gets full demand with probability $1-\gamma$. As soon as it deviates, we have $I(\omega) = 0$ and therefore zero demand.

An ethical firm faces a continuous demand function, leading to the continuous best response functions derived above. Consider the case that an unethical supplier would prefer mimicking over zero production. This is the only relevant case, as otherwise no supplier would choose unethical production in the first place. In this case the best response functions for the unethical firm are symmetric for the headquarter and the supplier and are given by

$$h(\omega)_k^u = \begin{cases} h(\omega)_k^e & \text{if } m(\omega)_k^u = m(\omega)_k^e \\ \textit{undetermined} & \text{if } m(\omega)_k^u = 0 \\ 0 & \textit{otherwise} \end{cases}$$

$$m(\omega)_k^u = \begin{cases} m(\omega)_k^e & \text{if } h(\omega)_k^u = h(\omega)_k^e \\ \textit{undetermined} & \text{if } h(\omega)_k^u = 0 \\ 0 & \textit{otherwise.} \end{cases}$$

The best response functions are illustrated in Figure I.2. Different to the ethical case, they take a value of zero for *any* investment of the other party deviating from the baseline ethical investment (indicated by the bold dashed lines). The only point with positive investments of both parties is when they both set the baseline ethical investment.

While the best response functions are fundamentally different from the ones for the ethical firm, they share the Nash equilibria at zero-zero and the baseline ethical investments. In fact, they lead to the same equilibrium of the investment game. To see this, note that no party would ever find it optimal to choose an investment that is not on its best response function, as it would be strictly dominated by playing the best response. This implies that only two investments can occur for each party: zero or the baseline ethical investment. As in the case with ethical production we invoke the Pareto-dominance criterion so that the equilibrium with positive investment is the one that is played.[21]

I.2.2.5 $t_1(a)$ (Un)ethical Technology Choice

We have seen how the non-cooperative investment decisions are taken for ethical and unethical firms in period $t_1(b)$. Based on this, we can now turn to period $t_1(a)$ analyzing the supplier's choice between the two technologies. In taking the technology decision, the supplier faces a trade-off between the cost savings implied by unethical production and the risk of losing its share of total revenues due to a consumer boycott.

First consider the determinants of the expected revenues of the supplier. A (mimicking) unethical firm still faces a boycott with probability $1-\gamma$ so that expected revenues are given by $E[R(\omega)_k^u] = \gamma R(\omega)_k^e$. With a fraction $1-\phi_k$ going to the supplier and given the equilibrium $R(\omega)_k^e$ in equation (I.11), expected revenues of an unethical supplier are given by

$$(1-\phi_k)E\left[R(\omega)_k^u\right] = \gamma(1-\phi_k)A\alpha^{\frac{\alpha}{1-\alpha}}\left[\left(\frac{c_h}{\phi_k}\right)^{\beta}\left(\frac{c_m^e}{1-\phi_k}\right)^{1-\beta}\right]^{-\frac{\alpha}{1-\alpha}}. \tag{I.12}$$

The expected difference between ethical and unethical revenues of the supplier is

$$E[\Delta R_S] = (1-\phi_k)\left(R(\omega)_k^e - E\left[R(\omega)_k^u\right]\right).$$

[21] An alternative way to rationalize the equilibrium with positive investments would be to assume that investments become relationship-specific if and only if both sides make a positive investment. So as soon as both sides make a positive investment, all the properties of the baseline model apply. But in the case in which one party makes zero investment, the input remains 'pure' and can be resold on the factor market at zero cost. Intuitively, this technology works like mixing red and white liquid paint. Two parties non-cooperatively decide the quantity of their type of paint they put into the same bucket. Once mixed, both inputs cannot be recovered. But in the special case where zero of the red paint is added, the white paint is not contaminated (not match-specific) and can be resold on the factor market for white paint (and vice versa).

This difference is always positive and reflects the fact that ethical firms have higher revenues in expectation, as they always face full demand. We refer to this difference as the *ethical revenue premium.* The supplier trades off its share of this ethical revenue premium against the cost savings of unethical production. The unit cost savings are determined by the scaling factor $\mu = \frac{c_m^u}{c_m^e}$ where $1 - \mu \in (0, 1)$ can be interpreted as the unit cost savings of unethical production which we refer to as the *unethical cost advantage.* Total cost savings of unethical production are given by $\Delta C = (c_m^e - c_m^u)\, m(\omega)_k^e$. With $m(\omega)_k^e$ given by equation (I.10).

In stage t_1, the organizational decision as well as the lump-sum transfer are fixed, as they are set in t_0. The supplier therefore takes the decision on unethical production by trading off $E[\Delta R_S]$ against ΔC. This decision can be described by a cutoff headquarter intensity β_S above which the supplier chooses the ethical technology and below which it produces unethically.

Proposition I.1 *The headquarter intensity of a sector influences the technology choice of the supplier. Specifically, the supplier chooses unethical production when the headquarter intensity β is lower than*

$$\beta_S = 1 - \frac{1 - \gamma}{\alpha\,(1 - \mu)}. \tag{I.13}$$

The cutoff β_S (i) increases in the unethical cost advantage, $\frac{\partial \beta_S}{\partial(1-\mu)} > 0$; (ii) decreases in the probability of a boycott, $\frac{\partial \beta_S}{\partial(1-\gamma)} < 0$; (iii) and decreases in the mark-up, $\frac{\partial \beta_S}{\partial(1/\alpha)} < 0$.
Proof: *See Appendix A.1.1.*

Proposition I.1 implies a direct link between headquarter intensity and (un)ethical production. Firms in sectors with a high supplier (low headquarter) intensity tend to implement the unethical technology, while ethical production is more likely in headquarter-intensive sectors. The choice between ethical and unethical production is driven by the trade-off between the supplier's total cost savings of unethical production and the supplier's expected loss of final revenue through a potential boycott. First, note that a high supplier intensity (low β) scales up the supplier's investment and therefore the potential cost savings from unethical production. Therefore, the unethical technology tends to be implemented in the supplier intensive sectors.

A stronger unethical cost advantage $(1 - \mu)$ scales up total cost savings and makes unethical production attractive also for suppliers with lower levels of investments (i.e. in more headquarter-intensive industries). The supplier trades off this per unit cost saving against the expected per unit ethical revenue premium, which is determined by $1/\alpha$ and $1-\gamma$. The former represents the mark-up a firm charges over its marginal cost, representing the per unit profit margin. The probability of facing boycott $(1 - \gamma)$ represents the risk of loosing these profits when unethical production is chosen.

Corollary 1 *The supplier's choice between the ethical and unethical technology is independent of the bargaining power and is therefore not affected by the organization of production (outsourcing vs. integration).*

Proof: *Simply note that the organization only affects the bargaining power of the headquarter and the supplier. It follows from equation* (I.13) *that the choice between ethical and unethical technology is independent of the bargaining power and does therefore not depend on the organization of production.*

The fact that the bargaining power and therefore the organization of production does not affect the choice between ethical and unethical production has an important implication in our model. We have seen in Section I.2.1.4 that, by choosing between integration and outsourcing, the headquarter can affect the bargaining power and thereby the investments of the two parties. The organization of production therefore provides an instrument for the headquarter to affect the non-contractible investment choice of the supplier. Corollary 1 implies, however, that this is no instrument the headquarter can use to influence the technology choice of the supplier: *the decision for or against unethical production is independent of the bargaining power and is therefore also independent of the organization of production.*

The reason for this is that it affects the technology decision through two opposing effects offsetting each other. On the one hand, a stronger bargaining power increases the share of total revenue going to the supplier. This increases the losses in case of a boycott and incentivizes ethical production. On the other hand, by increasing the share of total revenues, the higher bargaining power also increases the optimal investment level. This scales up the cost savings of unethical production. The derivation of equation (I.13) in the Appendix A.1.1 shows that the two effects exactly offset each other.

I.2.2.6 t_0: Optimal Organizational Structure and Transfer Payment

Transfer Payment Taking into account incomplete contracts, the investments in the manufacturing input and the equilibrium outcome of the ex-post bargaining a supplier in a sector in which $\beta > \beta_S$ knows its private profits are going to amount to

$$\pi^e_{k,S} = (1 - \phi_k)\, R(\omega)^e_k - c^e_m m(\omega)^e_k \tag{I.14}$$

if it enters the match with the headquarter which has chosen organizational form $k \in \{O, V\}$. In the other case, in which a supplier knows it will choose unethical production and mimicking because $\beta < \beta_S$, it expects to earn

$$E\left[\pi^u_{k,S}\right] = \gamma\,(1 - \phi_k)\, R(\omega)^e_k - c^u_m m(\omega)^e_k \tag{I.15}$$

in case of a successful match. Because the headquarter faces a large number of potential suppliers competing perfectly for the opportunity to produce the final good with it, these private profits represent the maximum amount a supplier is willing to pay for this opportunity. The headquarter knows its own β and has decided the optimal organizational form $k \in \{O, V\}$. Given this decision and anticipating the technology choice of the supplier in t_1 the headquarter extracts

$$T_k = \begin{cases} \pi^e_{k,S} & \text{if } \beta > \beta_S \\ E\left[\pi^u_{k,S}\right] & \text{if } \beta < \beta_S. \end{cases} \tag{I.16}$$

Organizational choice At the same time, the headquarter chooses between integration and outsourcing maximizing the total surplus of the match. Both decisions depend on the supplier's anticipated technology choice in stage t_1.

As the supplier's choice of technology does not depend on the bargaining power ϕ_k, the headquarter observes the headquarter intensity of its sector and perfectly foresees the technology choice of the supplier. Therefore, in the case of $\beta > \beta_S$, the headquarter anticipates ethical production by the supplier. In this case the total surplus of the match is given by the sum of the two parties' private profits

$$\Pi^e_k = R(\omega)^e_k - c^e_m m(\omega)^e_k - c_h h(\omega)^e_k. \tag{I.17}$$

If $\beta < \beta_S$, the headquarter knows the supplier will choose the unethical technology and mimic an ethical firm in investments, quantities and prices. The total surplus of the match is then subject to the uncertainty generated by the threat of a consumer boycott and is given by

$$E\left[\Pi^u_k\right] = \gamma R(\omega)^e_k - c^u_m m(\omega)^e_k - c_h h(\omega)^e_k. \tag{I.18}$$

In deciding the organizational form of the firm the headquarter compares the overall value of the relationship under outsourcing to the overall value under integration taking the technology choice of the supplier as given. Given ethical production by the supplier, the ratio of total profits under integration and total profits under outsourcing is given by

$$\Theta^e(\beta) = \left[\left(\frac{\phi_V}{\phi_O}\right)^{\beta}\left(\frac{1-\phi_V}{1-\phi_O}\right)^{1-\beta}\right]^{\frac{\alpha}{1-\alpha}} \frac{1-\alpha\left(1-\beta\right)+\phi_V\alpha\left[1-2\beta\right]}{1-\alpha\left(1-\beta\right)+\phi_O\alpha\left[1-2\beta\right]}.$$

The cutoff headquarter intensity above which the headquarter offers to the supplier a contract stipulating integration of the supplier and the transfer payment T_V given that it produces ethically ($\beta > \beta_S$) is implicitly defined by

$$\Theta^e(\beta_e) = 1. \tag{I.19}$$

Given unethical production by the supplier, the ratio of total expected profits is given by

$$\Theta^u(\beta) = \left[\left(\frac{\phi_V}{\phi_O}\right)^{\beta}\left(\frac{1-\phi_V}{1-\phi_O}\right)^{1-\beta}\right]^{\frac{\alpha}{1-\alpha}} \frac{\gamma - \alpha(1-\beta)\mu + \phi_V\alpha\left[\mu - \beta(1+\mu)\right]}{\gamma - \alpha(1-\beta)\mu + \phi_O\alpha\left[\mu - \beta(1+\mu)\right]}.$$

The cutoff headquarter intensity β^u above which the headquarter offers to the supplier a contract stipulating integration of the supplier and the transfer payment T_V given that it produces unethically ($\beta < \beta_S$) is implicitly defined by

$$\Theta^u(\beta_u) = 1. \tag{I.20}$$

The expression differs from $\Theta^e(\beta_e)$ in two respects. Because of unethical production there is now a threat of a boycott and second, the unethical cost advantage is exploited by the supplier. We summarize our result in the following subsection.

I.2.3 (Un)ethical Production, Factor Intensity and Ownership Structure

We can now combine the above insights on the implementation of the (un)ethical technology and the organizational choices of the firm conditional on technology to analyze the equilibrium of the model. Most notably, we are interested in the question of how the technology choice of the supplier interacts with the integration decision of the headquarter.

I.2.3.1 The Unethical Outsourcing Incentive

Based on equations (I.19) and (I.20), we can state the following proposition:

Proposition I.2 *There exists a unique β_e below which the headquarter chooses outsourcing irrespective of the technology choice of the supplier. Integration is always chosen for headquarter intensities above β_u and it always holds that $\beta_e < \beta_u$. A sufficient condition for a unique interior solution $\beta_u \in (\beta_e, 1)$ to exist is given by $\gamma > \frac{4\phi_V}{3+\phi_V}$. For any $\beta \in (\beta_e, \beta_u)$ the headquarter chooses integration if and only if the supplier produces ethically and chooses outsourcing if and only if unethical production is anticipated.*

Proof: *See Appendix A.1.2.*

The parameter condition $\gamma > \frac{4\phi_V}{3+\phi_V}$ is sufficient to ensure that $\beta_u < 1$ implying that both outsourcing and integration are chosen for some levels of headquarter intensity. Since we are interested in the interaction of unethical production with the organization of production, we focus on the cases in which both types of organizational form can emerge. However, $\beta_e < \beta_u$ regardless of whether the above condition holds.

Figure I.3: Unethical Production and the Two Integration Cutoffs.

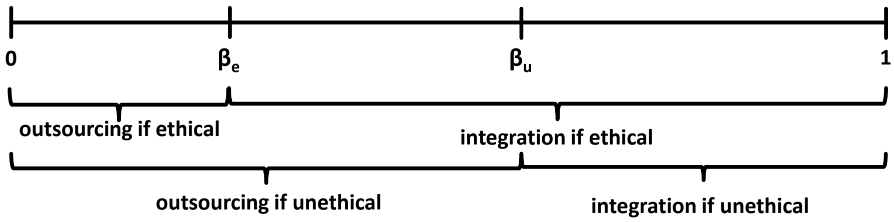


Figure I.3 highlights the pattern described in Proposition I.2. The axis shows the range of admissible headquarter intensities implying high supplier intensity on the left and high headquarter intensity on the right. The cutoff β_e is identical to the cutoff in Antràs (2003). It reflects the fact that the headquarter faces two underinvestment problems in period t_1 (the headquarter's and the supplier's). The organization of production is an instrument to alleviate the underinvestment of either the headquarter (through integration) or the supplier (through outsourcing). The mechanism is that integration and outsourcing imply different residual rights of control for the headquarter and the supplier. This changes the bargaining power and thereby the share of total revenue each party obtains. As a larger share of revenue increases the optimal investment, integration alleviates the headquarter's underinvestment while outsourcing alleviates the supplier's underinvestment. We refer to this pattern as the *Antràs implication*.

When the supplier chooses unethical production, the attractiveness of outsourcing increases above and beyond the Antràs implication: unethical production reduces the unit costs of the manufacturing input so that the difference between the actual and the optimal investment increases. This aggravates the underinvestment problem of the supplier compared to the case of ethical production with the same headquarter intensity. The headquarter responds to this by expanding the use of the now cheaper manufacturing input as much as possible. It can achieve this by shifting the residual rights of control to the supplier through outsourcing to incentivize a larger ex-ante investment. We call this the *unethical outsourcing incentive*. It is captured by the cutoff β_u. The fact that $\beta_e < \beta_u$ shows that outsourcing is chosen by the headquarter for a larger range of headquarter intensities if the supplier produces unethically. In particular, the *unethical outsourcing incentive* distorts the *Antràs implication* towards outsourcing so that the headquarter chooses outsourcing solely *because of* unethical production for $\beta \in (\beta_e, \beta_u)$. This implies that the supplier's technology choice can affect the organizational choice of the headquarter. Specifically, the headquarter tends to *keep unethical suppliers at arm's length*.

I.2.3.2 Ethical Integration and Unethical Outsourcing?

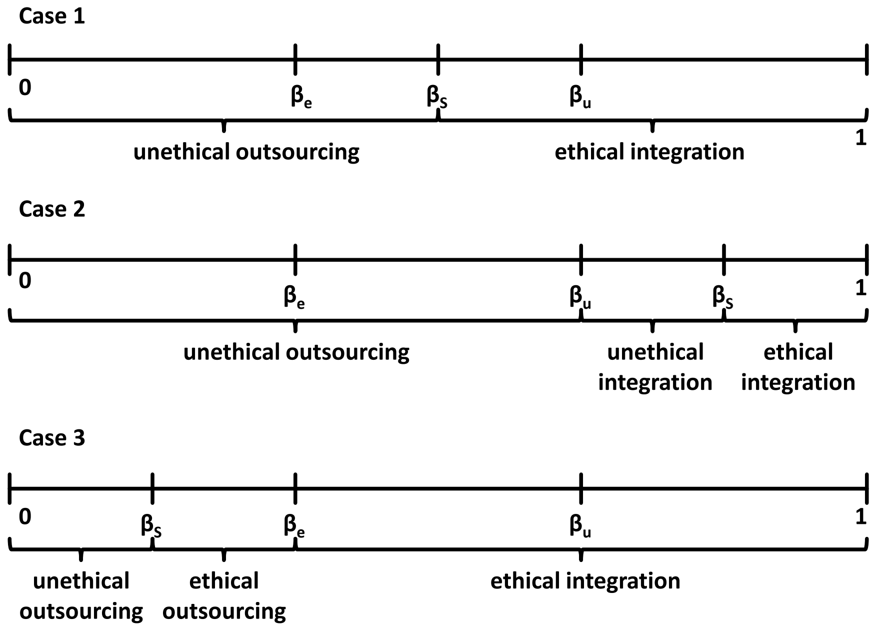
The equilibrium pattern of (un)ethical production and the organization of production depends on how the cutoffs β_S, β_e and β_u relate to one another. The following proposition summarizes the relevant cases to be distinguished.

Proposition I.3 *There exist three possible equilibria of the model characterized by $\beta_e < \beta_S < \beta_u$ (Case 1); $\beta_e < \beta_u < \beta_S$ (Case 2) and $\beta_S < \beta_e < \beta_u$ (Case 3). Unethical outsourcing and ethical integration are equilibrium outcomes in all three cases. Unethical integration and ethical outsourcing can occur in equilibrium in Cases 2 and 3, respectively.*
Proof: *See Appendix A.1.3.*

Proposition I.3 implies that unethical production and outsourcing are associated in our model as are ethical production and integration. The reason is that the *per unit cost savings of unethical production are scaled by the size of the supplier's investment*, which is larger in sectors with high supplier intensity (lower headquarter intensity) of production. At the same time, the Antràs mechanism implies that sectors with a high supplier intensity optimally shift bargaining power to the supplier through outsourcing to mitigate the underinvestment problem where it is most severe. Taken together, *sectors with high supplier intensities tend to implement outsourcing and unethical production*, while sectors with a high headquarter intensity tend to feature ethical production and integration.

This is illustrated in Figure I.4. In Case 1, β_S is in between β_e and β_u. In this case the cutoff splitting sectors into ethical and unethical ones also splits the sectors into integrating and outsourcing ones. Cases 2 and 3 illustrate what happens if the attractiveness of unethical production is very strong or very weak (e.g. because of the cost advantage of unethical production analyzed in detail below). In Case 2, unethical production is so attractive that the headquarter decides to integrate despite the use of the unethical technology by the supplier. In Case 3, ethical outsourcing occurs for a range of headquarter intensities. This illustrates that there is no mechanical link between outsourcing and unethical production in our model. Both unethical integration and ethical outsourcing can be equilibrium outcomes.

Figure I.4: Interaction of Unethical Production and the Outsourcing Decision.



I.2.3.3 Incentives for (Un)ethical Production and the Organization of the Firm

We are ultimately interested in the question if and how the (un)ethical technology choice of the supplier interacts with the organization of production. To address this question, we define $\bar{\beta}$ as the headquarter intensity above which integration actually takes place. This cutoff is given by $\bar{\beta} = \beta_S$ in Case 1; $\bar{\beta} = \beta_u$ in Case 2; and $\bar{\beta} = \beta_e$ in Case 3. With $\beta_e < \beta_u$, we can write the integration cutoff as:

$$\bar{\beta} = \begin{cases} \min\{\beta_S; \beta_u\} & \text{if } \beta_S > \beta_e \\ \beta_e & \text{otherwise.} \end{cases} \tag{I.21}$$

Proposition I.4 *The outsourcing cutoff is weakly increasing in the unethical cost advantage, i.e.* $\frac{\partial \bar{\beta}}{\partial(1-\mu)} \geq 0$.
Proof: *See Appendix A.1.4.*

We can see from Proposition I.4 that the outsourcing cutoff is weakly increasing in the unethical cost advantage given by $1 - \mu$. An increase in the unethical cost advantage increases both β_S and β_u and when unethical production surpasses a minimum level of attractiveness for the supplier ($\beta_e < \beta_S$), this unambiguously increases the integration cutoff $\bar{\beta}$. This implies that besides the variables that affect β_e that have already been accounted for in the literature, our model identifies the unethical cost advantage as a new parameter that affects the integration decision of the firm. We will exploit this implication in our empirical analysis in Section I.4.

The intuition behind the above result is as follows. Case 3 represents the case where unethical production is very unattractive. In this case a marginal change in $1 - \mu$ does not affect outsourcing. Consider the case where there is no unethical cost advantage at all ($1 - \mu = 0$). In this case unethical production is never optimal for the supplier and outsourcing is determined by the Antràs mechanism only. When we increase $1 - \mu$, the least headquarter-intensive industries start to use the unethical technology, but they are under the outsourcing regime anyway, so that the unethical outsourcing incentive does not alter the policy of the headquarter.

Once $1 - \mu$ is large enough to have $\beta_e < \beta_S$ the picture changes. In this case the unethical outsourcing incentive makes firms opt for outsourcing that would otherwise choose integration. As both β_S and β_u increase in $1-\mu$, outsourcing increases in $1-\mu$ both in Case 1 and Case 2. The cutoff β_S represents the incentives for unethical production for the supplier while β_u reflects the optimal response to it by the headquarter. As a stronger cost advantage makes unethical production more attractive, β_S increases in $1 - \mu$.

For β_u, note that when the headquarter anticipates unethical production, the damage is done (in expectation) on the demand side: a boycott occurs and reduces demand to zero with probability $1 - \gamma$. As the headquarter can influence neither the technology decision nor the effect of a boycott, it takes these as given and has an incentive to maximize the benefits of unethical production by increasing the supplier's manufacturing investment through outsourcing. This is the *unethical outsourcing incentive* discussed above. A higher cost advantage of unethical production therefore increases the range of headquarter intensities for which outsourcing is chosen by the headquarter, i.e. β_u increases.

I.2.3.4 Headquarter's Perspective on Ethical Production: Aspirations and Reality

Before we proceed to analyzing the microfoundation of the link between the boycott and prices, output and investments and before we present empirical test of Proposition I.4 in the following sections, we now highlight an interesting tension that can arise between the headquarter's aspirations and actions regarding (un)ethical production. Consider a headquarter that states that it would like to source its products ethically but then incentivizes its suppliers to expand unethical production. An external observer may interpret this as evidence of a dishonest attempt of greenwashing or - simply put - a lie by the firm. Our model, however, implies that this combination of actually *wishing* to source ethically but *expanding* unethical production can be an equilibrium outcome.

For this situation to occur two conditions have to be met. First, we need to be in a situation where the headquarter chooses outsourcing if and only if unethical production is anticipated, i.e. $\beta \in (\beta_e, \beta_u)$ (condition 1). We have seen in the discussion of Proposition I.2 that in this range the only reason to opt for outsourcing rather than integration is to expand unethical production to fully benefit from the unethical cost advantage. Second, within this range there must be a non-empty set of headquarter intensities for which the headquarter would impose ethical production if it could (while the supplier would not chose it on its own). As the headquarter can extract the full expected profits of the match, it seeks to maximize *joint profits* (while the supplier trades off the cost savings only against its own fraction of the expected revenues). Define the technology cutoffs $\beta_{H,k}$ with $k \in \{V, O\}$ as the cutoff headquarter intensities above which joint profits are maximized by ethical production. The supplier only chooses ethical production for $\beta > \beta_S$. We will see below that $\beta_{H,V} < \beta_{H,O} < \beta_S$. Then, the second condition is given by $\beta \in (\beta_{H,O}, \beta_S)$ (condition 2): in this range the headquarter *would like* the supplier to produce ethically (and would then like to choose integration as long as condition 1 is satisfied). But the supplier will implement the unethical technology. Under condition 1 this implies that outsourcing is chosen by the headquarter in order to incentivize the supplier to expand unethical production. Therefore, if there is a non-empty set of headquarter intensities that simultaneously satisfy conditions 1 and 2, the described tension between aspirations and reality is a possible equilibrium outcome. The following proposition establishes that this is the case.

Proposition I.5 *The technology cutoffs maximizing joint profits satisfy $\beta_{H,V} < \beta_{H,O} < \beta_S$. There is a non-empty set of headquarter intensities that satisfy $\beta \in (\beta_{H,O}, \beta_S) \wedge \beta \in (\beta_e, \beta_u)$. That is, the headquarter would oblige the supplier to produce ethically if it could, but, as it cannot, chooses outsourcing in order to expand unethical production.*
Proof: *See Appendix A.1.5.*

I.3 Firm Choices and Boycotts: a Microfoundation with Private Information

In the baseline model we made two simplifying assumptions concerning the link between unethical production and the occurrence of boycotts. First, unethical firms that mimic ethical firms (i.e. choose the same level of investment, quantities and prices) face a boycott with an exogenous probability of $1 - \gamma$. Second, unethical firms who deviate from mimicking face a boycott with certainty. This allowed us to focus our analysis on the predictions for the international organization of production. In this section we show that these assumptions can be microfounded. We present an extension of the model that features private information on technology and an advocacy NGO investigating firms. We will take a clear stand on how consumer boycotts emerge, how unethical production affects the risk of facing a boycott as well as the resulting investment and pricing decisions (mimicking) as equilibrium outcomes. We show that the qualitative results of the baseline model and the empirical prediction we derive from it continue to hold in this microfounded extension of the model.

The underlying intuition is that maintaining at least some degree of uncertainty about the technology used may reduce the probability of facing a consumer boycott. And indeed, acquisition of verifiable information on pollution and working conditions and the link to final consumer brands is a costly and possibly dangerous (and illegal) activity in many countries. One example is the Detox campaign by Greenpeace addressing, among other things, the toxic water pollution of the Pearl and Yangtze River Deltas (Greenpeace, 2011) and the Qiantang River (Greenpeace, 2012) in China by local textile and apparel producers. According to Greenpeace, a year-long investigation into production practices and buyer-seller linkages preceded its campaign to push a large number of top labels in the apparel industry to 'detox' their supply chain. Another well-mediatized example of the dangers of investigating working conditions in countries like China is the case of a labor activist being arrested for trying to document poor working conditions in a factory producing shoes for Ivanka Trump's brand in southern China (New York Times, 2017).

We argue that this strong preference for discretion regarding pollution and working conditions, backed even by the governments in key countries like China, is an important feature worth modeling explicitly. Our microfoundation therefore grounds on the technology implemented by the supplier being private information of the firm and being costly to verify by a third party.

I.3.1 Private Information

Private information about the type of technology implies that the technology cannot be directly observed from outside the match (while the headquarter and the supplier observe it). Other variables like organization of production, investments, output and prices are observable.

In the baseline model, either all firms in a sector choose the ethical technology or all choose the unethical technology. This is a very stylized pattern that directly stems from the fact that all firms in a sector are identical. In a sector in which all firms implement the unethical technology, mimicking would not make sense, as there are no ethical firms to mimic. We therefore assume that only a fraction κ of suppliers in each sector is able to use the unethical technology. Because of this, in equilibrium there will be at least a fraction $1 - \kappa$ of firms that produce ethically.

In period zero, when the headquarter offers the transfer payment to the supplier and decides the organizational form of the firm, neither party knows whether unethical production will be possible. This is only revealed at the next stage just before investment decisions are taken and the (un)ethical technology choice is made.[22] This assumption implies that the organizational choice of the firm does not contain information on the type of the firm: when it is taken, the headquarter does not know whether the unethical technology will be available in period $t_1(a)$.

I.3.2 NGO and Consumer Boycotts

In contrast to the baseline model, we now have to be more specific about how a consumer boycott emerges. We assume that there is an NGO that is able to organize such boycotts. As the focus of this paper remains the international organization of production, we keep the modeling of the NGO relatively stylized.[23]

The objective of the NGO is simply to start boycotts against as many unethical firms as possible. The NGO can trigger a consumer boycott if it can provide sufficient proof that a supplier has implemented an unethical technology. For simplicity, we assume that triggering the boycott is costless for the NGO, while proving the use of the unethical technology is (potentially) costly. The NGO is sophisticated enough to determine the optimal choices of an ethical firm in a given sector. It then potentially faces two types of firms. First, firms that are openly unethical and deviate from these choices. In this case identifying the firm as unethical is costless for the NGO.[24] Second, a group of *seemingly ethical firms* that are all identical in terms of observables, but which contains ethical and (mimicking) unethical firms. In this case the NGO has to incur a cost to identify the type of the firm and to collect sufficient proof to build a campaign upon.

As investigations are costly, the fraction of firms the NGO can monitor $(1-\gamma)$ depends on the funds it can raise F. To organize ideas, we assume that this relation is determined by $1-\gamma = \Psi(F)$, where $\Psi(F)$ is strictly increasing in F. Also here, we keep the modeling very stylized and simply take the funds F as exogenous.[25]

[22] One way to think about this is as follows. Ex-ante the supplier knows that there is some probability κ that it can e.g. bribe government officials to turn a blind eye on toxic waste disposal into a river or on the violation of work safety standards. If this is actually possible in the individual case, only turns out after the match is formed and some investments are made.

[23] Different to e.g. Krautheim and Verdier (2016) or Aldashev and Verdier (2009) we do not intend to contribute to a better understanding of the endogenous emergence of NGOs, interactions with donors, the trade-offs shaping the fundraising process or the optimal allocation of funds across firms or sectors.

[24] We will see below that this is not an assumption but an outcome of the microfoundation.

[25] It would be conceptually straightforward to design a model of fundraising, where an endogenous fundraising-effort of the NGO determines F taking into account different elements of the model that affect e.g. the donors' willingness to donate. As outlined in Footnote 23 this is beyond the scope of this

These are the extensions and refinements we make in order to microfound the occurrence of consumer boycotts. All other events in the different periods are just like in the baseline model. Transfer payment and organizational choice take place in t_0. In $t_1(a)$, the supplier first observes whether it can use the unethical technology and then chooses its preferred one. Both supplier and headquarter then set investments non-cooperatively to maximize their respective profits in $t_1(b)$. In t_2, intermediates are produced and create the hold-up problem. In t_3, nature decides which of the firms that are not openly unethical are undergoing a costly investigation by the NGO. The NGO spends all its resources and monitors a fraction $1-\gamma$ of firms and starts a boycott against all firms it finds to be unethical. Supplier and headquarter renegotiate the distribution of revenue in period t_4 and in t_5, final goods are produced, sold, and the resulting revenue is distributed to both parties according to the rule established in the bargaining at t_4. We will next discuss the informational content of the firms' choices as well as belief formation of the NGO.

I.3.3 Setting a 'Signal' Non-Cooperatively?

There are three variables that are observable to the NGO and that potentially contain information on the type of technology implemented. Investments, the quantity produced, and the prices set. The organization of production (outsourcing vs. integration) is decided upon in period zero, which is before nature decides whether the unethical technology is available to the supplier. We argued in Footnote 17 that the produced quantity and the price directly follow from the investment decisions. This implies that the investment stage is decisive for the signaling considerations.

When the investment and pricing decisions of the firm are interpreted by the NGO as containing information on the implemented technology, there is room for strategic signaling when setting investments and prices. This would place us in the context of a signaling game similar to the one in Krautheim and Verdier (2016). The core idea of the signaling literature in economics (Spence 1973, 1974) is that an agent of a 'high' type may deviate from an otherwise optimal action for the sole purpose to differentiate itself from a 'low' type which would otherwise pool with the 'high' type in terms of observables. This requires that all parties understand that an action is taken on purpose in order to signal one's type.

The obvious difference to our setting is that investments - the decision that contains information about the type of the firm - are set non-cooperatively. So there is not one agent rationally choosing an investment in order to signal its type: headquarter and supplier cannot coordinate to choose the profit maximizing investment, neither can they

paper. Plausible and empirically relevant relations between variables in our model and F are discussed in Subsection I.4.3 in the empirical part of the paper.

coordinate on an investment in order to signal their type. This implies that we are not in the context of a signaling game.

While investments cannot be set in a strategic attempt to signal the type of the firm, they are still interpreted by the NGO as potentially containing information on the firm type. In the case of an unethical firm this means that the 'wrong' investment choices can trigger an investigation by the NGO and lead to a boycott. We will see below that this changes the best response function of headquarter and supplier in the non-cooperative investment game.

I.3.4 NGO Beliefs and Investigations

The only difference between firms in a sector is whether they have the option to implement the unethical technology. The ex-ante probability that a given supplier has this option is given by κ. Here, we are interested in the question what optimal choices of an ethical and unethical firm are conditioning on their type $\theta \in \{e, u\}$. Whether the firms with an option to produce unethically actually decide to do so, is determined at an earlier stage.

When unethical production is profitable in expectation, the NGO knows that a fraction κ of firms are unethical. The non-cooperative investment game results for each firm in an observable investment profile $i(\theta) = \{h(\theta), m(\theta)\}$ with $h(\theta) \geq 0$ and $m(\theta) \geq 0$.[26] In period t_3 the NGO picks an action $s_i \in \{0, 1\}$ which is to initiate an investigation on firms with investment profile i.

The NGO has a belief function $\eta(\theta \mid i)$. Conditional on observing some investment profile i, it assigns a probability of $\eta(\theta \mid i)$ to the firm being of type θ. If $\eta(\theta = u \mid i) = 1$, the NGO immediately starts an investigation.

Proposition I.6 *In the extended model, (i) ethical firms are indifferent to NGO investigations and therefore set their investments independently of NGO beliefs; (ii) unethical firms face an NGO investigation with certainty unless they mimic (i.e., set the same investment as) ethical firms. If unethical firms mimic ethical firms, their probability of being investigated is reduced to* $1 - \gamma < 1$.
Proof: *In the text.*

The expectations of the NGO follow Bayes' Law implying the following belief function

$$\eta(\theta = e \mid i) = \frac{Pr(i \mid \theta = e)\ Pr(\theta = e)}{Pr(i \mid \theta = e)\ Pr(\theta = e) + Pr(i \mid \theta = u)\ Pr(\theta = u)}. \tag{I.22}$$

[26] For ease of exposition we suppress the organizational subscript k and the variety index ω where possible. It is well understood that the strategies are chosen and decision are made conditional on outsourcing or vertical integration chosen by the headquarter at an earlier point in the game.

Note that ethical firms are indifferent to being investigated: they always get full demand in period t_5, as they never face a boycott. Denote by $\tilde{i}$ the investment profile of an ethical firm resulting from the non-cooperative investment game. An ethical firm would never adjust $\tilde{i}$ to accord with an arbitrary belief of the NGO, as this only affects the probability of being investigated, which has no effect on the firm.

We therefore have $Pr(\tilde{i} \mid \theta = e) = 1$ and $Pr(\bar{i} \mid \theta = e) = 0$ for any $\bar{i} \neq \tilde{i}$.[27] Therefore, $\tilde{i}$ is the only investment profile for which the NGO assigns a positive probability to ethical production: $\eta(\theta = e \mid \tilde{i}) > 0$ and $\eta(\theta = e \mid \bar{i}) = 0$ for any $\bar{i} \neq \tilde{i}$. Any other investment profile triggers an immediate investigation by the NGO.

The NGO can compute if in a given sector firms have an incentive to be unethical. When unethical firms in that sector pool with ethical firms by setting $\tilde{i}$, they form a group of *seemingly ethical firms* for which investigation is costly for the NGO. As in this case $\eta(\theta = e \mid \tilde{i}) < 1$, the NGO trivially maximizes its objective of starting a boycott against the largest possible number of unethical firms by spending its whole budget on investigations of firms in the seemingly ethical group (and then start costless boycotts against all identified unethical firms).[28]

I.3.5 Non-Cooperative Investments with Degenerate Demand

We have seen above that unethical firms can only generate positive demand (in expectation) by investing $\tilde{i}$. For this investment the firm faces full demand if it arrives at stage t_5 without a boycott.

[27] In a signaling setup, one would have to further investigate the question if ethical firms would want to deviate from $\tilde{i}$, choosing an investment profile that is unprofitable to mimic for unethical firms. As outlined above, in our model investments are not contractible and are set non-cooperatively. Therefore, investments cannot be used to signal the type of the firm to the NGO.

[28] One may think that the fact that the NGO interprets the investment levels as containing information of the type of the firm can only work in a context of homogeneous firms. And indeed, when firms differ in productivity (and if this productivity is private information to the firm) different investment levels would be in line with ethical production. One could probably construct a complicated argument on how the NGO forms expectations on the probability of unethical production conditional on observing the investment level and accounting for the underlying productivity distribution. The NGO may then assign a higher probability to controlling firms with 'unlikely' investment levels. There is, however, a very simple alternative way to include firm heterogeneity into the model without raising such concerns. Already Melitz (2003) highlights that heterogeneity in technology (differences in productivity) or in preferences (differences in quality) are isomorphic in his model. For the latter case, it is quite obvious that being part of the utility function of the consumer, quality can hardly be private information of the firm. So conditional on the - observable - quality, the ethical investment level can again be computed. Therefore, an extension of the model to a setting with heterogeneous firms would not be inconsistent with our microfoundation. As argued in Footnote 12 in the introduction, we doubt that the additional insights of such an extension would outweigh the likely costs in terms of tractability.

Lemma I.1 *The equilibrium investment profile* $\tilde{i}$ *of an ethical firm is characterized by the same expressions, i.e. equations* (I.9) *and* (I.10)*, as the equilibrium profile* i^* *in the baseline model.*
Proof: *This directly follows from the fact that the optimal choices of the headquarter and the supplier in a match that only has the ethical technology available (or in a sector where all firms endogenously choose ethical production), is unaffected by any element of the microfoundation.*

It remains to be shown that $\tilde{i} = i^*$ is the equilibrium outcome of the non-cooperative investment game also for an unethical firm. Clearly, it is a Nash equilibrium of the investment game if it yields positive profits in expectation, as any deviation from it would lead to zero demand. As in the Antràs (2003) model, zero-zero is a Nash equilibrium that is ruled out by the Pareto dominance assumption.

Consider the case of an unethical firm (i.e. the decision to use the unethical technology has already been taken). The right-hand side graph in Figure I.2 illustrates the best responses of the investment game in this case. The best response to any investment level other than $i_k^* = \{h_k^e, m_k^e\}$, with $k \in \{V, O\}$ is zero for both parties, as any deviation from i_k^* leads to an investigation by the NGO resulting in a boycott with zero demand. No party would ever find it optimal to choose an investment that is not on its best response function, as it would be strictly dominated by playing the best response. We can therefore state the following proposition.

Proposition I.7 *In the extended model, unethical firms mimic ethical firms, i.e. the equilibrium investment profile of an unethical firm is identical to the equilibrium investment profile of an ethical firm.*
Proof: *In the text.*

Using the results of this section, we show in Appendix A.1.7 that the microfounded version of our model produces the same qualitative results as the baseline model. Expressions only differ as they now also contain the fraction $1 - \kappa$ of firms that cannot use the unethical technology, which we introduced for consistency in the microfoundation.

I.4 Implementation of the Empirical Test

The key prediction of our model is the unethical outsourcing incentive. It implies that the possibility of reducing costs by implementing an unethical technology *does* affect the international organization of production. Specifically, we should observe more outsourcing in sectors that are more prone to produce unethically. Unethical production is hard to measure in the data. We therefore use our model to shift the analysis to the level of the *incentive* for unethical production. Equation (I.13) implies that the decision to implement the unethical technology depends on the unethical cost advantage $(1-\mu)$ and the ethical revenue premium which is determined by the mark-up $(1/\alpha)$ and the probability of facing a boycott $(1-\gamma)$. We show in Appendix A.1.6 that $1/\alpha$ and $1-\gamma$ have ambiguous effects on the outsourcing decision in our model. Proposition I.4, however, implies a clear prediction for the effect of $1-\mu$: an increase in the cost advantage of unethical production leads to an increase in $\bar{\beta}$. Our model therefore implies that a strong cost advantage of unethical production in an industry increases the prevalence of international outsourcing relative to vertical integration. We now test this prediction.

I.4.1 Intrafirm Import Share

We follow the established empirical literature and take Nunn and Trefler (2013), Antràs and Chor (2013) and Antràs and Yeaple (2014) as our main references. We use U.S. Census Bureau data on intrafirm trade for the years 2007 to 2014.[29] We employ the standard measure of vertical integration at the industry level: the share of U.S. intrafirm imports in total U.S. imports. Data on intrafirm trade at a detailed country-industry level come from the Related Party Trade Database administered by the U.S. Census Bureau.[30] We use information on U.S. imports in manufacturing from all over the world at the NAICS 6-digit level for the years 2007 to 2014. We convert the data to IO2007 industries from the BEA's input-output tables.

Crucially, the trade flows are distinguished by the relationship between the entities who trade them. A trade flow is marked as taking place between two related parties when the importer holds at least a 6% equity stake in the exporter and as unrelated trade otherwise. We construct our dependent variable, the intrafirm import share, as the value of related party imports over the sum of the value of related and unrelated party imports for each IO2007 industry-country-year.[31] Our regression sample includes 231 manufacturing industries in the least data-demanding specification. In our main specifications, we cover around 215 industries.

[29]One reason for using industry-level data is that the very few firm-level datasets that contain information on organizational decisions are not publicly available. Several authors have used such data, including Tomiura (2007), Corcos, Irac, Mion, and Verdier (2013), Defever and Toubal (2013), Kohler and Smolka (2014) and Alfaro, Conconi, Fadinger, and Newman (2016). Second, we need information on the incentives to produce unethically, which, to our knowledge, are not available in these data.

[30]The data are available online from http://sasweb.ssd.census.gov/relatedparty/.

[31]A third category, unreported trade, captures import flows that are not marked as either type of trade. The share of unreported trade flows in total imports is usually negligible. Antràs and Chor (2013) provide a more detailed discussion of the distribution of unreported trade across industries and source countries.

I.4.2 The Unethical Environmental Cost Advantage

The key parameter in our model is the *unethical cost advantage* $1 - \mu$. μ measures the ratio of unethical to ethical marginal cost of the manufacturing input in the model, and we stress that the input m in the model stands for everything the supplier contributes to the production process. The marginal cost c_m therefore captures not only payments to workers, but also other expenditures by the supplier, such as provisions for workplace safety and the cost of compliance with local environmental regulation. For reasons of data availability, we focus our analysis on the *environmental* incentives of unethical production.

I.4.2.1 The Industry Dimension

An industry producing large volumes of toxic waste as well as carbon dioxide emissions and which is intensive in the use of natural resources arguably benefits more from unethical production. To measure this environmental unethical cost savings *potential* of an industry we draw on data from the Annual Survey of Manufactures (ASM) provided by the U.S. Census Bureau. Starting from 2007, the survey records the industry-level expenditure on water, sewer, and refuse removal, as well as other non-electric utility payments including the cost of hazardous waste removal. We use this expenditure category as a proxy for the money amount an industry would save if production took place in an unregulated environment.

One advantage of this measure is that, according to the survey manual, it excludes payments for machinery, equipment, and electric utility.[32] This makes us confident that we capture only those costs that are directly related to the removal of hazardous materials and other waste and that more capital-intensive industries are not mechanically more intensive in waste removal costs.[33]

We construct our variable of an industry's environmental cost savings potential (ECSP) as the log of an industry's expenditure on waste removal relative to its payroll, total cost, or total sales, respectively. We will explain in Section I.4.4 why the normalization by total costs and total sales are our preferred specifications. We provide the results for normalization with payroll for direct comparison to the literature and show that our results are

[32] The survey manual contains detailed instructions about the forms to be filled out by sampled establishments. The manual for the survey year 2015 is available from https://bhs.econ.census.gov/bhs/cosasm/ASMInstructions.pdf. The instruction pertaining to our variable can be found on p.17 of that manual.

[33] Another advantage is that it appears plausible to consider expenditure on waste removal a lower bound for the unethical environmental cost advantage of an industry for two reasons. First, because our measure excludes salaries of employees whose work includes waste removal or treatment. Second, because we are using data from a technologically advanced country, it is likely that the implemented technology in the US is less environmentally intensive than in most other countries. It is therefore likely that production in many other countries takes place with more environmentally intensive technologies implying that the true potential cost savings are likely to be higher than measured by our variable.

not driven by the change in normalization.

In Figure I.5 we provide evidence of the variation in our proxy in a histogram of the ECSP calculated as spending on waste removal relative to industry payroll (left panel) and a proxy of total cost of the industry (right panel) across industries and years.[34] The distribution is very right-skewed in both cases and in the bulk of industries spending on hazardous waste removal makes up between 0% and 10% of payroll or between 0% and 1% of total cost.[35]

I.4.2.2 The Country Dimension

The extent to which the *potential* cost savings translate into *actual* savings depends crucially on the strictness of regulation in the source country. Only if regulation there is more lenient than in the U.S., can (some of) the potential cost savings be realized.

To measure the country dimension of the unethical environmental cost advantage, we employ the Environmental Policy Stringency Index (EPSI) computed by the OECD for 26 member countries (excluding the U.S.) and the six non-member countries Brazil, China, India, Indonesia, Russia, and South Africa for the years 2007 to 2012. The index combines information on 14 environmental policy instruments that are mainly related to air and climate pollution and is suitable for comparisons across countries. According to the OECD's definition, a policy is more stringent if it puts a higher explicit or implicit price on pollution or environmentally harmful behavior. An index value of 0 is the lowest stringency possible, while an index value of 6 denotes the highest stringency. The maximum value the index attains in our sample is 4.41 for Denmark in 2009. The lowest value is .375 for Brazil in 2011.

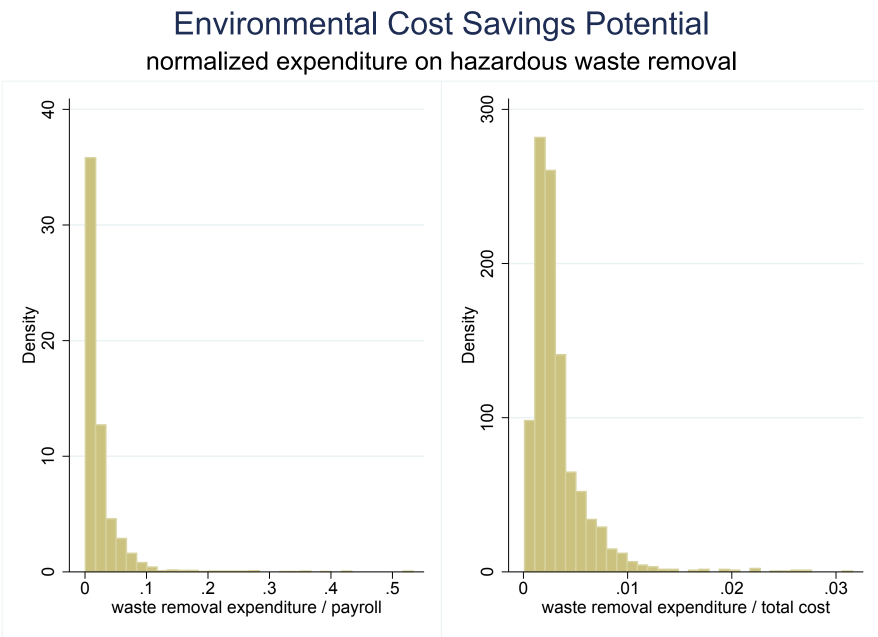
I.4.3 Control Variables

In addition, we use various control variables that have been identified in the literature as determinants of intrafirm trade or have been used for robustness checks therein (see Nunn and Trefler, 2013, Antràs and Chor, 2013 and Antràs and Yeaple, 2014). In particular, we control for the logs of capital intensity, R&D intensity and high-skill intensity. We take the data on physical capital expenditure and the share of non-production worker wages from the ASM. R&D intensity is defined as R&D expenditure relative to sales and is calculated from Compustat data on U.S. firms. In addition, we control for material intensity (normalized expenditure on materials, from ASM). We follow the literature and

[34]The construction of the proxy for total cost is described in Section I.4.6.2.

[35]In Appendix A.2.2 we document that our measures generate rankings of industries that are arguably in line with common preconceptions about environmentally 'dirty' industries.

Figure I.5: Variation in Environmental Cost Savings Potential.



disaggregate capital into its components, which arguably differ in relationship-specificity, to obtain a cleaner proxy for headquarter intensity.

As outlined in the beginning of this section, our model does not provide unambiguous predictions for the probability of facing a boycott $1-\gamma$ and the mark-up $1/\alpha$ in the context of this analysis. We therefore control for the two without interpreting the coefficients.

Concerning $1-\gamma$, we link the probability of facing a boycott to the support the NGO gets from donors in Section I.3.[36] NGOs tend to choose targets that are well-known to consumers/donors. It is plausible and in line with theoretical modelling (e.g. Eesley and Lenox, 2011) as well as empirical evidence (e.g. King, 2008, and Hatte and Koenig, 2018) that NGOs therefore tend to select large firms and those with a high brand valuation. These variables should therefore correlate with the probability of facing a boycott. This leads us to include the within-industry size dispersion measure from Nunn and Trefler (2008) as a proxy for average firm size in a sector. We also include the estimates of the elasticity of substitution from Broda and Weinstein (2006) to control for the feature of brand valuation that it makes varieties less substitutable. Concerning $1/\alpha$, the mark-up is directly linked to the elasticity of substitution, which is given by $1/(1-\alpha)$ in our model. By controlling for the elasticity of substitution, this effect (that also relates to the aspect of brand valuation from above) is also accounted for in the estimates.[37]

[36] In a model focusing on the NGO-firm-donor-consumer interaction, this could also include support from consumers in terms of willingness to boycott or to protest.

[37] Further details on the sources of these variables and their construction are delegated to Appendix A.2.2.

I.4.4 Intensities

We normalize our explanatory variables by industry payroll to make them consistent with the construction of the proxies for headquarter intensity in the literature.[38] Regressions using this definition will provide an easy point of reference to compare our results with those from the preceding literature.

In our preferred specifications, however, we construct all intensities (except for R&D) as the log of the respective expenditure relative to total industry cost. We assess the robustness of our results by normalizing with total sales as well. While total industry sales can be taken directly from the data, we must construct a proxy for total cost, for which we sum payroll, cost of materials, total capital expenditure, total rental payments and an aggregate term for all other expenditures from the ASM. We prefer these definitions because we believe they capture more directly the relative importance of a particular type of cost for the overall production process. As explained in Section I.2.1.2, we interpret the factors of production in the model as aggregate inputs each party brings into the production relationship. Different types of costs play more or less significant roles in these aggregates. For example, firms typically spend on R&D, invest in physical capital and hire labor at the same time. They also incur other types of costs, including expenditure on the removal of (hazardous) waste or investments in workplace safety or costs of acquiring inputs and intermediate products. Some of these costs tend to be incurred by the headquarter, others by a supplier (integrated or independent). In our view, all these different types of costs should be accounted for when factor intensities are computed as the question we seek to address is: Do industries outsource *more* in low regulation countries, when they can potentially save a *larger fraction* of *total cost* by producing unethically?

An additional argument for using broader measures of factor intensities is the fact that the share of capital expenditure in total cost and the share of the wage bill (payroll) in total cost are significantly correlated with a positive coefficient of 0.1345 in our data.[39] This casts some doubt on the consistency of computing capital intensity - the key variable in the existing literature - by normalizing by payroll in our sample.

[38] An exception is R&D intensity, which is normalized by total sales in the literature, which we also follow for comparability.

[39] The correlation coefficient is 0.1687 when using total sales in the denominator. This correlation is puzzling when one has a Cobb-Douglas production function in mind with labor and capital as inputs. In the data, a very large portion of an industry's expenditure is allocated to intermediate inputs. When we correlate the sum of payroll and material input expenditure relative to total cost with the share of capital expenditure in total cost, the correlation coefficient is highly significant at -0.5677.

I.4.5 Empirical Specification

We estimate variants of the following regression equation.

$$intrafirm_{ijt} = \eta_0 + \eta_1\ ECSP_{jt} + \eta_2\,(ECSP_{jt} \times EPSI_{it}) + \rho X_{jt} + \zeta_{it} + \epsilon_{ijt}. \qquad \text{(I.23)}$$

$intrafirm_{ijt}$ is the share of related party imports in total imports by the U.S. from country i in industry j in year t. $ECSP_{jt}$ is our proxy for the part of the *unethical environmental cost advantage* varying across industries j and over time t. $EPSI_{it}$ proxies for the part of the *unethical environmental cost advantage* that varies across source countries i and time t. X_{jt} contains the established determinants of intrafirm trade and the other control variables mentioned above. ζ_{it} is a set of country-year fixed effects to control for everything that is specific to a country in a given year. The fixed effects therefore control for the level effect of the $EPSI_{it}$. They also control for the endogenous choice of a sourcing location to the extent that this is driven by country- or country-year-specific factors, such as geography, corporate tax rates or cultural linkages. We want to take out this variation to be able to make statements about the tendency to outsource production conditional on the chosen source country. In all our regressions, we cluster standard errors at the IO2007-industry level as this is the level of variation of our main explanatory variables and industry characteristics are highly auto-correlated over time.

Our data on intrafirm imports cover 230 countries and territories. But our measure of the level of regulation, EPSI, is limited to 26 OECD countries (excluding the U.S.) plus the six non-member countries listed above. We therefore run the specification in equation (I.23) in two versions.

In the first specification we only include $ECSP_{jt}$ but not the interaction effect. This allows us to make use of the full sample. In this case the prediction of the model holds under the premise that most of the 230 countries and territories have more lenient regulation and enforcement (capacity) than the U.S. Within the set of countries for which EPSI data are available the U.S. takes a middle position. Arguably, many, if not most, of the 198 countries and territories for which EPSI is *not* available (the remaining non-OECD countries plus OECD members Chile, Estonia, Iceland, Israel, Latvia, Luxembourg, Mexico, and New Zealand) should indeed be expected to have more lenient regulation and enforcement (capacity) than the U.S. The presence of some countries with similar or higher levels of regulation should bias the results against our hypothesis, so it is save to keep them in the sample.[40] We therefore expect $\eta_1 < 0$: industries with a higher potential cost advantage should have a lower share of intrafirm trade.

[40] We have experimented with leaving out countries with a stricter EPSI value than the US based on the OECD data. As expected, this changes significance levels and coefficient mildly in favor of our hypothesis.

In the second specification, we add the interaction of the cost savings potential $ECSP_{jt}$ and $EPSI_{it}$, the OECD Environmental Stringency Index. Due to the limited coverage of the $EPSI_{it}$ we have a strongly reduced sample size in this specification. On the other hand, the interaction effect allows for more flexibility to analyze the differential impact a given level of $ECSP_{jt}$ has across varying regulatory environments. The tendency to outsource production in industries with a given $ECSP_{jt}$ should be stronger when the goods are sourced from countries with more lenient environmental policies. In the second specification, we therefore expect $\eta_2 > 0$ and continue to expect $\eta_1 < 0$.

I.4.6 Empirical Results

In this subsection we present our estimation results. In our preferred specification, we normalize the explanatory variable with total cost. We then show that the results we find also hold qualitatively when we normalize with total sales and payroll. First, however, we show that the well-established results in this literature also hold in our data.

I.4.6.1 Previous Literature

Replication of earlier results provides a useful benchmark for our empirical work as we use data from the same sources but for the years 2007 to 2014.[41] Intensities are constructed relative to industry payroll. In the case of R&D intensity, we follow Antràs and Yeaple (2014) and add 0.001 to the ratio of R&D expenditure over sales before taking the natural log in order to avoid throwing away the zeros.[42]

Column 7 of Table I.1 reports results of a regression specification as in the previous literature, including the established decomposition of capital into its components and normalization with payroll. Other machinery is arguably the most relationship-specific of the four capital components and is strongly associated with more intrafirm trade as is R&D intensity. Dispersion is also highly significant and positively associated with intrafirm trade. These results are consistent with prior evidence on the determinants of intrafirm trade. In columns 1 and 4 we rerun the established specification using total cost and total sales, respectively, as normalization variable. The results are quite similar, both quantitatively and qualitatively.

[41] Nunn and Trefler (2013) use data for the year 2005 only, Antràs and Chor (2013) use data from 2000 to 2010. Antràs and Yeaple (2014) use data from 2000 to 2011 from the intrafirm trade data and shorter subsets of this time span for the industry controls.

[42] We recognize that this way of handling zeros is not innocuous but follow the literature to ensure comparability. We have experimented with other values, such as adding 0.00001 as Nunn and Trefler (2013) do, and this does not change our results qualitatively.

I.4.6.2 Core Findings

In column 2 of Table I.1 we add our measure of environmental cost saving potential (ECSP) to our preferred specification with the total cost normalization. We indeed find that a larger ECSP is associated with less intrafirm trade on average and is significant at the 10% level. The other coefficients do not change much compared to column 1 and continue to have the right signs. Industries with a higher ECSP seem to be more likely to outsource production. The number in brackets reports the standardized beta coefficient associated with the respective coefficient. When the log of the ECSP increases by one standard deviation, the intrafirm trade share decreases by 4.5% of a standard deviation on average.

In column 3 we add the interaction term of the ECSP with the index of environmental policy stringency (EPSI). As expected, we find the interaction effect to be positive and significant at the 5%-level. The level effect of the ECSP almost doubles in absolute magnitude and is negative and significant at the 1% level. The interaction effect uncovers a strong cross-country pattern of heterogeneity in the effect of the ECSP. This underscores the empirical importance of both the industry-specific and the country-specific components of the parameter $1 - \mu$.

These results hold when we control for the elasticity of substitution (log sigma) and within-industry size dispersion. The effect of the elasticity of substitution is negative and insignificant throughout, while the effect of dispersion is highly significant and positive in all specifications. This is consistent with findings in the previous literature and with our theory, which predicts an ambiguous effect.

Due to to the limited coverage of the EPSI our sample drops to roughly one fourth of its former size as we have to exclude the many non-OECD countries (except the six emerging economies mentioned above) for which we do not have data. In Appendix A.2.1.2 we provide additional tables which show that the level effect of the ECSP is also negative when we remove the interaction effect and hold the (small) sample size constant. In many cases the level effect is not significant when the sample size is reduced, indicating that it is indeed countries outside the realm of developed OECD countries driving our results.

To analyze the cross-country dimension further, we report marginal effects of the ECSP at various percentiles of the distribution of the EPSI. In Table I.2, columns 2 and 3 show the marginal effect and the corresponding p-value for the total cost specification from Table I.1. There is sizable variation in the marginal effect. The coefficients are significant at the 1% level up to and including the first decile. The four countries in the first decile are Brazil, China, Indonesia, and South Africa. They turn insignificant by conventional levels at the fourth decile. The marginal effect continues to fall until it reaches a value of almost zero at the ninth decile of our sample. Table I.2 clearly shows that the effect of the ECSP

Table I.1: The Effect of Unethical Environmental Cost Advantage on Intrafirm Trade

	Dependent Variable: Intrafirm Import Share								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intensity Definition:	Total Cost	Total Cost	Total Cost	Total Sales	Total Sales	Total Sales	Payroll	Payroll	Payroll
log ECSP		-0.0223*	-0.0401***		-0.0201*	-0.0387***		-0.0237**	-0.0270*
		(0.0123)	(0.0143)		(0.0121)	(0.0143)		(0.0115)	(0.0140)
		[-0.0443]	[-0.0897]		[-0.0390]	[-0.0843]		[-0.0621]	[-0.0784]
log ECSP			0.00892**			0.00917**			0.00174
X EPSI			(0.00429)			(0.00435)			(0.00410)
			[0.176]			[0.187]			[0.0262]
log sigma		-0.00682	-0.00232		-0.00436	-0.000124		-0.00627	-0.00194
		(0.00702)	(0.00889)		(0.00685)	(0.00865)		(0.00703)	(0.00907)
		[-0.0151]	[-0.00599]		[-0.00965]	[-0.000320]		[-0.0139]	[-0.00500]
log other machinery intensity	0.0299***	0.0393***	0.0588***	0.0306***	0.0391***	0.0503***	0.0276***	0.0395***	0.0490***
	(0.0110)	(0.0110)	(0.0140)	(0.00974)	(0.0102)	(0.0144)	(0.00948)	(0.0101)	(0.0138)
	[0.0490]	[0.0643]	[0.103]	[0.0494]	[0.0630]	[0.0909]	[0.0629]	[0.0899]	[0.123]
log skill intensity	0.0402*	0.0369*	0.0578***	0.0350***	0.0336***	0.0375**	0.0497*	0.0507*	0.0490
	(0.0221)	(0.0212)	(0.0210)	(0.0119)	(0.0120)	(0.0152)	(0.0282)	(0.0274)	(0.0373)
	[0.0837]	[0.0767]	[0.131]	[0.0739]	[0.0708]	[0.0862]	[0.0445]	[0.0453]	[0.0487]
log R&D intensity	0.0221***	0.0207***	0.0267***	0.0224***	0.0210***	0.0278***	0.0214***	0.0196***	0.0269***
	(0.00390)	(0.00404)	(0.00483)	(0.00382)	(0.00396)	(0.00496)	(0.00450)	(0.00452)	(0.00544)
	[0.0960]	[0.0898]	[0.130]	[0.0970]	[0.0913]	[0.135]	[0.0928]	[0.0853]	[0.130]
log materials intensity	0.0747	0.0648	0.131**	0.0554**	0.0494**	0.0455	-0.00568	0.00424	-0.00949
	(0.0637)	(0.0628)	(0.0582)	(0.0224)	(0.0244)	(0.0328)	(0.0115)	(0.0119)	(0.0118)
	[0.0405]	[0.0351]	[0.0796]	[0.0391]	[0.0349]	[0.0366]	[-0.0118]	[0.00882]	[-0.0215]
dispersion	0.0840***	0.0779***	0.0858***	0.0836***	0.0785***	0.0871***	0.0821***	0.0757***	0.0846***
	(0.0138)	(0.0134)	(0.0141)	(0.0139)	(0.0135)	(0.0148)	(0.0137)	(0.0132)	(0.0149)
	[0.0966]	[0.0898]	[0.113]	[0.0962]	[0.0905]	[0.115]	[0.0944]	[0.0872]	[0.112]
log building intensity	-0.0108*	-0.00822	-0.0114	-0.00844	-0.00690	-0.0103	-0.0138**	-0.0107*	-0.0146*
	(0.00643)	(0.00639)	(0.00776)	(0.00638)	(0.00632)	(0.00746)	(0.00608)	(0.00621)	(0.00780)
	[-0.0227]	[-0.0174]	[-0.0275]	[-0.0174]	[-0.0142]	[-0.0241]	[-0.0347]	[-0.0270]	[-0.0407]
log auto intensity	-0.0116**	-0.0118***	-0.0181***	-0.0133***	-0.0132***	-0.0211***	-0.0106**	-0.0107**	-0.0181***
	(0.00457)	(0.00435)	(0.00594)	(0.00459)	(0.00442)	(0.00614)	(0.00470)	(0.00442)	(0.00626)
	[-0.0351]	[-0.0355]	[-0.0569]	[-0.0410]	[-0.0405]	[-0.0677]	[-0.0304]	[-0.0304]	[-0.0537]
log computer intensity	-0.00912	-0.0119	0.000841	-0.00693	-0.00998	0.00338	-0.0117	-0.0146*	-0.00229
	(0.00765)	(0.00784)	(0.0106)	(0.00711)	(0.00754)	(0.0108)	(0.00769)	(0.00768)	(0.0109)
	[-0.0222]	[-0.0289]	[0.00216]	[-0.0167]	[-0.0241]	[0.00860]	[-0.0224]	[-0.0280]	[-0.00459]
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IO2007 industry clusters	212	212	212	212	212	212	212	212	212
Observations	130,985	130,364	35,434	130,985	130,364	35,434	130,985	130,364	35,434
R-squared	0.179	0.181	0.169	0.181	0.182	0.169	0.179	0.181	0.167

Note: Estimation by OLS with standard errors clustered at the industry level reported in parentheses. Standardized beta coefficients reported in brackets. ***, **, and * denote significance the 1%, 5%, and 10% level, respectively. log ECSP is the log of expenditure on waste and hazardous materials removal over payroll, total cost or total sales. sigma is the estimate of the import demand elasticity from Broda and Weinstein (2006).

on intrafirm trade is driven by the countries with the lowest environmental regulation. This supports our theoretical setting in which the possibility of environmentally unethical production arises due to differences in regulation across countries.

Dividing our explanatory variables by total sales in columns 4 to 6 of Table I.1, it becomes clear that our result is not driven by the normalization variable we use. The coefficient of the ECSP is weakly significant and negative in column 5, and becomes larger in absolute terms and highly significant when we add the interaction term, which is positive and significant at the 5%-level here as well. Turning to the marginal effects in columns 4 and 5 of Table I.2, it is evident that the pattern is qualitatively and quantitatively almost identical to the one from the total cost specification.

Table I.2: Marginal Effects of the ECSP

Intensity Definition	Total Cost		Total Sales		Payroll	
EPSI percentile	Marginal Effect	p-value	Marginal Effect	p-value	Marginal Effect	p-value
5	-0.036	0.007	-0.034	0.009	-0.026	0.043
10	-0.035	0.008	-0.033	0.010	-0.026	0.041
20	-0.027	0.024	-0.025	0.032	-0.024	0.035
30	-0.022	0.060	-0.020	0.080	-0.024	0.039
40	-0.020	0.102	-0.018	0.135	-0.023	0.045
50	-0.017	0.153	-0.015	0.198	-0.023	0.053
60	-0.016	0.204	-0.014	0.262	-0.022	0.060
70	-0.014	0.275	-0.012	0.348	-0.022	0.071
80	-0.012	0.374	-0.009	0.463	-0.021	0.085
90	-0.010	0.447	-0.008	0.546	-0.021	0.097

Note: Marginal effects of log ECSP at deciles of the EPSI are calculated from the regressions in Table I.1, columns 3, 6, and 9, respectively.

In Columns 7 to 9 of Table I.1, we test our prediction using the established payroll definition of intensities. When included by itself in column 8, the effect of the ECSP is negative with roughly the same magnitude as the coefficients from columns 2 and 5. It is even significant at the 5%-level. When we add the interaction effect in column 9, the pattern holds qualitatively, with a negative level effect and a positive interaction term. However, significance levels are lower than in the other specifications. This result is mirrored in columns 6 and 7 of Table I.2. The magnitude of the marginal effect changes only very little over the distribution of the EPSI while significance levels range from 5% below the median and a 10%-level of significance up to the ninth decile.

We conduct various checks to assess the robustness of the effect we find. In particular, we add a measure of downstreamness and its interaction with the elasticity of substitution as in Antràs and Chor (2013) and include further controls used in that paper as robustness checks. We report the results in the Appendix A.2.1.

I.5 Conclusion

In this paper we developed a model of the international organization of production with international regulatory differences, unethical cost savings and consumer boycotts. We have shown that a high supplier intensity of the production process favors the implementation of the unethical technology as well as international outsourcing, while headquarter-intensive sectors tend to choose integration and ethical production. The headquarter has no instrument to affect the supplier's technology choice. The implementation of the unethical technology by the supplier, however, feeds back on the headquarter's choice of the boundaries of the firm. When the headquarter anticipates unethical production by the supplier, it is more inclined to keep the supplier at arm's length. This new *unethical outsourcing incentive* therefore creates a link between unethical production and outsourcing from within the logic of the property rights theory of the firm: outsourcing increases the optimal investment of the supplier and thereby increases the cost savings of unethical production. We also show that it is possible that the headquarter would prefer ethical production (if technology was contractible) but incentivizes an expansion of unethical production as an optimal response to contract incompleteness. To focus on the implications of unethical production for the international organization of production, in the baseline model, we imposed that any deviation from investments, quantities or prices of an ethical firm immediately triggers a consumer boycott (mimicking). We also analyzed a fully microfounded version of the model where the link between a deviation from the ethical observables and a boycott emerges from asymmetric information, credence goods and an NGO monitoring suppliers and potentially starting boycotts. We found that all results from the baseline model hold qualitatively. Using U.S. Census Bureau data, we have provided evidence that, as predicted by the model, the share of U.S. intrafirm imports is higher in sectors with a strong unethical cost advantage. Also in line with the theory, this effect is strongest in countries with a low level of regulatory stringency.

Chapter II

Trade, Migration and Economic Disintegration

II.1 Introduction

North America and Europe are currently experiencing a globalization backlash. In recent years, parties and politicians have been elected to parliaments and offices who blame globalization in its two dimensions of international trade and international migration for a wide range of social and economic problems. In 2016, Britons voted to leave the EU to "take back control" over migration, and Donald Trump won the U.S. presidential election on a protectionist anti-immigration platform. In continental Europe, several right-wing populist parties and candidates have scored successes in recent elections, many of them with anti-EU or anti-immigration agendas.[1] As a consequence, the European integration framework is under severe strain. While negotiations over Brexit are already underway, political tensions within the EU over immigration concern refugee reallocation in Eastern Europe as well as pressures from economic migrants from North and Sub-Sahara Africa in Italy and Spain. The danger of a break-up of the European Union is a common theme in the public debate.

[1]Marine Le Pen made it to the runoff of the 2017 French presidential election with a promise to leave the EU once elected to office. The parties forming the new governing coalition in Austria won the 2017 election with a promise of a tougher position on immigration. In the German general election, the new right-wing AfD party won 13% of Bundestag seats with a strong anti-immigration stance in the campaign. Italy is currently governed by a populist alliance combining EU and Euro-criticism with tough anti-immigration rhetoric.

In the academic debate about the causes of anti-immigration and anti-EU sentiment within the European Union, Rodrik (2018) argues that immigration is simply a politically salient topic that provides right-wing populist movements with a narrative to mobilize voters, while the roots of the grievances are not cultural but in fact economic in nature. Consistent with this view, a number of recent papers highlight the relationship between "disintegrative" voting behavior (i.e. pro-Brexit or pro right-wing populists) on the one hand and import competition (Dippel, Gold, and Heblich, 2015, as well as Colantone and Stanig, 2018a, 2018b), inequality (Pastor and Veronesi, 2018), low incomes, high unemployment and past dependence on manufacturing (Becker, Fetzer, and Novy, 2017) on the other.

The perhaps more controversial side of the argument points to *direct* adverse economic effects of immigration as a possible explanation for the success of disintegrative forces. Barone, d'Ignazio, de Blasio, and Naticchioni (2016) identify labor market competition as one channel through which immigration has raised vote shares for parties with tougher positions on immigration in Italian municipalities. Becker and Fetzer (2018) find for the U.K. that immigration from Eastern Europe following the 2004 Eastern Enlargement is linked to negative effects on wages at the lower end of the wage distribution as well as increased pressure on the welfare state and a reduction in home-ownership rates among U.K.-born citizens.[2]

In this paper, I put the direct adverse economic effects of immigration to a more comprehensive test in a quantitative general equilibrium model of trade and migration, addressing the following question: Considering welfare-maximizing decisions of governments, is international labor market integration able to cause a country's endogenous exit from the EU? More generally, how resilient are deep regional integration projects like the EU in the face of migration shocks?

To answer these questions I build a quantitative multi-country model of trade and labor migration that features rich interactions between these two dimensions of globalization. I simulate the model to analyze the conditions under which a fall in migration costs can lead to welfare losses for some countries in a world with costly trade. Such welfare losses present the affected countries with the *disintegration trade-off*: Because of the indivisibility of the free movement of labor and goods inside the EU Single Market, unilateral migration policies designed to restrict immigration are only possible outside of it. Exit, however, entails a rise in mutual tariff levels between the exiting country and the remaining EU countries, hindering trade.

To study the quantitative importance of the *disintegration trade-off* I confront the

[2]For the U.S., Mayda, Peri, and Steingress (2018) find evidence on voting behavior in response to immigration that is also consistent with competition on the labor market and for public resources.

model with changes in migration and trade policy during the first phase of the EU Eastern Enlargement between 2004 and 2007 and evaluate the welfare consequences. Based on the findings, I use counterfactual exercises to study the trade-off. I consider an exit scenario involving tariff increases and a reset of migration policies to pre-Enlargement levels and assess welfare effects for the exiting country as well as remaining members of the EU Single Market.

The model features workers of different nationalities with heterogeneous preferences over their desired place to live and work as in Redding (2016). Workers consume goods and rent residential land. To the setup in Redding (2016) I add bilateral utility costs of migration and keep track of the nationality of the workers.[3] They maximize their utility by choosing the location that offers them the highest real income, taking into account migration frictions and worker-specific preference draws over locations. The use of idiosyncratic preference draws allows the model to generate a stable spatial equilibrium featuring two-way migration flows and analytical expressions for migration shares that can easily be matched to the data.

The production side of the economy consists of a single industry with perfect competition, productivity draws and a fixed set of differentiated varieties as in Eaton and Kortum (2002). Trade is based on comparative advantage due to technological differences and labor is the only factor of production. Trade between countries is costly and subject to iceberg trade costs as well as ad valorem tariffs that are redistributed to the residents of the collecting country as in Caliendo and Parro (2015).

Trade and migration interact in a natural way in this model. A change in trade policy directly changes the terms of trade of the affected countries. This does not only influence trade patterns but also migration decisions through changes in relative real incomes across countries. Conversely, changes in migration costs directly affect the distribution of workers across locations, which in turn influences trade patterns through the effects of migration on labor markets, changing the nominal wage and thereby the terms of trade.

In addition, the model features two externalities of migration and economic outcomes described by Peri (2016). First, there is a productivity spillover from migration. An increase in the number of workers in a country raises the overall technology level as in Eaton and Kortum (2001) and Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016). Empirical studies show that immigration and denser interactions among economic agents can be associated with higher rates of innovation and productivity (Kerr and

[3] In the context of the Eastern Enlargement both modeling additions are important. Bilateral migration costs are needed to be able to construct the necessary policy changes during the labor market integration. Nationalities are needed because the enlargement affected migration costs differentially across country *pairs*. It lowered the cost of migrating to the U.K. for Polish workers, but not for German citizens, for example.

Lincoln, 2010, and Hunt and Gauthier-Loiselle, 2010). Second, residential land is a fixed factor owned by immobile landlords. Growth of a country's workforce creates congestion effects through increasing land prices as in Redding (2016) or Monte, Redding, and Rossi-Hansberg (2018), lowering real income. Saiz (2007) provides empirical evidence of the relevance of this channel.

In the simulation exercise, I let 100 countries with randomly drawn economic fundamentals conduct costly trade with one another and then lift a prohibitive migration barrier separating the labor markets of an "eastern" and a "western" section of the country grid. If the two integrating regions are similar, lifting the barrier generally increases average utility of each country's citizens. Lower migration costs decrease the utility costs of living in a foreign country and bring the world economy closer to its frictionless equilibrium.

If the two regions are sufficiently dissimilar, however, for example in their levels of technology, lifting the migration barrier causes migration flows to be skewed towards the high technology countries. Large migration inflows into these countries then exert downward pressure on the nominal wage and worsen the terms of trade in the receiving countries so that the real wage there may fall. This effect can be so large that it dominates the gains in utility that arise from lower costs of migration. Average utility of a country's workers may then also fall, generating the *disintegration trade-off*: unilaterally reversing the adverse effects of immigration through higher migration costs requires an exit from the Single Market leading to higher tariffs.

While utility of the world economy as a whole increases as it moves towards the frictionless equilibrium, the welfare loss in a receiving country is just one side of a redistribution of the gains from trade towards the workers of net sending countries: those leaving enjoy higher real wages in their high technology destinations while those who stay at home get access to goods produced with the foreign, more efficient technology at lower cost. When the integrating regions are dissimilar enough in economic fundamentals, this redistributive effect is large enough to dominate the first-order decrease in utility costs of migration.

To assess the quantitative importance of the disintegration trade-off, I match the model to data on trade and migration from before the EU Eastern Enlargement and feed into it actual changes in tariffs and estimates of migration cost reductions for the first episode of the Enlargement between 2004 and 2007 from Caliendo, Opromolla, Parro, and Sforza (2017), who also study the welfare effects of the Eastern Enlargement.

I find that this episode of trade and labor market integration raised aggregate EU utility by 0.47%. However, there is substantial heterogeneity across countries.[4] Using

[4]This is in line the results from Caliendo, Opromolla, Parro, and Sforza (2017), who find that aggregate EU welfare rose by 0.62%. They also find that in the aggregate, the EU15 countries would have experienced welfare losses in the absence of trade liberalization.

average utility of the citizens of a country as a welfare measure, U.K. and Greek citizens lose the most with a loss of 0.41% and 0.50% in their utility, respectively, while the citizens of Slovakia (+10.61%), Lithuania (+5.16%) and the Czech Republic (+2.55%) gain the most. Looking at changes in real incomes across countries, the magnitude of the effects is smaller, but the ranking of winners and losers is roughly the same.

I then use these findings to study political economy considerations of optimizing governments facing the impact of the Eastern Enlargement. From the perspective of a government involved in the negotiations, the Eastern Enlargement can hardly be considered an exogenous shock. In light of the heterogeneous welfare effects, I rationalize the joint agreement to the enlargement decision by all involved governments by considering an objective function that attaches some weight to aggregate European welfare in addition to welfare of the government's own citizens. I calculate how large these pro-European weights would have to be to make a government at least indifferent between agreeing to and rejecting the enlargement decision. Not surprisingly, the governments of the U.K. and Greece have the largest implied pro-European weights with 46.61% and 51.17%, respectively. For other Western European governments, single-digit or low double-digit weights are sufficient to explain agreement to the Eastern Enlargement based on the model's assessment.

In the final part of the paper, I consider a "Brexit" scenario based on the welfare assessment of a "populist" government that maximizes the welfare of the median British citizen and ignores aggregate EU welfare. This scenario entails mutual tariff increases between the U.K. and the remaining EU countries as well as a reset of the costs of migrating to the U.K. to pre-Enlargement levels for Eastern European citizens. I find that "Brexit" can improve U.K. citizens' welfare relative to the enlargement scenario with continued U.K. membership. However, even with "Brexit", British citizens are slightly worse off than before the Enlargement.

This paper builds on recent developments in the use of quantitative models in economic geography and international trade. Redding (2016) uses idiosyncratic preference draws to study the welfare effects of a reduction in transport costs in the presence of goods trade and labor mobility. Monte, Redding, and Rossi-Hansberg (2018) use this approach to study commuting in local U.S. labor markets.[5] In contrast, I use this modeling to study the welfare consequences of the interaction of trade and migration when migration barriers fall.

In a two-country Ricardian model based on Dornbusch, Fischer, and Samuelson (1977), Davis and Weinstein (2002) show that labor mobility makes the net receiving country worse off when it is technologically superior. I show that this result also holds in a

[5]See for example Allen and Arkolakis (2014), Caliendo, Parro, Rossi-Hansberg, and Sarte (2017) for further quantitative work involving the allocation of labor across space. Redding and Rossi-Hansberg (2017) provide an overview.

multi-country setting when the integrating economic regions are sufficiently dissimilar.

To focus on the terms of trade effect as clearly as possible, I stick to a simple Ricardian setup with only one factor of production and one sector. In doing so, I neglect possible complementarity effects of immigration that arise in models with multiple factors of production as highlighted by Borjas (1995, 1999) and studied jointly with the Davis and Weinstein (2002) effect by Felbermayr and Kohler (2007).[6]

In assessing the welfare consequences of the EU Eastern Enlargement this paper is also related to Caliendo, Opromolla, Parro, and Sforza (2017), who do so in a discrete-time dynamic setting exploiting the differences in timing of the labor market liberalization across EU15 countries. Similar to my results, they find an increase in aggregate EU welfare, while EU15 countries lose from the enlargement. My study differs in two respects. First, for the purpose of my question it is not necessary to incorporate the dynamic structure. Instead, I conduct a comparative statics analysis of the part of the Eastern Enlargement that began in 2004 and ended in 2007. Second, I take the model one step further and consider the political economy behind the agreement of the EU governments to the enlargement as well as the decision to leave the EU in response to a migration shock. This connects this paper to Galiani and Torrens (2018), who study the political economy of migration in Ricardian trade models. Contrary to their stylized setup with corner solutions, this model can easily be matched to data and allows for the assessment of continuous policy changes.

More generally, this paper relates to literature studying the interaction of trade and migration in various settings, such as welfare effects of remittances in di Giovanni, Levchenko, and Ortega (2015) or labor market adjustment in tradeable and non-tradeable sectors as in Burstein, Hanson, Tian, and Vogel (2017). A further connection exists to literature that quantitatively analyzes changes in trade policy, such as Costinot and Rodríguez-Clare (2014), Ossa (2014), and Caliendo and Parro (2015). These papers abstract from labor mobility, however, and do not feature labor mobility frictions as a policy variable.

This paper also connects with studies on the welfare implications of economic integration using the EU Enlargement as a policy example, e.g. Dustmann and Frattini (2013) and Kennan (2017), and older studies by Baldwin (1995) and Baldwin, Francois, and Portes (1997), as well as literature analyzing the causes of Brexit (e.g. Becker, Fetzer, and Novy, 2017 and Becker and Fetzer, 2018), its consequences (e.g. Dhingra, Huang, Ottaviano, Pessoa, Sampson, and Van Reenen, 2017), as well as literature measuring the economic costs of further EU integration reversal as in Felbermayr, Gröschl, and Heiland (2018) and Mayer, Vicard, and Zignago (2018).

[6]These effects are relevant for a more comprehensive quantitative assessment of the Eastern Enlargement. The model can easily be extended to a setting with multiple factors of production and sectors with differing factor intensities to incorporate Borjas-type effects.

The remainder of this paper is organized as follows. Section II.2 outlines the model and discusses the theoretical findings, Section II.3 presents the simulation results, Section II.4 assesses the EU Eastern Enlargement and Section II.5 discusses the political economy considerations. Section II.6 concludes.

II.2 A Quantitative Model of Migration and Trade

The world consists of I countries indexed by i (or n) $= 1, \ldots, I$ and each country i is home to N_i workers, who are also citizens of that country.[7] Workers are indexed by ω. Each country is endowed with H_i units of residential land owned by immobile landlords. Workers are mobile across countries and while they retain their citizenship throughout the model, they may migrate to live and work in another country as a consequence of utility maximization.

II.2.1 Demand and Indirect Utility

Utility of a worker ω, citizen of i, living and working in n is given by

$$U_{ni\omega} = \frac{b_{ni\omega}}{\kappa_{ni}} \left(\frac{Q_{n\omega}}{\alpha}\right)^{\alpha} \left(\frac{H_{n\omega}}{1-\alpha}\right)^{1-\alpha}. \tag{II.1}$$

Each worker derives utility from the consumption of a Cobb-Douglas bundle of goods $Q_{n\omega}$ and residential housing $H_{n\omega}$ with goods consumption weight $\alpha \in (0,1)$. While labor is mobile across countries, the supply of housing is exogenously fixed at H_n and introduces congestion effects from migration. These congestion effects are empirically relevant as argued by Peri (2016) and Saiz (2007). Empirical support for the constant expenditure share implied by the Cobb-Douglas form can be found in Davis and Ortalo-Magné (2011). A worker incurs migration costs $\kappa_{ni} \geq 1$ as reduction in utility.[8] Utility is also determined by an idiosyncratic and country-pair-specific utility draw $b_{ni\omega}$. The composite consumption good $Q_{n\omega}$ is given by the CES aggregate

$$Q_{n\omega} = \left[\int_0^1 q_{n\omega}(j)^{\frac{\sigma-1}{\sigma}} dj\right]^{\frac{\sigma}{\sigma-1}},$$

where $\sigma > 0$ is the elasticity of substitution between varieties j.

[7] I use the terms worker and citizen interchangeably.

[8] An alternative approach would be to model migration costs as a reduction in the quantity of labor a worker can offer. This would not change a lot in the model. However, wages would have to be computed differently.

A worker earns the wage rate w_n in her location of residence and receives a lump-sum redistribution of tariff income t_n from the government of the country of her *place of residence.* The budget constraint is then given by

$$P_n Q_{n\omega} + R_n H_{n\omega} = w_n + t_n = \nu_n,$$

where P_n is the ideal price index of consumption varieties dual to the consumption index $Q_{n\omega}$ and R_n is the rental rate for residential housing $H_{n\omega}$ prevailing in n. With the Cobb-Douglas formulation of utility, two-stage budgeting can be applied and expenditures on consumption and housing are given by

$$\begin{aligned} P_n Q_{n\omega} &= \alpha \nu_n \\ R_n H_{n\omega} &= (1-\alpha)\,\nu_n. \end{aligned}$$

A worker's demand for variety j is then given by

$$q_{n\omega}(j) = \frac{p_n(j)^{-\sigma}}{P_n^{1-\sigma}} \alpha \nu_n,$$

where $P_n = \left[\int_0^1 p_n(j)^{1-\sigma} dj\right]^{\frac{1}{1-\sigma}}$. Using the above equations in (II.1), indirect utility of worker ω then becomes

$$U_{ni\omega} = \frac{b_{ni\omega}}{\kappa_{ni}} \frac{\nu_n}{P_n^{\alpha} R_n^{1-\alpha}}. \tag{II.2}$$

II.2.2 Mean Utility and Migration Shares

In modeling migration I follow Caliendo, Opromolla, Parro, and Sforza (2017) and Redding (2016) in assuming that the idiosyncratic preference draws $b_{ni\omega}$ are distributed according to an extreme value distribution. I choose the Fréchet distribution because it delivers compact closed-form expressions for migration shares and average utility of workers from a particular country as will be shown below.[9] Specifically, preference draws in country n are distributed according to the CDF

$$\bar{G}_n(b) = \exp\left\{-B_n b^{-\epsilon}\right\}, \tag{II.3}$$

where B_n governs the (country-specific) location of the distribution and ϵ is the shape parameter. In the model, I assume that amenities - or average attractiveness - B_n may

[9] Other extreme value distributions can also be used to get tractable expressions for migration shares. For example, Caliendo, Opromolla, Parro, and Sforza (2017) use a Type I extreme value distribution in their dynamic framework.

differ across countries, while the shape parameter ϵ is constant across countries.[10] Solving indirect utility for b and inserting this into the distribution gives the distribution of utility for workers of nationality i living and working in n as

$$G_{ni}(U) = \exp\left\{-\Psi_{ni}U^{-\epsilon}\right\},$$

with $\Psi_{ni} = B_n \kappa_{ni}^{-\epsilon}\left(\frac{\nu_n}{P_n^{\alpha}R_n^{1-\alpha}}\right)^{\epsilon}$, where $\frac{\nu_n}{P_n^{\alpha}R_n^{1-\alpha}}$ is real income of a worker living and working in country n. Accordingly, $G_{ni}(U)$ is also the probability that utility of a worker from i who chooses to live and work in n is lower than U.

Workers choose the country that offers them the highest indirect utility. Assuming that the idiosyncratic preference draws are independent across workers and locations, the probability that a worker from i attains utility larger than U is then given by the complement of the probability that she attains utility smaller than U in all countries, hence

$$Pr\left[U_i > U\right] = 1 - \prod_n G_{ni}(U) = 1 - G_i(U)$$

with $G_i(U) = \exp\left\{-\Psi_i U^{-\epsilon}\right\}$ and $\Psi_i = \sum_n \Psi_{ni}$. Because agents maximize their utility, the distribution of maximum utility $G_i(U)$ is of particular interest.

The mean of this distribution gives the mean utility of workers from i after they have optimally chosen their place of residence taking real wages, migration costs and their idiosyncratic preferences into account. As I show in Appendix B.1.1,

$$\bar{U}_i = \int_0^{\infty} U dG_i(U) = \delta\left[\sum_n B_n \kappa_{ni}^{-\epsilon}\left(\frac{\nu_n}{P_n^{\alpha}R_n^{1-\alpha}}\right)^{\epsilon}\right]^{\frac{1}{\epsilon}}, \tag{II.4}$$

where $\delta = \Gamma\left(\frac{\epsilon-1}{\epsilon}\right)$, $\Gamma(\cdot)$ is the Gamma function and I assume $\epsilon > 1$. Equation (II.4) shows how mean utility of workers from country i is shaped by the migration options around them. Naturally, the higher amenities and real incomes are in the surrounding countries, the higher is mean utility. Migration frictions κ_{ni} are key because they are the only diadic part of the expression. Workers who face low migration costs have easier access to the real incomes foreign countries offer. Migration costs might be low because a country is in close geographical proximity to many other countries. They might also be low because of similarities in culture and language and, importantly, also for political reasons.

The distributions from above can also be used to determine the fraction of each country's citizens living in a particular country. These migration shares are computed by

[10]The assumption that B_n is country-specific is not necessary for the workings of the model. In particular, the results of the quantitative exercise do not depend on it. B_n is a constant and cancels out when the model is expressed in changes. All quantitative results obtained in Sections II.4 and II.5 remain the same if I assume $B_n = B = 1\ \forall n$.

calculating the probability that some country n is the one that offers the highest utility to a worker from i, or equivalently, the fraction of workers from i who choose to migrate to n. In particular,

$$\lambda_{ni} = Pr\left[U_{ni} \geq \max\left\{U_{ki}\right\} \ \forall \ k\right]$$

is the probability that country n offers higher utility to a worker from country i than all other possible migration destinations. As I show in Appendix B.1.2, evaluation of this probability using the Fréchet distribution gives migration shares as

$$\lambda_{ni} = \frac{\Psi_{ni}}{\Psi_i} = \frac{B_n \kappa_{ni}^{-\epsilon} \left(\frac{\nu_n}{P_n^{\alpha} R_n^{1-\alpha}}\right)^{\epsilon}}{\sum_k B_k \kappa_{ki}^{-\epsilon} \left(\frac{\nu_k}{P_k^{\alpha} R_k^{1-\alpha}}\right)^{\epsilon}}. \tag{II.5}$$

The share of workers from i migrating to n is increasing in amenities and real income in n and decreasing in the migration costs κ_{ni} *relative* to the attractiveness of all other countries as migration destinations.

II.2.3 Production and Goods Trade

Production and goods trade follow the well-known structure of Eaton and Kortum (2002). To keep the setup as simple as possible, labor is the only factor of production.[11] Goods can be traded subject to spatial frictions $\phi_{ni} = (1 + \tau_{ni})\, d_{ni}$, where d_{ni} is an iceberg-type trade costs and τ_{ni} is an ad-valorem tariff. Total factor productivity in a country is given by $\mu_i L_i^{\beta}$, where μ_i is an exogenous country-specific shifter and L_i is the size of the labor force in country i as in Eaton and Kortum (2001), Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016) and Caliendo, Opromolla, Parro, and Sforza (2017). This introduces a positive spillover from migration on productivity regulated by the parameter $\beta \geq 0$. Empirical studies show that immigration and denser interactions among economic agents can be associated with higher rates of innovation and productivity, see e.g. Kerr and Lincoln (2010) and Hunt and Gauthier-Loiselle (2010).

Using the properties of the Fréchet distribution following Eaton and Kortum (2002),

[11] This assumption is made to illustrate the mechanism in the simplest way possible. Relaxing it is easy and would make migrants of different skill levels complements or substitutes in production to the native population depending on the initial endowments. As this distinction is an important effect of immigration on native welfare, I will include in continuing work.

bilateral expenditure shares π_{ni} and price indeces P_n are then given by

$$\pi_{ni} = \frac{\mu_i L_i^{\beta} \left(\phi_{ni} w_i\right)^{-\theta}}{\sum_k \mu_k L_k^{\beta} \left(\phi_{nk} w_k\right)^{-\theta}} \tag{II.6}$$

$$P_n = \gamma \left(\sum_k \mu_k L_k^{\beta} \left(\phi_{nk} w_k\right)^{-\theta} \right)^{-\frac{1}{\theta}}, \tag{II.7}$$

where $\gamma = \Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)^{\frac{1}{1-\sigma}}$ and $\Gamma(\cdot)$ is the Gamma function. I assume $\theta > \sigma - 1$ to obtain a finite price index.

II.2.4 Closing the Model

With N_i workers from each country and migration shares λ_{ni}, labor supply in country n is the sum of migrants from all countries including n itself,

$$L_n = \sum_i \lambda_{ni} N_i, \tag{II.8}$$

where λ_{ni} is defined in equation (II.5). With labor as the sole factor of production and perfect competition, labor income in country n equals worldwide sales net of tariffs,

$$w_n L_n = \sum_i \frac{\pi_{in}}{1+\tau_{in}} X_i, \tag{II.9}$$

where π_{in} is defined in equation (II.6). Workers spend a fraction α of their income on goods and the remaining fraction $1-\alpha$ on housing so that the rental rate of housing is given by

$$R_n = (1-\alpha) \frac{\nu_n L_n}{H_n}. \tag{II.10}$$

Following Monte, Redding, and Rossi-Hansberg (2018) I assume that landlords are immobile and spend all their income $R_n H_n$ on consumption goods. The advantage of this assumption is that it precludes mechanical externalities from landlords' consumption on workers' migration choices.[12] Tariff revenues T_n are redistributed to the residents of a country as a pure income transfer. Aggregate spending on goods X_n in n is then equal to

$$X_n = \alpha \nu_n L_n + R_n H_n = \alpha \nu_n L_n + (1-\alpha) \nu_n L_n = w_n L_n + t_n L_n = w_n L_n + T_n, \tag{II.11}$$

[12]If also landlords spent a part of their income on housing, an increase in the rental rate that results from an inflow of workers would drive up house prices even further because also landlords would then spend more on housing. An alternative modeling approach is taken by Caliendo, Opromolla, Parro, and Sforza (2017), who let worldwide land rents be redistributed through a global portfolio. This allows them to generate endogenous trade imbalances.

where $T_n = \sum_i \tau_{ni} \frac{\pi_{ni}}{1+\tau_{ni}} X_n$. Workers spend a fraction α, landlords all of their income on goods. Because landlords' income is just the fraction $1-\alpha$ of worker income, total spending on goods is equal to total worker income. This can be divided into income from labor $w_n L_n$ and total tariff redistribution $T_n = t_n L_n$.

II.2.5 Equilibrium in Levels

The model can be simplified so that the equilibrium is expressed in terms of four endogenous variables: wages w_n, labor supplies L_n, migration shares λ_{ni} as well as expenditure shares π_{ni}.

Inserting (II.11) into the definition of tariff revenues T_n, solving for T_n and plugging this back into (II.11) gives that

$$X_n = \frac{w_n L_n}{\sum_i \frac{\pi_{ni}}{1+\tau_{ni}}}. \tag{II.12}$$

Using this on the right-hand side of equation (II.9) yields a balanced trade condition expressed in terms of wages and labor supply as

$$w_n L_n = \sum_i \frac{\pi_{in}}{1+\tau_{in}} \frac{w_i L_i}{\sum_k \frac{\pi_{ik}}{1+\tau_{ik}}}.^{13} \tag{II.13}$$

In Appendix B.1.3 I show how, using the conditions for housing market clearing (II.10) and (II.11) as well as expenditure shares (II.6), migration shares (II.5) can be written as

$$\lambda_{ni} = \frac{B_n \kappa_{ni}^{-\epsilon} \left(\frac{\mu_n L_n^{\beta}}{\pi_{nn}}\right)^{\frac{\alpha\epsilon}{\theta}} \left(\frac{H_n}{L_n}\right)^{(1-\alpha)\epsilon} \left(\sum_k \frac{\pi_{nk}}{1+\tau_{nk}}\right)^{-\alpha\epsilon}}{\sum_l B_l \kappa_{li}^{-\epsilon} \left(\frac{\mu_l L_l^{\beta}}{\pi_{ll}}\right)^{\frac{\alpha\epsilon}{\theta}} \left(\frac{H_l}{L_l}\right)^{(1-\alpha)\epsilon} \left(\sum_m \frac{\pi_{lm}}{1+\tau_{lm}}\right)^{-\alpha\epsilon}}. \tag{II.14}$$

The three parentheses divide real income in the destination country n into three components. Goods consumption and trade contribute to real income with a weight α and are determined by the well-known ratio of aggregate productivity $\mu_n L_n^{\beta}$ over the domestic expenditure share π_{nn} taken to the power of the inverse of the trade elasticity θ. The remaining share of income goes to housing whose contribution to real income is determined by the intensity of congestion given by the ratio of housing supply H_n relative to the number of workers L_n living in country n. The third component captures income effects of tariffs raised by the government. If tariffs were not raised at all, the sum in the parenthesis would add up to unity. With positive tariffs, any increase in tariffs will increase real income through higher transfers. Because tariffs are taken from goods trade

[13] To see this, note that plugging in equation (II.12) on the left-hand side of equation (II.9) gives that imports net of tariffs are equal to exports net of tariffs as in Caliendo and Parro (2015), eq. (9).

flows, they enter with a weight α as well. Together with the resource constraint

$$L_n = \sum_i \lambda_{ni} N_i \tag{II.15}$$

and expenditure shares

$$\pi_{ni} = \frac{\mu_i L_i^{\beta} \left(\phi_{ni} w_i\right)^{-\theta}}{\sum_k \mu_k L_k^{\beta} \left(\phi_{nk} w_k\right)^{-\theta}} \tag{II.16}$$

equations (II.13) and (II.14) constitute a system of four equations in the four endogenous variables $\{w_n, L_n, \lambda_{ni}, \pi_{ni}\}_{i=1,n=1}^{I,I}$.

The fundamentals of the economy are $\Theta \equiv \left(\{d_{ni}\}, \{\mu_n\}, \{B_n\}, \{H_n\}, \{N_n\}\right)_{n=1,i=1}^{I,I}$, trade and migration policies are given by $\Xi \equiv \left(\{\tau_{ni}\}, \{\kappa_{ni}\}\right)_{n=1,i=1}^{I,I}$.

Definition II.1 *Given fundamentals Θ and policy variables Ξ as well as a set of values for the elasticities $(\alpha, \beta, \epsilon, \theta)$, the equilibrium of the model is given by a set of wages, labor supplies, expenditure and migration shares $\{w_n, L_n, \pi_{ni}, \lambda_{ni}\}_{n=1,i=1}^{I,I}$ that solve the problem given by equilibrium conditions* (II.13), *(*II.14*),* (II.15), *and* (II.16).

II.2.6 Equilibrium in Changes

Using the exact hat algebra method introduced by Dekle, Eaton, and Kortum (2008) and applied to trade policy evaluation by Caliendo and Parro (2015), it is possible to express the above equilibrium conditions in changes. Defining the relative change of an endogenous variable $\hat{x}$ as the ratio of its value in the new equilibrium relative to the old one, $\hat{x} = \frac{x'}{x}$, the equilibrium of the model is calculated as follows.

Given data on expenditure shares π_{ni}, trade policy changes $\hat{\phi}_{ni}$ and values for β and θ, the change in the price index $\hat{P}_n$ can be calculated using an initial guess for the change in wages $\hat{w}_i$ and labor forces $\hat{L}_i$ using

$$\hat{P}_n = \left[\sum_i \pi_{ni} \hat{L}_i^{\beta} \left(\hat{\phi}_{ni} \hat{w}_i\right)^{-\theta}\right]^{-\frac{1}{\theta}}. \tag{II.17}$$

This can in turn be used to calculate the implied changes in expenditure shares $\hat{\pi}_{ni}$ using

$$\hat{\pi}_{ni} = \hat{L}_i^{\beta} \left(\hat{\phi}_{ni} \hat{w}_i\right)^{-\theta} \hat{P}_n^{\theta}. \tag{II.18}$$

Given $\hat{\pi}_{ni}$, the implied change in aggregate expenditure can be calculated as

$$\hat{X}_n = \hat{w}_n \hat{L}_n \sum_k \frac{\pi_{nk}}{1+\tau_{nk}} \left(\sum_i \frac{\hat{\pi}_{ni}}{\hat{\phi}_{ni}} \frac{\pi_{ni}}{(1+\tau_{ni})}\right)^{-1} \tag{II.19}$$

to iterate on the guess for the change in wages $\hat{w}_n$ until the balanced trade condition in the new equilibrium holds. It is given by

$$w_n' L_n' = \sum_i \frac{\pi_{in}'}{1+\tau_{in}'} X_i', \tag{II.20}$$

where the left-hand side can be calculated using the current guess $\hat{w}_n \hat{L}_n$ multiplied by $w_n L_n$, which can be constructed using data on aggregate spending X_n and equation (II.12). On the right-hand side, $\pi_{in}' = \hat{\pi}_{in}\pi_{in}$ and $1+\tau_{in}' = \hat{\phi}_{in}(1+\tau_{in})$. Furthermore, $X_i' = \hat{X}_i X_i$. This inner loop produces changes in nominal wages, expenditure shares and price indeces as well as aggregate expenditure consistent with balanced trade, given the initial guess for the change in the labor force. Using these outcomes in addition to data on migration shares λ_{in} in the initial equilibrium, changes in migration frictions $\hat{\kappa}_{in}$ and values for α and ϵ gives the implied change in mean utility as

$$\hat{\bar{U}}_n = \left[\sum_i \lambda_{in} \hat{\kappa}_{in}^{-\epsilon} \left(\frac{\hat{L}_i^{\beta}}{\hat{\pi}_{ii}} \right)^{\frac{\alpha\epsilon}{\theta}} \hat{L}_i^{-\epsilon(1-\alpha)} \left(\sum_m \frac{\pi_{im}}{1+\tau_{im}} \right)^{\alpha\epsilon} \left(\sum_k \frac{\hat{\pi}_{ik}}{\hat{\phi}_{ik}} \frac{\pi_{ik}}{(1+\tau_{ik})} \right)^{-\alpha\epsilon} \right]^{\frac{1}{\epsilon}}, \tag{II.21}$$

which can in turn be used to calculate the implied changes in migration shares $\hat{\lambda}_{ni}$ as

$$\hat{\lambda}_{ni} = \hat{\kappa}_{ni}^{-\epsilon} \left(\frac{\hat{L}_n^{\beta}}{\hat{\pi}_{nn}} \right)^{\frac{\alpha\epsilon}{\theta}} \hat{L}_n^{-\epsilon(1-\alpha)} \hat{\bar{U}}_i^{-\epsilon} \left(\sum_m \frac{\pi_{nm}}{1+\tau_{nm}} \right)^{\alpha\epsilon} \left(\sum_k \frac{\hat{\pi}_{nk}}{\hat{\phi}_{nk}} \frac{\pi_{nk}}{(1+\tau_{nk})} \right)^{-\alpha\epsilon}. \tag{II.22}$$

Finally, the outer loop iterates over guesses for changes in the labor force $\hat{L}_n$ until the resource constraint

$$\hat{L}_n = \sum_i \hat{\lambda}_{ni} \frac{\lambda_{ni} N_i}{L_n} \tag{II.23}$$

holds, where data on initial labor forces L_n and native population sizes N_i are needed. These new values for $\hat{L}_n$ are then used to update the inner loop. The algorithm then converges to a vector of wage changes $\hat{w}_n$ and a vector of labor force changes $\hat{L}_n$ that are consistent with the resource constraint, balanced trade and the exogenous change in policy variables $\hat{\kappa}_{ni}$ and $\hat{\phi}_{ni}$.

Defining L_{ni} as the *number* of workers with nationality i living and working in n, labor forces $L_n = \sum_i L_{ni}$, national populations $N_i = \sum_n L_{ni}$ and migration shares $\lambda_{ni} = L_{ni}/N_i$. Furthermore, with X_{ni} being gross trade flows between countries, total expenditure are $X_n = \sum_i X_{ni}$ and trade shares are $\pi_{ni} = X_{ni}/X_n$.

Proposition II.1 *When the model is expressed in changes, it can be solved by only using data on gross bilateral trade flows* $\{X_{ni}\}_{n=1,i=1}^{I,I}$*, international migrant stocks* $\{L_{ni}\}_{n=1,i=1}^{N,N}$ *as well as an initial tariff structure* $\{\tau_{ni}\}_{n=1,i=1}^{I,I}$*, a set of policy changes* $\left\{\hat{\phi}_{ni}, \hat{\kappa}_{ni}\right\}_{n=1,i=1}^{I,I}$ *and values for the elasticities* $(\alpha, \beta, \epsilon, \theta)$ *using equations* (II.17) *through* (II.23).
Proof: *In the text.*

II.2.7 Trade, Migration and Welfare

To understand how trade and migration interact in this model how this interaction affects welfare, it is useful to start from equation (II.4).[14] It shows that mean utility of the citizens of country i is shaped by real incomes in all possible migration destinations, with higher weight on those locations that are more attractive places to live in (high B_n) as well as those that are more accessible (low κ_{ni}). While the B_n are exogenous and constant parameters, a decrease in migration costs κ_{ni} has a direct effect on utility. The remaining effect of the migration shock goes through general equilibrium adjustments in real incomes around the world in response to the change in κ_{ni}. Equation (II.4) implies that mean utility of the citizens of country i will fall in response to a migration shock if real incomes fall in countries where many of them live, which typically are the home country and neighboring locations, and if they do so strongly enough to dominate the positive effect of reduced migration frictions.

To study these general equilibrium adjustments in real incomes in more detail, it is useful to consider the relative change in mean utility of the citizens of country i based on equation (II.21),

$$\hat{\bar{U}}_i = \left[\sum_n \lambda_{ni} \hat{\kappa}_{ni}^{-\epsilon} \left(\frac{\hat{L}_n^{\beta}}{\hat{\pi}_{nn}} \right)^{\frac{\alpha\epsilon}{\theta}} \hat{L}_n^{-\epsilon(1-\alpha)} \left(\sum_m \frac{\pi_{nm}}{1+\tau_{nm}} \right)^{\alpha\epsilon} \left(\sum_k \frac{\hat{\pi}_{nk}}{\hat{\phi}_{nk}} \frac{\pi_{nk}}{(1+\tau_{nk})} \right)^{-\alpha\epsilon} \right]^{\frac{1}{\epsilon}},$$

which is restated here for easier reference.

The effect of migration on mean utility can be decomposed into four channels. First, there is the technology spillover. An inflow of workers increases the level of technology $\mu_n L_n^{\beta}$ in n with an elasticity β thereby increasing real income. Second, an inflow of workers increases demand for housing relative to the available fixed supply H_n. The strength of the effect is governed by the share $1-\alpha$ that workers spend on residential housing. The larger $\hat{L}_n$, the stronger is the increase in the rental rate R_n, reducing real income. The relative strength of these two effects is governed by the relationship between the parameters α, β, and θ. In particular, the congestion effect will dominate the spillover effect *conditional*

[14]Because I do not consider it in the quantitative exercise, I abstract here from the discussion of land owners' utility. I leave this analysis for future work.

on domestic expenditure shares and tariff income if $\beta < \theta\frac{1-\alpha}{\alpha}$, that is, if the spillover effect from labor force size on technology is small enough or the share of income spent on housing is large enough. When parameter estimates from the literature are considered, this is typically the case.

Third, and most importantly, there is an interaction between migration and trade through the change in the domestic expenditure share $\hat{\pi}_{nn}$. Migration affects π_{nn} through two channels. First, net immigration increases labor supply and puts downward pressure on the nominal wage w_n. Second, in the presence of technology spillovers, an inflow of workers increases the level of technology $\mu_n L_n^{\beta}$. Both effects, better technology and lower nominal wages, make domestic sourcing more attractive and lead to an increase in π_{nn}, lowering the real wage in n. As is well known from the work of Arkolakis, Costinot, and Rodríguez-Clare (2012), the inverse of the domestic expenditure share is a sufficient statistic for the gains from goods trade. An increase in π_{nn} therefore implies a decrease in the extent to which n benefits from trade with other countries because an inflow of labor leads to better technology and lower production costs at home.

Looking at the effect through the terms-of-trade lens, an inflow of workers puts downward pressure on nominal wages, reducing export prices relative to import prices, which tends to imply a welfare loss. This interaction through the nominal wage is present even if technological spillovers as well as congestion effects are turned off by setting $\beta = 0$ and $\alpha = 1$.

In the presence of tariffs, there is a fourth effect that works through tariff income. An inflow of workers makes domestic sourcing more attractive. Holding tariffs constant so that $\hat{\phi}_{nk} = 1 \; \forall n, k$, an inflow of workers implies that the summation in the last parenthesis becomes larger because there is an increase in domestic expenditure, $\hat{\pi}_{nn} > 1$, from which no tariffs are levied. This implies a negative effect on real income because of reduced tariff income available for redistribution. The main result of this analysis is summarized in the following proposition.

Proposition II.2 *Mean utility of the workers from country i depends on real incomes around the world. In a trade equilibrium, an increase in the size of the workforce affects real incomes because it interacts with the domestic expenditure share π_{nn}. An inflow of workers in a country puts downward pressure on the nominal wage there, increasing the domestic expenditure share and depressing real income.*
Proof: *In the text.*

I show in Section II.3 that, ignoring tariffs and shutting down congestion as well as productivity spillovers, the terms of trade effect of a migration shock alone can be large enough to cause a net loss in welfare relative to the initial trade equilibrium if the change in migration frictions causes sufficiently large migration flows. This is the case when the countries whose labor markets integrate are different enough in initial fundamental characteristics. If these negative welfare effects occur in countries in which many of country i's workers live and are strong enough to dominate the positive welfare effects of the decrease in κ_{ni}, this leads to a fall in mean utility of those workers.

Two qualifications are in order. First, it is important to stress that this argument about the possibly negative welfare effects of a migration shock is only valid in an equilibrium with (costly) trade. Starting from complete autarky with fixed populations and no trade any decrease in either trade costs or migration frictions will have unambiguously positive welfare effects. The negative effects only occur *relative* to the level of welfare in an equilibrium with trade.

Second, while the negative welfare effects may occur for countries that receive a sufficiently large inflow of migrants, the sending countries naturally experience a welfare increase. Abstracting from congestion and productivity spillovers, labor mobility therefore redistributes the welfare gains from goods trade from high real income countries to those with low real income. In particular, countries with high real income tend to be attractive migration destinations. Citizens of *sending* countries gain for two reasons. Those who emigrate enjoy a higher real income in their destination than what they would have earned at home. Those who stay benefit from cheaper access to foreign high-technology goods because the cost of production there is lowered by the increase in labor supply. This improves their terms of trade.

The aggregate welfare effect of a migration shock can be measured using the population-weighted change in mean utility around the world,

$$\hat{\bar{U}} = \sum_i \frac{N_i}{N} \hat{\bar{U}}_i, \tag{II.24}$$

where $N = \sum_i N_i$ is the total number of workers around the world.[15] In Sections II.3 and II.4 I show that $\hat{\bar{U}}$ is positive in response to a migration shock, while some countries' workers may experience an increase or a decrease in their mean utility.

II.3 Simulation

In this section I simulate the model using random numbers as fundamentals of the economies. The purpose of the simulation is twofold. First, control over initial conditions allows me to show that negative effects on utility of citizens of some countries do not occur mechanically in this model, but require sufficiently dissimilar countries. Second,

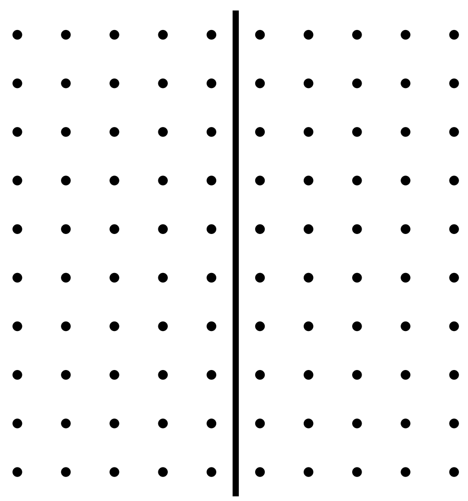
[15]In the quantitative assessment, I also calculate $\hat{\bar{U}} = \prod_i \hat{\bar{U}}_i^{\frac{N_i}{N}}$. The differences are minimal.

I can disentangle the different channels outlined above and show that even in the absence of technology spillovers and congestion effects, the terms of trade channel can produce the negative welfare effect.

II.3.1 Setup

I construct a grid of 100 points representing countries. For each country I draw values for the number of citizens N_i, technology μ_i and amenities B_i from a log-normal distribution. All countries are assigned the same value for the endowment of residential land H_i. Distances between the countries are measured as the Euclidean distance between the points on the grid and determine trade and migration costs in the model. For simplicity, I abstract from tariffs here. I also need to calibrate the four structural parameters, the trade elasticity θ, the migration elasticity ϵ, the share of goods consumption in the households' budget α as well as the strength of the technology spillover controled by β. Following Head and Mayer (2014) and Simonovska and Waugh (2014), I set $\theta = 4$, and $\epsilon = 3$ following Bryan and Morten (2017). The goods consumption $\alpha = 0.75$ is taken from Davis and Ortalo-Magné (2011) and I set $\beta = 1$ to be consistent with Eaton and Kortum (2001).

Figure II.1: Country Grid and the Migration Barrier



Note: Grid of simulated countries in latitude-longitude space and the migration barrier.

The policy change I consider in this simulation is the removal of a migration barrier between the two halves of the grid, called "West" and "East". Figure II.1 depicts the migration barrier as a black line. In the initial situation all points on the grid trade with each other, but migration is only possible on either side of the grid. The removal of the barrier then allows workers to migrate to the other region. The welfare effects of this change are used to demonstrate the mechanisms and channels active in the proposed model.

II.3.2 Results

To show that the terms of trade effect inducing utility losses for citizens of some countries does not occur mechanically, I consider the opening of the migration barrier under two scenarios. In the first, countries on either side of the grid draw all their fundamental values from distributions with identical means, implying that countries on both sides of the divide are on average equally attractive, equally productive, and have the same number of citizens on average. In the second scenario, I let countries west of the divide draw their productivity levels μ_i from a distribution with a larger mean, making them more productive on average than the eastern countries. Table II.1 shows the mean values of fundamentals on both sides of the migration barrier for each scenario.

Table II.1: Fundamental Values in the Simulation

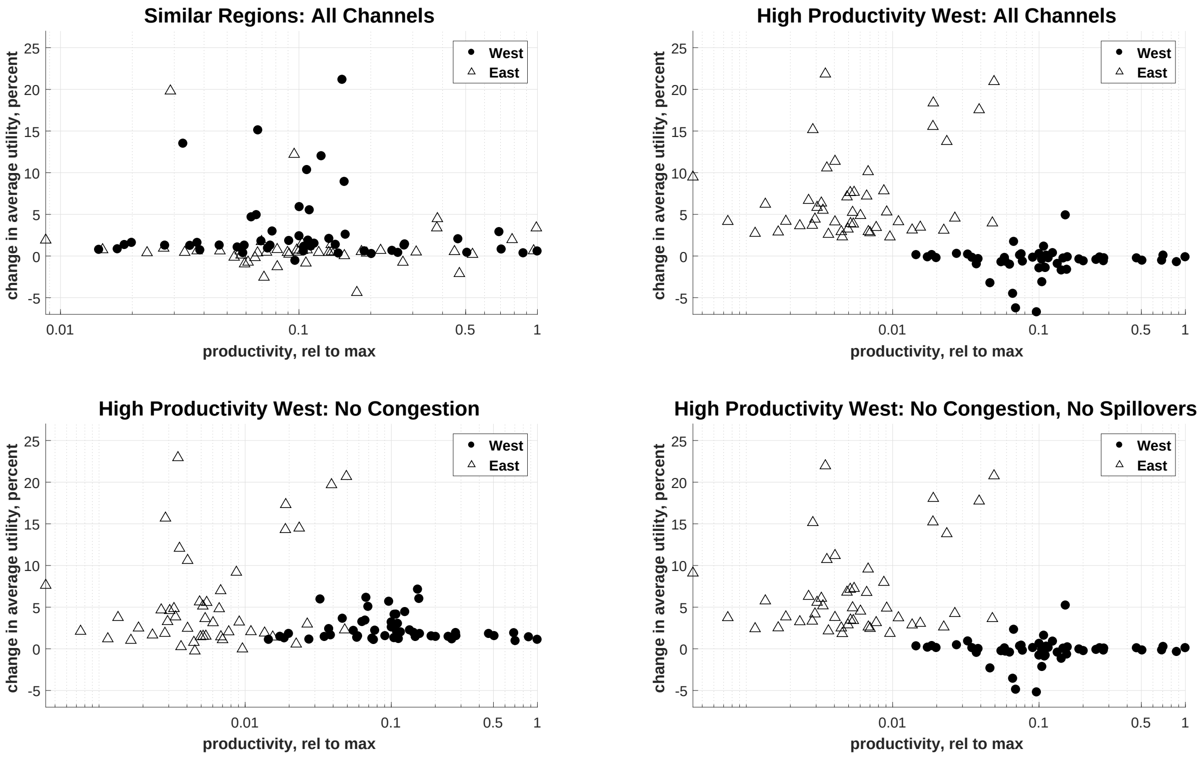
	avg. prod.		avg. amen.		avg. nat. pop.	
	West	East	West	East	West	East
equal distr.	1.64	1.71	1.63	1.71	1532	1498
high μ	7.37	0.38	1.63	1.71	1532	1498

Note: Means of random draws of location fundamentals for 100 simulated countries.

Essentially, this is an application of the idea from Davis and Weinstein (2002) in a quantitative multi-country setting. Figure II.2 plots each country's value of μ_i relative to the most productive country on a log-scale on the horizontal axis and the change in average utility of the country's citizens $\hat{U}_i$ on the vertical axis. It is important to note that each point represents the change in average utility for the *citizens* of a country, wherever they may live. This means that the value also accounts for the utility increases of workers who left their home country, for example.

The top left panel of Figure II.2 shows the results when the two regions draw their fundamentals from identical distributions. Accordingly, both triangles (East) and circles (West) are homogeneously spread over the horizontal axis. The vast majority of points lie slightly above the zero-change line indicating that there are utility gains from reduced migration frictions for the citizens of most countries. In the top right panel the exercise is repeated but with countries in West drawing the productivities from a distribution with a higher mean. Accordingly, the circles are clustered at the higher end of the relative productivity line. A clear pattern emerges in which the citizens of most countries in West lose slightly from labor market integration, some outliers in both directions notwithstanding.

Figure II.2: Removal of the Migration Barrier - Welfare Effects



Note: Results of a simulation of the removal of the migration barrier with 100 countries.

The utility gains for the citizens from East are disproportionately larger. This underscores that the aggregate change in welfare is positive. In fact, weighting the changes in average utility with the citizen shares accounted for by each country, the migration liberalization scenario increases global utility by 3.43% when the geometric mean is considered. The global change in real income is calculated as the geometric mean of the changes in real income in each country, with the new equilibrium labor forces as weights. Global average real income increases by 0.09%.[16]

The bottom left panel keeps productivity high in West but removes the congestion effect by setting $\alpha = 1$. This exercise shows that in the presence of technology spillovers alone, the redistributive mechanism is not strong enough to generate systematic welfare losses in the more productive region. Finally, the bottom right panel additionally removes the technology spillover, leaving only the terms of trade effect through changes in the nominal wage as the only channel through which trade and migration interact. The familiar pattern reemerges, with small but systematic losses in West and larger gains in East.

In the next section, I confront these theoretical results with the data.

[16]The numbers only change mildly, when the arithmetic mean is considered. Global average utility then increases by 3.68% and global average real income increases by 0.13%.

II.4 Eastern Enlargement

The Eastern Enlargement of the European Union was the largest experiment in labor market integration in recent history. In this section, I match the model to data on trade and migration from before the Eastern Enlargement and confront it with changes in tariffs and migration costs during the first phase of the enlargement period from 2004 to 2007. I use this experiment to assess the welfare effects of the EU Eastern Enlargement through the lens of the model proposed in Section II.2.[17]

For the assessment of the economic effects of the Eastern Enlargement, I consider the migration and trade interactions between 25 countries or country groups and a constructed rest of the world. The sample includes the EU15 countries Austria, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Portugal and Sweden. For data reasons I aggregate Belgium, the Netherlands and Luxembourg to one country (BNL). As new member states I consider the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia, who all joined in 2004 as well as Bulgaria and Romania, who joined in 2007. The sample also includes Croatia, which did not join the EU until 2013.[18]

Upon joining the EU, all new member states forfeited their own trade agreements and joined those already signed by the EU. In addition, tariffs between all EU states fell to zero. In contrast to the trade liberalization, the opening of labor markets had a considerable time dimension. Only the U.K., Ireland and Sweden opened their borders to all new member states in 2004, who in turn reciprocated by opening theirs. Hungary, Poland and Slovenia were the only new states that did non open their labor markets to all EU15 states. All new states opened their labor markets to citizens from other new members. In 2006, Italy, Greece, Spain and Portugal allowed for free worker movement, with the Netherlands and Luxembourg following in 2007, France in 2008, Belgium and Denmark in 2009. Germany and Austria opened their labor markets only in 2011.

Because the model is static, I cannot use the time variation in the counterfactual exercise. Instead, I follow Caliendo, Opromolla, Parro, and Sforza (2017) and consider labor market liberalizations that took place until 2007 to avoid picking up effects of the beginning financial crisis and compute comparative statics taking all the changes in tariffs and migration costs into account that happened until then. As a consequence, the welfare effects presented below do not take into account migration movements that happened after 2007, for example due to Germany and Austria's opening up of their labor markets.

[17] In the welfare assessment, I focus on the welfare changes of workers, neglecting the welfare of land owners. Their inclusion in the welfare calculus is left for future work.

[18] Cyprus and Malta complete the list of ten new member states that joined in 2004. They are added to the rest of the world for data availability reasons.

This is an important caveat and should be kept in mind when interpreting the results. To evaluate the effects of these I use the model with all channels throughout. I also continue to use the value for the structural parameters as given in the simulation in Section II.3.

II.4.1 Data and Calibration

According to Proposition II.1, only data on labor force composition, trade flows, the initial tariff structure and on the changes in tariffs and migration costs are needed to solve the model in changes.

II.4.1.1 Tariffs

Tariff data come from WITS, where I use effectively applied rates for the years 2003 and 2007 from TRAINS. Where observations are missing, I impute values from earlier years.[19] I construct two tariff matrices for the year 2003, one using tariffs with industry trade flows as weights and another with a simple average. The main results presented below are produced using the weighted tariffs. Robustness checks using simple averages are reported in Appendix B.2.2. Under the weighted scheme, the average tariff level for the Eastern European countries under consideration when exporting to the EU was 2.4% in 2003, down from 4.85% in 2001. EU15 countries faced an average tariff of 3.1% when exporting to Eastern Europe, down from 4.6% in 2002. I calculate tariff changes by constructing a similar tariff matrix for the year 2007 and dividing the values by one another.

II.4.1.2 Changes in Migration Costs

Changes in the cost of migration are not as easily measurable as changes in tariffs. Caliendo, Opromolla, Parro, and Sforza (2017) present a model-consistent strategy to identify changes in migration costs by exploiting time variation in migration shares in a difference-in-difference setting. Unfortunately, the comprehensive data from Eurostat's Labor Force Survey they use are currently not available publicly. For lack of another data source with similar characteristics, I turn to their estimates and apply them to my model. This is possible because both models generate gravity-type expressions for migration shares. The fixed effects structure derived from the migration shares in Caliendo, Opromolla, Parro, and Sforza (2017) can therefore also be constructed from my model.[20] This means that given the same data and the consistent fixed effects structure, I can take

[19]Tariffs charged by Latvia and Romania in 2003 are taken from 2001, those charged by Slovakia and Hungary for 2003 are taken from 2002.

[20]Caliendo, Opromolla, Parro, and Sforza (2017) use a Type I extreme value distribution for the individual shocks together with a dynamic framework which gives their migration costs a fixed-cost flavor. In my model, the Type II extreme value distribution is very tractable with a multiplicative utility cost of migration. Both approaches produce analytically similar expressions for migration shares.

their point estimates and relate them to the structure of my model. In particular, the coefficient of interest measuring the change in migration costs for workers of new member states for a destination country n is given by

$$\upsilon_{n,NMS,post} = -\epsilon \left(\ln \kappa_{ni,post} - \ln \kappa_{ni,pre}\right),$$

where $\kappa_{ni,post}$ is the data equivalent of κ'_{ni}, migration costs in the new equilibrium. With the left-hand side taken from Caliendo, Opromolla, Parro, and Sforza (2017), and a value of the migration elasticity ϵ, the ratio $\hat{\kappa}_{ni}$ can be recovered.[21] They estimate values of υ for migration between new member states and the countries that opened their labor markets between 2004 and 2006, i.e. the U.K., Greece, Italy, Spain, and Portugal as well as for the changes in migration costs between the new members themselves. These are then also the country pairs for which I compute implied changes in migration costs for the quantitative exercise. The coefficients found by Caliendo, Opromolla, Parro, and Sforza (2017) for the change in the cost of migrating from an EU15 country to one of the new member states were insignificant. Like them, I therefore hold migration costs constant in this direction.

II.4.1.3 Trade and Migration Data

Bilateral (net) trade flows come from WIOD (Timmer, Dietzenbacher, Stehrer, and de Vries, 2015). I consider data for the year 2003, directly before the enlargement. I add tariffs to generate the matrix of X_{ni} in the model and calculate initial aggregate expenditure levels X_n. The raw data naturally reflect trade imbalances that exist between the sample countries. In the exposition of the model, I have abstracted from these imbalances. For the quantitative exercise, I remove the imbalances before I evaluate the welfare effects of changes in migration and trade costs. To do so, I measure trade imbalances net of tariffs in the data. Then I feed the raw data into the inner loop of the solution algorithm outlined in Section II.2.6 and correct the excess demand vector by the vector of imbalances. I hold labor forces fixed as found in the data and solve the model for a vector of wage changes that is consistent with balanced trade as given by equation (II.20). Using this vector of wage changes I construct a new matrix of bilateral trade flows that are consistent with balanced trade and evaluate the policy changes starting from these constructed data.[22]

As noted above, the detailed labor force surveys used by Caliendo, Opromolla, Parro,

[21] The estimation strategy is explained in detail in Caliendo, Opromolla, Parro, and Sforza (2017), Section 4.3.

[22] Caliendo and Parro (2015) also remove trade imbalances from their data before they apply the NAFTA tariff changes.

and Sforza (2017) to construct migration shares are not publicly available on the Eurostat website. I therefore turn to the Extended Database on Immigrants in OECD and non-OECD countries (DIOC-E) used also by Biavaschi, Burzyński, Elsner, and Machado (2018). These data contain information on the number of migrants in OECD and many non-OECD countries, among other things differentiated by level of education and age. Unfortunately, they are only available every five years. The last available data before the Eastern Enlargement date to the year 2000/2001. These are the data from which I construct the matrix of bilateral migration stocks L_{ni} using the numbers for people aged 15 to 64 (age groups 1 and 2). Due to missing data I need to impute some of the values in the matrix to get a full matrix to feed into the model. The changes and assumptions I make in the course of the procedure are described in Appendix B.2.1.

II.4.2 Results

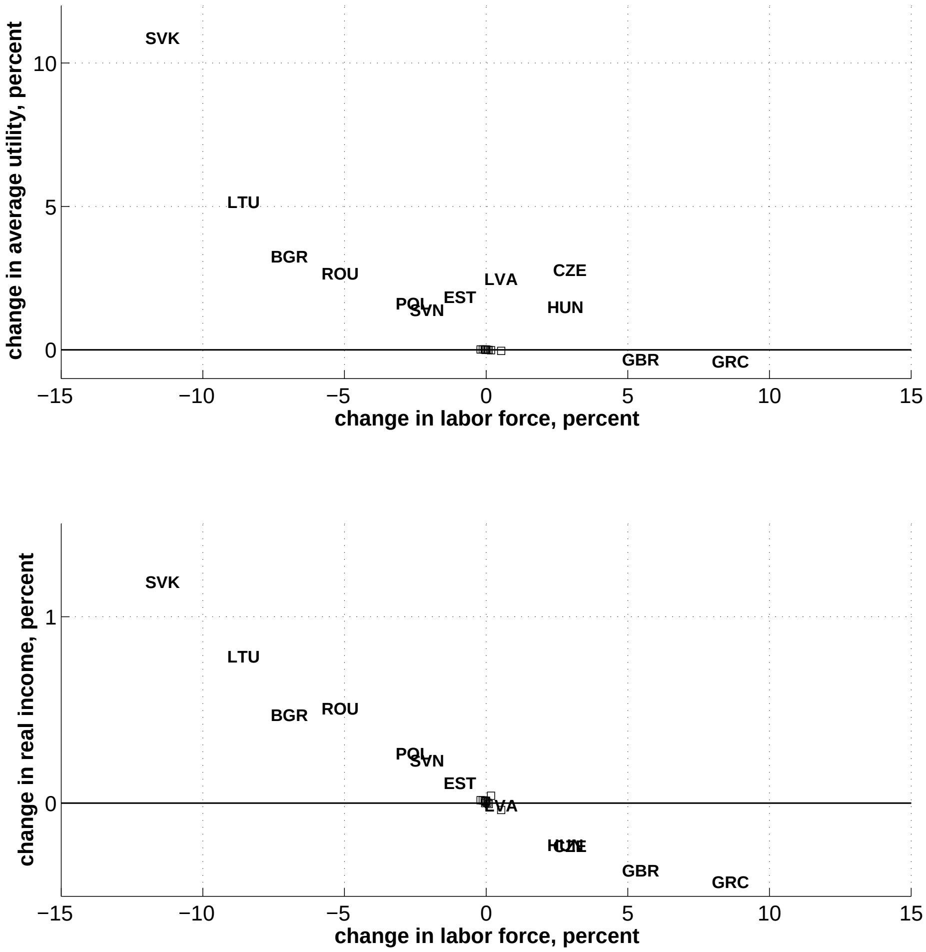
When I assess the welfare effect of the Eastern Enlargement between 2004 and 2007, I consider two scenarios. In the first scenario, tariff levels are held constant at their 2003 level and only migration costs are lowered. The second scenario features the full liberalization including tariff changes.

II.4.2.1 Scenario 1: Migration Liberalization Only

Figure II.3 presents the two key welfare outcomes in this scenario. The top panel plots percentage changes in average utility of the citizens of a country in relation to the percentage change in the labor force of the home economy. The bottom panel plots the change in real income in each country with the same horizontal axis. Where data points are too close to be individually discernible, I replace them with squares. It is important to recall that a data point in the top panel represents the change in utility of the *citizens* of the designated country, wherever they live. That means the welfare measure takes into account the real income they earn abroad as well as the utility costs they incur from living in a foreign country. The values are calculated from equation (II.21). In contrast, the bottom panel shows the changes in real income that workers earn who live in the designated country - irrespective of their nationality. This measure of welfare does not account for utility losses from migration. The numbers corresponding to the plots are presented in Table II.2.

The top panel shows that the utility gains from the Eastern Enlargement are quite substantial and that it is the workers of the new member states who benefit greatly from the migration liberalization. Slovakian workers take the lead with an increase of 10.8% compared to the initial equilibrium. All other workers of the new states gain between

Figure II.3: Eastern Enlargement - Migration Liberalization Only



Note: The countries plotted as squares are Austria, Benelux, Germany, Denmark, Spain, Finland, France, Croatia, Ireland, Italy, Portugal, and Sweden. Rest of the World is not plotted.

1.5% and 5% on average. The welfare effects for the citizens of the EU15 countries are much smaller. At the top end, Austrian, German and Swedish workers gain about 0.01% in utility. The model predicts workers from the U.K., Greece, Ireland, Italy and Portugal to incur utility losses from the migration liberalization. The strongest effects are found in the U.K. and Greece, whose workers lose about 0.3% to 0.4% of their utility. Aggregate EU welfare *increases* by 0.57% in this scenario.

The percentage changes in real income plotted in the bottom panel are smaller in absolute terms than the changes in utility as can be seen from the smaller range of the vertical axis. It is again the new member states' real incomes that rise the most, with the two notable exceptions of Hungary and Czech Republic, whose real incomes fall. Among the EU15 countries, effects on real incomes are very small with Greece and the U.K. standing out with real income losses. The common factor among the four main real income losers U.K., Greece, Hungary and the Czech Republic is the strong increase in

Table II.2: Eastern Enlargement - Migration Liberalization Only

Country	Code	Avg. Utility	Real Income	Labor Force	EU Weight
		——— change in percent ———			pct. pts.
Austria	AUT	0.014	0.016	-0.196	0
Bulgaria	BGR	3.254	0.473	-7.603	0
Benelux	BNL	0.011	0.013	0.000	0
Czech Rep.	CZE	2.790	-0.230	2.366	0
Germany	DEU	0.012	0.015	-0.118	0
Denmark	DNK	0.009	0.011	-0.019	0
Spain	ESP	0.002	0.002	0.041	0
Estonia	EST	1.850	0.108	-1.500	0
Finland	FIN	0.009	0.010	-0.012	0
France	FRA	0.006	0.007	-0.006	0
U.K.	GBR	-0.335	-0.362	4.801	36.90
Greece	GRC	-0.393	-0.424	7.969	40.69
Croatia	HRV	0.003	0.000	-0.035	-
Hungary	HUN	1.496	-0.225	2.158	0
Ireland	IRL	-0.012	0.040	0.173	2.06
Italy	ITA	-0.036	-0.037	0.533	5.85
Lithuania	LTU	5.168	0.788	-9.136	0
Latvia	LVA	2.479	-0.013	-0.067	0
Poland	POL	1.627	0.267	-3.193	0
Portugal	PRT	-0.004	-0.005	0.093	0.75
Romania	ROU	2.660	0.509	-5.810	0
Rest of World	ROW	0.003	0.003	-0.003	-
Slovakia	SVK	10.873	1.186	-12.026	0
Slovenia	SVN	1.390	0.229	-2.696	0
Sweden	SWE	0.012	0.014	-0.052	0

Note: The table shows the percent changes in average utility, real income, the size of the labor force as well as the implied pro-European welfare weight of the government objective function for each country in the sample.

the labor force these countries experience. The labor forces of Greece and U.K. increase by 7.9% and 4.8%, respectively, those of Hungary and the Czech Republic by 2.1% and 2.3%, respectively.

More generally, an increase in the size of the labor force in the home economy tends to be associated with losses in real income and average utility of workers and vice versa: Slovakia and Lithuania experience the largest labor force outflows (-12% and -9.1%) and see the largest increases in average utility and real income.

However, Hungary and the Czech Republic differ from the U.K. and Greece in an important respect. While the latter see losses in average utility of their citizens as well as in real income in the national economy, the citizens of Hungary and the Czech Republic *gain* on average in terms of utility, while their national economies can only offer a lower real income. This difference is rooted in the asymmetric changes in migration costs that follow from the estimates provided by Caliendo, Opromolla, Parro, and Sforza (2017). Hungary and the Czech Republic are net recipient countries of migrants but their citizens can escape the downward pressure on their wage by exploiting the improved migration options to the EU15 countries. In contrast, the U.K. and Greece receive workers from the new member states, but their utility costs of migrating have not changed. It is important to note that this is an exogenous feature of the model as the cost of migrating from a EU15 country to a new member state were held constant in the quantitative exercise following the insignificant estimates in this direction of migration by Caliendo, Opromolla, Parro, and Sforza (2017). In addition, even if migration costs had fallen for British or Greek citizens, the new migration options would have been relatively less attractive than those faced by Eastern European citizens. In addition to the U.K. and Greece, also the citizens of Ireland, Italy and Portugal face average utility losses, albeit on a much smaller scale.

II.4.2.2 Scenario 2: Migration and Trade Liberalization

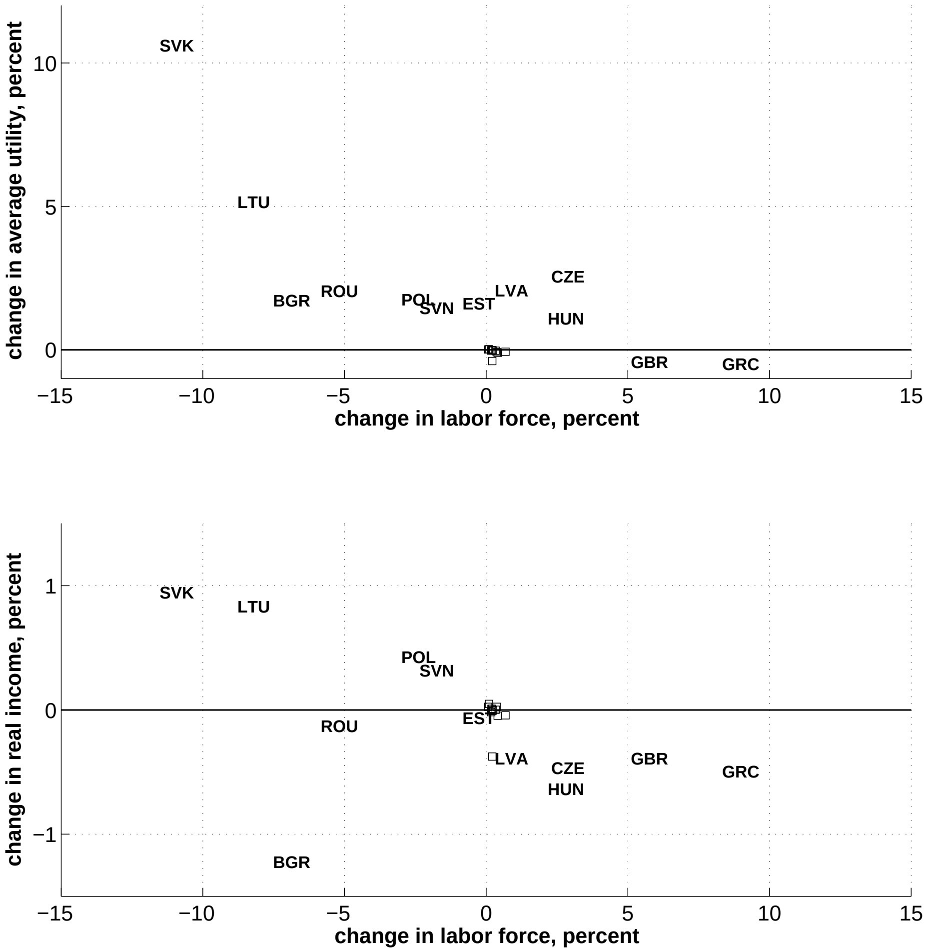
Scenario 2 considers both the liberalization in migration as well as the tariff cuts that came with the accession of the new member states. The top panel, showing again changes in average utility in relation to relative initial market size, reveals only minor differences to the results from Scenario 1. Again, the new member states gain from the Eastern Enlargement while effects in the EU15 countries are quite small in comparison. It is again the U.K. and Greece whose citizens experience the largest utility losses. At -0.41% and -0.5%, they are even a bit larger in absolute terms than in Scenario 1. In addition, the total number of countries whose citizens see a loss in average utility has more than doubled to 11 from 5. Aggregate EU welfare *increases* by 0.47% in this scenario.[23]

Looking at the changes in real income, it is interesting to see that more new member states see real income losses than in Scenario 1 and that they also tend to be larger. Given that the changes in average utility are similar in both scenarios for the new member states, the interaction of trade liberalization and lower migration costs seems to widen the gap between real income changes in the national economies on the one hand and the change in average utility for the country's citizens.

Consider the case of Bulgaria. In Scenario 2, the model predicts a 1.7% increase in average utility for Bulgaria's citizens, but a loss of -1.2% in real income in the national economy. According to equation (II.21), this is only possible if migration costs decrease strongly and Bulgaria's neighbors experience sufficiently large real income growth. The size of the labor force in Bulgaria does decrease by 7.5% in the model. How does the loss in real income come about? Although Bulgaria's domestic expenditure share falls in

[23] The magnitude of this value is in line with Caliendo, Opromolla, Parro, and Sforza (2017), who find an aggregate EU welfare increase of 0.62%.

Figure II.4: Eastern Enlargement - Migration and Trade Liberalization



Note: The countries plotted as squares are Austria, Benelux, Germany, Denmark, Spain, Finland, France, Croatia, Ireland, Italy, Portugal, and Sweden. Rest of the World is not plotted.

response to the enlargement, pointing to higher gains from trade, the strong migration outflow reduces the level of technology through the spillover channel and causes a net loss in real income through the goods consumption channel (-0.66%). Tariff reductions lead to more trade but reduce income through the tariff channel (-2.49%). The large outflow of workers lets the rental rate for residential land fall so that real income increases via the congestion channel ($+1.97\%$), but the effect is not strong enough leaving a net loss in real income.[24] In this model, Bulgaria is an example of how positive effects of trade liberalization on real income can be overturned by losses from reduced tariff income and due to factor mobility. Utility of Bulgarian labor, however, increases.

The main take-away from Scenario 2 is that even in the presence of a concurrent trade liberalization, the model predicts negative welfare effects for the citizens of some

[24]The joint effect can be recovered by dividing the three percentages by 100, adding 1, and multiplying the three resulting numbers.

Table II.3: Eastern Enlargement - Migration and Trade Liberalization

Country	Code	Avg. Utility	Real Income	Labor Force	EU Weight
		——— change in percent ———			pct. pts.
Austria	AUT	0.022	0.049	0.102	0
Bulgaria	BGR	1.729	-1.224	-7.520	0
Benelux	BNL	-0.021	-0.003	0.245	4.20
Czech Rep.	CZE	2.554	-0.467	2.299	0
Germany	DEU	-0.031	0.001	0.335	6.22
Denmark	DNK	-0.011	0.009	0.185	2.23
Spain	ESP	-0.029	-0.018	0.183	5.70
Estonia	EST	1.618	-0.064	-0.833	0
Finland	FIN	0.012	0.025	0.070	0
France	FRA	-0.018	-0.008	0.222	3.69
U.K.	GBR	-0.412	-0.392	5.108	46.62
Greece	GRC	-0.495	-0.493	8.328	51.17
Croatia	HRV	-0.389	-0.375	0.217	-
Hungary	HUN	1.091	-0.637	2.180	0
Ireland	IRL	-0.080	0.025	0.371	14.47
Italy	ITA	-0.065	-0.044	0.682	12.04
Lithuania	LTU	5.160	0.832	-8.777	0
Latvia	LVA	2.077	-0.391	0.307	0
Poland	POL	1.752	0.428	-2.990	0
Portugal	PRT	-0.104	-0.046	0.407	18.00
Romania	ROU	2.054	-0.129	-5.834	0
Rest of World	ROW	-0.835	-0.842	-0.034	-
Slovakia	SVK	10.613	0.945	-11.523	0
Slovenia	SVN	1.455	0.317	-2.349	0
Sweden	SWE	-0.008	0.009	0.212	1.61

Note: The table shows the percent changes in average utility, real income, the size of the labor force as well as the implied pro-European welfare weight of the government objective function for each country in the sample.

countries, mainly the U.K. and Greece. Based on these results, I now study quantitatively the trade-off between staying inside the EU Single Market given the effects of the Eastern Enlargement on the one hand, and leaving the Single Market in order to be able to set unilateral migration policies on the other.

II.5 On the Political Economy of Economic Disintegration

Governments are responsible for setting migration and trade policies. In the analysis of the political economy of these two policy dimensions, I address two questions. The first concerns the problem that the Eastern Enlargement is by no means an exogenous shock to a welfare-maximizing government because the enlargement was supported and the accession treaty ratified by each of the EU15 member countries. Using this model to assess the consequences of the Eastern Enlargement in 2003, a British government would not have agreed to the accession of the new member states, for example. The second question concerns the trade-off between staying in the EU and exiting with a loss of access to the Single Market.

II.5.1 How Pro-European Does the Government Have to Be?

I tackle the first question by noting that governments change over time and with them their attitude towards Europe. Starting from the fact that all the EU15 countries including the U.K. did agree to the Eastern Enlargement in 2004 and that the U.K. in particular was part of the group that most aggressively liberalized its labor market in the beginning of the transition period, I calculate the weight that each government must have attached to aggregate EU welfare to be at least indifferent between accession and no accession of the Eastern European countries.[25]

To do so, I calculate the aggregate change in utility of EU workers including both old and new member states according to the formula given in equation (II.24), summing over all countries in the sample except Rest of World and Croatia. I then create a vector ι of political economy weights that measure the importance given to the change in aggregate EU welfare in the *pro-European* government objective function given by

$$O_{i,EU} = \iota_i \hat{\hat{U}}_{EU} + (1 - \iota_i)\, \hat{\hat{U}}_i. \tag{II.25}$$

As long as a government's objective function evaluates at a loss compared to the initial equilibrium (i.e. $O_{i,EU} < 1$), I increase the EU weight ι_i in the objective function. Column 6 of Table II.3 shows the results. For countries whose citizens gain on average in terms of utility, the value remains at zero as the Eastern Enlargement is preferred even without a political economy weight for aggregate EU welfare. Although the utility losses for Greek and British citizens are below 1%, the political economy weight of aggregate EU welfare needed to produce an indifferent government is nonetheless substantial at 51.2% for Greece and 46.6% for the U.K. This results from the fact that the aggregate increase in EU welfare is not particularly large at only 0.47%. For other EU15 countries like Germany, Denmark, France and the Benelux countries, EU weights below 10% are sufficient to tilt the government's decision in favor of the enlargement. Note that these countries did not open their labor markets until 2009 or 2011. Therefore the cost of migrating from Eastern Europe to those countries remains constant in the model. Other early migration liberalizers like Ireland, Italy and Portugal need two-digit EU weights to

[25] I thank Sebastian Krautheim for this suggestion.

rationalize consent.

I contrast these results with the welfare evaluation of two other government types. The *populist* government does not care about aggregate European welfare, but - for political economy considerations - maximizes the change in the welfare of the median citizen. Median utility of workers from i is defined as

$$\tilde{U}_i = G_i^{-1}\left(\frac{1}{2}\right).$$

In Appendix B.1.4 I show that the relative changes of mean and median utility are identical in this model so that

$$O_{i,pop} = \hat{\tilde{U}}_i = \hat{\bar{U}}_i. \tag{II.26}$$

The change in the mean and median of a Fréchet distributed variable are identical because the ratio of the two statistics is not affected by the location of the distribution. Median and mean utility of workers of a particular nationality are thus identical up to a constant. It follows that the relative changes in median and mean utility of workers from country i for a given change in real incomes around the world are also the same. Therefore the only difference in the valuation of welfare outcomes between the pro-European and the populist governments comes from the inclusion of aggregate European welfare in the pro-European's objective function.

Finally, the *technocratic* government does not look at welfare of its citizens but instead aims to maximize real income of the workers living in its area of jurisdiction, independent of their nationality. In doing so, it also ignores changes in utility that derive from changes in migration costs so that

$$O_{i,tech} = \frac{\hat{\nu}_i}{\hat{P}_i^{\alpha}\hat{R}_i^{1-\alpha}}. \tag{II.27}$$

There are several countries for which differences in the government objective function also make a qualitative difference in the assessment of the Eastern Enlargement. According to Table II.3, in Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, and Romania, the median and mean workers gain in terms of utility, but real income in the country itself falls. Strong support for the Eastern Enlargement in these new member states can be rationalized in this model by governments that take into account the improved mobility and earnings prospects of their citizens abroad, be they populist or pro-European in nature. Based on the real income losses, the technocratic government type would object to the enlargement.

On the other hand, there is a number of EU15 countries including Germany, Denmark, Ireland and Sweden, whose economies see increases in real income following the Eastern Enlargement but whose citizens lose in terms of utility at the median. Here a technocratic government type or a pro-European one with a sufficiently large EU weight in the objective function can rationalize support for the enlargement. It is important to stress, however, that the welfare assessment conducted here only includes the changes made up to 2007 and can thus not be considered a full analysis. Subsequent labor market liberalizations in other western and central European countries can significantly affect the outcomes of the model.

II.5.2 An Exit Scenario

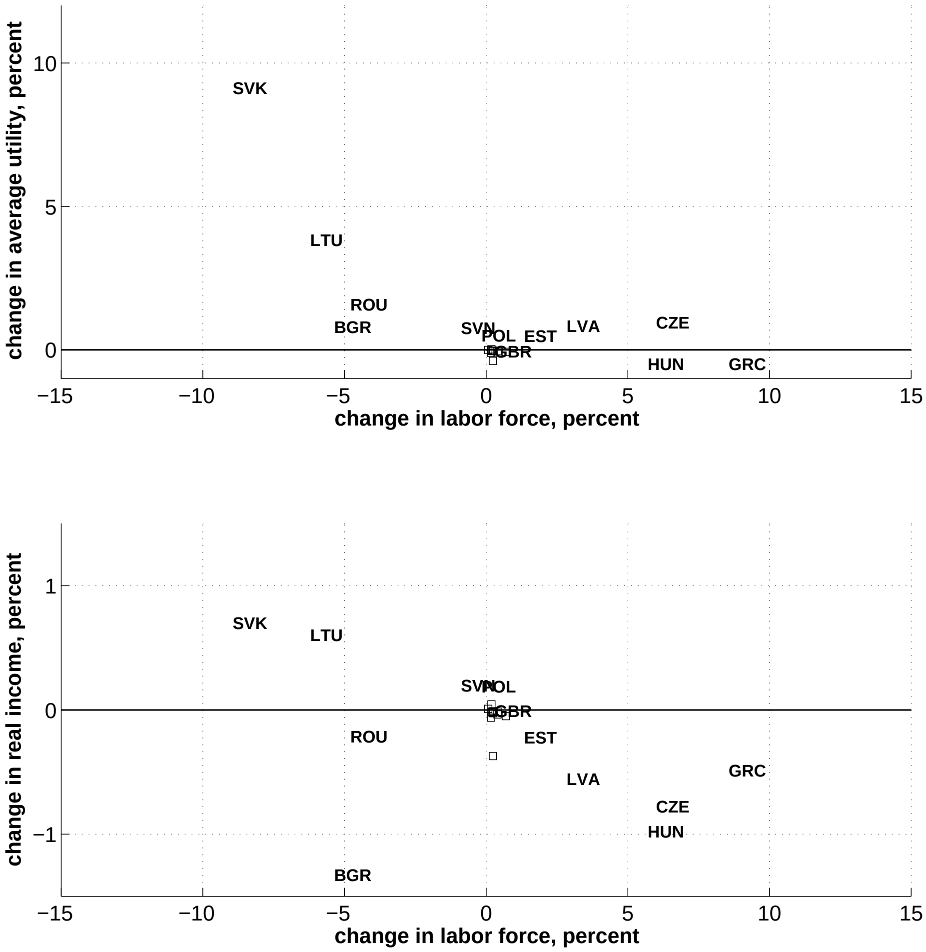
Motivated by the ongoing Brexit negotiations, I use the model to assess the trade-off between the consequences of the Eastern Enlargement on the one hand, and leaving the EU Single Market on the other for the U.K., whose citizens take the second largest utility losses in the full liberalization Scenario 2 (next to Greece).

I make the following assumptions. When the enlargement decision was taken, the government in power in the U.K. was sufficiently "pro-European" to agree to it and to open up its labor markets. Now a government of the "populist" type has come to power and re-assesses the enlargement decision. According to the numbers in Table II.3, the median U.K. worker has lost 0.41% in utility as a consequence of the Eastern Enlargement. The government therefore considers a move to "take back control" over migration policy and set unilateral migration policies. Because membership in the EU Single Market requires upholding the freedom of movement of goods and labor, the only way to re-raise migration barriers is to leave the Single Market. In this case the EU would impose tariffs on U.K. goods and the U.K. would lose the benefits of trade agreements negotiated by the EU.

To quantify the effects of an exit scenario, I re-calculate Scenario 2 with the difference that the costs of migrating from a new member state to the U.K. remain constant while they fall for the other liberalizing EU countries. At the same time, tariffs for new member states with EU countries drop to zero as before, but U.K. tariffs with all (including the new) EU countries increase to U.K. tariffs with the rest of the world just like the EU applies rest of world tariffs to imports from the U.K. These tariffs are at about 2% in the data. This is similar to a "chaotic Brexit" scenario, in which tariffs automatically return to MFN levels with the rest of the world because no new trade agreement has been signed between the EU and the U.K. at the end of the negotiation period.

Figure II.5 plots the results of this exercise. The first important point is that leaving the Single Market can indeed improve the British position relative to Scenario 2. In the top panel, the U.K. value is now almost exactly on the zero change line together with Germany, Italy and France. A look at the numbers in Table II.4 shows that the U.K. is still worse off than before the Eastern Enlargement and "Brexit", but only by -0.056% compared to a loss of -0.412% in Scenario 2. Second, the utility gains for the new member

Figure II.5: Eastern Enlargement and U.K. Single Market Exit



Note: The countries plotted as squares are Austria, Benelux, Germany, Denmark, Spain, Finland, France, Croatia, Ireland, Italy, Portugal, and Sweden. Rest of the World is not plotted.

states are smaller than in the case of enlargement without Brexit. This can be seen from eyeballing Figures II.4 and II.5, where for example the gains for Slovakian citizens have fallen below 10%. Column 6 of Table II.4 shows the *percentage-point* difference between the change in average utility in the Brexit scenario compared to Scenario 2. For example, Bulgarian citizens lose almost one percentage point in utility growth and Polish citizens lose 1.2%-points. This reflects the fact that the important migration destination U.K. has not become more accessible which affects utility growth negatively: a lower share of citizens of a new member state moves to an important high real income location. In fact, the only country whose citizens experience substantial improvements relative to Scenario 2 are British citizens. They are still worse off than before the enlargement, but less so.

Re-raising migration costs to the U.K. to pre-Enlargement levels leads to migration diversion. In the model, Greece's labor increases by 8.5% in the Brexit scenario compared to 8.3% in Scenario 2. But it is other Eastern European countries who are predicted to receive large migration inflows when Britain is not available as a destination. While the Czech labor force increases by 2.3% in Scenario 2, including Brexit increases the labor force growth rate to almost 6%. Similarly, Hungary's labor force grows by 2.2% in Scenario 2, but by 5.7% in the Brexit case.

Table II.4: Eastern Enlargement and U.K. Single Market Exit

Country	Code	Avg. Utility	Real Income	Labor Force	Diff. to Scen. 2
		——— change in percent ———			pct. pt. change
Austria	AUT	0.018	0.044	0.187	-0.0042
Bulgaria	BGR	0.794	-1.327	-5.363	-0.935
Benelux	BNL	-0.042	-0.026	0.243	-0.022
Czech Rep.	CZE	0.950	-0.774	5.995	-1.604
Germany	DEU	-0.044	-0.014	0.400	-0.013
Denmark	DNK	-0.031	-0.014	0.190	-0.020
Spain	ESP	-0.029	-0.020	0.187	-0.001
Estonia	EST	0.493	-0.223	1.342	-1.126
Finland	FIN	-0.003	0.009	0.076	-0.015
France	FRA	-0.026	-0.017	0.224	-0.008
U.K.	GBR	-0.056	-0.006	0.300	0.357
Greece	GRC	-0.486	-0.485	8.565	0.009
Croatia	HRV	-0.388	-0.371	0.242	0.001
Hungary	HUN	-0.495	-0.976	5.707	-1.586
Ireland	IRL	-0.103	0.062	0.175	-0.023
Italy	ITA	-0.070	-0.050	0.700	-0.005
Lithuania	LTU	3.843	0.606	-6.208	-1.317
Latvia	LVA	0.841	-0.554	2.841	-1.236
Poland	POL	0.505	0.189	-0.162	-1.247
Portugal	PRT	-0.095	-0.036	0.403	0.009
Romania	ROU	1.590	-0.213	-4.790	-0.464
Rest of World	ROW	-0.836	-0.843	-0.0334	-0.001
Slovakia	SVK	9.134	0.701	-8.940	-1.478
Slovenia	SVN	0.757	0.198	-0.886	-0.698
Sweden	SWE	-0.026	-0.011	0.243	-0.018

Note: The table shows the percent changes in average utility, real income, the size of the labor force and the difference in the change in average utility relative to Scenario 2 in percentage points.

II.5.3 Discussion

The results of this Brexit scenario must be interpreted with the assumptions in mind that have been made in both policy dimensions. First, I have assumed that Brexit means that migration policy returns to its state before the Eastern Enlargement. This neglects the fact that the U.K. might restrict its migration policy only for some Eastern European countries or that it might impose additional restrictions for EU citizens. In the tariff dimension I have imposed that both the EU and the U.K. set their tariff levels towards each other to the duties they charge from the rest of the world. This does not account for a possible new trade agreement. Because the sample does not distinguish between other major trading partners of the U.K., such as Japan or the U.S., the tariff changes that the U.K. faces because it drops out of the EU's existing trade agreements are also not included in this exercise.

Additionally, the migration diversion predictions need to be interpreted with caution. It would be wrong to take away from the model that the occurrence of Brexit would lead to strong re-migration of Eastern European workers to their home or neighboring countries. The above exercise neglects the fact that within the time that has passed, other western European countries have also liberalized their labor markets, making it more likely that migration is diverted to other western economies like Germany or France. In the absence of estimates for the change in migration costs from Eastern Europe to these countries, accounting for these important policy changes for a more realistic assessment of the consequences of Brexit for migration is beyond the scope of this paper.

In the spirit of doing trade theory with numbers, however, this exercise is interesting because it highlights the quantitative importance of the trade-off between unilateral migration policy and membership in a comprehensive free trade agreement. In the exercise considered above, a full reversal of migration policy with mild mutual tariff increases upon exit can almost bring the U.K. back to its initial welfare level before the Eastern Enlargement.

II.6 Conclusion

In this chapter I studied the interaction of migration and trade in a quantitative multi-country model with a particular focus on the trade-off between unilateral migration policy and the benefits of membership in a deep regional integration framework. Idiosyncratic preference shocks generate a stable spatial equilibrium of migration featuring two-way flows in tractable analytical expressions, while trade is based on the standard Ricardian multi-country framework. In addition to its interaction with trade through the labor market, migration affects welfare outcomes through technology spillovers and congestion effects on the market for residential land.

I showed that countries that are popular migration destinations following a fall in migration costs may lose from labor market integration in the presence of trade if and only if the integrating countries are dissimilar enough. This is the case because a large inflow of workers exerts downward pressure on the nominal wage, worsening the terms of trade of the receiving country. In a simulation of the model this effect is active even when the externality channels are turned off.

I confronted the model with data on trade and migration from Europe before the

Eastern Enlargement of 2004 and fed into it changes in tariffs and estimates of changes in migration costs for the first phase of the enlargement process from 2004 to 2007. The model predicted the U.K. and Greece to be the main losers from the Eastern Enlargement, while the citizens of the new member states enjoy substantial utility gains, profiting from increased migration opportunities to high wage countries and cheaper access to high-technology goods.

Finally, I considered a simple counterfactual scenario in which the U.K. leaves the European Single Market. Resetting migration costs to pre-Enlargement levels and mutually raising tariffs with the remaining EU can almost return U.K. citizens' welfare to its initial level.

One important avenue for future work is the addition of the complementarity channel of migration as in Borjas (1995, 1999) by differentiating between high-skill and low-skill labor as well as the inclusion of multiple sectors of production. Another fruitful direction for continued research lies in the application of the quantitative approach to trade policy as pioneered by Ossa (2014) to this model, including an extension to the second dimension of migration policy. This would allow for a more comprehensive assessment of equilibrium migration policies and tariff levels following a migration-induced exit from the European Single Market.

Chapter III

Gains from New Goods in a Ricardian Model of Trade

III.1 Introduction

Since David Ricardo's insights on comparative advantage over 200 years ago, there is broad consensus among trade economists that international trade is mutually beneficial for the participating economies. In the public debate, this insight requires continuous defending against variations of the mercantilist position that exports are good and imports are bad. These positions may come in the form of blunt protectionism of the Trumpian kind, or with more subtlety in the form of pride in ever increasing German current account surpluses. While there is agreement on their existence, the academic debate about the sources and the size of the gains from trade is ongoing and constitutes one of the most important questions in the field of international economics.

A wide class of models in the theory of international trade - labeled "quantitative trade models" by Costinot and Rodríguez-Clare (2014) - identify the gains from trade as the inverse of the domestic expenditure share taken to the power of one over the trade elasticity. Since shown by Arkolakis, Costinot, and Rodríguez-Clare (2012), henceforth ACR, this result has found widespread use in quantitative work. The variety of micro structures from which this result can be derived underscores its generality.[1]

[1]The formula is valid for perfect competition models with country-level product differentiation (Armington, 1969) or producer heterogeneity (Eaton and Kortum, 2002), as well as for monopolistic competition models with homogeneous firms (Krugman, 1980) or heterogeneous firms, i.e. Melitz (2003) with

At the same time, there is a sharp divide in the sources of gains from trade these models are based on. While the models proposed by Armington (1969) and Krugman (1980) feature gains from variety only, the more recent models with heterogeneous producers by Eaton and Kortum (2002) and Melitz (2003) with Pareto-distributed productivity predict gains to arise solely because of the reallocation of resources towards the most productive goods (Ricardian specialization) or firms (selection into exporting).[2] In an attempt to quantify the welfare effects of globalization, it seems restrictive to consider only one source of gains from trade at a time.

This paper therefore develops a quantitative model of international trade that features gains from access to new goods and from the reallocation of resources. The model is tractable enough to be matched to aggregate or sectoral trade data. This allows for a quantitative assessment of the magnitude of the gains from trade in comparison to the established models in which those gains are given by the formula from ACR.

The model builds on the multi-country version of the Ricardian trade model by Eaton and Kortum (2002), henceforth EK, in which resources are reallocated towards comparative advantage goods when a country opens up to trade. Introducing one simple change to the model, I assume that countries randomly and independently of one another draw a measure of goods they are able to produce in autarky out of the continuum of producible goods. Given countries' sets of goods available for production, they draw productivities for each of these goods from an appropriately scaled Fréchet distribution. In the open economy different goods are then produced by different sets of producer countries, or *producer sets* for short. Some goods are produced only by two countries, others by more. This implies that, in contrast to the EK model, there is only a subset of goods that is produced by all countries in the world.

This has two important consequences. First, and as in EK, out of the set of goods that were already available for consumption in autarky, consumers can buy from the lowest-cost producer who is potentially located in a foreign country when their country opens up to trade. Second, consumers get access to new goods they were unable to consume in autarky. Unlike in a Krugman or Armington world, consumers are able to choose from which producer to source the newly available goods. In this sense, gains from new goods

Pareto-distributed productivity.

[2]In the Melitz-Pareto model there may be more or fewer varieties available for consumption after the move from autarky to trade depending on the relative size of production and exporting fixed costs. More than just counting varieties, the productivity of the entering firms relative to those exiting matters for welfare. Arkolakis, Demidova, Klenow, and Rodríguez-Clare (2008) make the point that in the case of countable variety gains from abroad, those varieties' prices are higher than those of the exiting domestic firms' prices, canceling the positive welfare effect of increased variety through lower aggregate productivity. Also Feenstra (2010) shows that there are no variety gains on the consumption side using the Sato-Vartia index. In the working paper version of their paper, Hsieh and Ossa (2016) show and discuss this result in a multi-sector environment with asymmetric countries and CES preferences.

and gains from specialization interact in this model and increase the overall gains from trade compared to the standard EK setup. On the other hand, because the vast majority of goods is only offered by a subset of producer countries, the number of possible sourcing locations is reduced for those goods. This reduces the specialization gains. I determine the net effect of these two forces in a quantitative exercise.

Despite the different sets of producible goods across countries the model retains its tractability. It delivers analytical expressions for bilateral trade flows, the real wage and the gains from trade, as well as an (augmented) structural gravity equation. The standard EK model is nested as a special case in which all countries know how to produce all goods.

However, the different measures of goods produced across countries do break the convenient result - highlighted by EK - that the distribution of prices importing consumers actually pay is independent of the origin of the imported goods. Countries produce different sets of goods and the competitive environment differs across producer sets. It matters for the average price whether it is the three most productive countries that produce a good or the three least productive, for example. Consumers optimally shift expenditure to the goods produced by sets of countries that offer particularly cheap prices. This may be the case because the countries in a producer set are all very productive, very close to the importing country, or have low wages. With CES preferences, this expenditure shifting term is parsimonious and helps deliver compact analytical expressions.

To assess the magnitude of the gains from trade in this model, I calibrate it to match aggregate bilateral trade flows between 26 OECD economies. To calibrate the measure of goods produced by each country, I consider two approaches. First, I take guidance from theory and assume that the measure of goods produced by each country is proportional to the size of its labor force so that the share of goods each country is able to produce is proportional to its share of the world population. This is in the spirit of Krugman (1980). This way of calibrating the country-specific goods measures implies that gains from new goods are particularly large in small countries. To alleviate the concern that the average increase in the gains from trade is driven by this small country bias, I also consider a symmetric case in which the share of goods produced by each country is an exogenous constant. This is different from assuming that all countries can produce all goods as in EK. Because countries randomly draw from a continuum of goods, the goods shares producible by each country are equally-sized but still country-specific.

A first important result is that both versions of the model predict more trade than the standard EK model. This stems from the fact that for most of the goods consumed by each country, domestic sourcing is not an option because each country only produces a subset of all goods. The level of trade costs needed to match the calibration target, the observed average trade share in the data, is therefore larger than in a standard EK model. This in itself decreases the implied gains from moving from autarky to trade.

Nonetheless, I find that on average the gains from trade increase by 43% relative to the EK model in the size-proportional case and by 47% in the symmetric case. This implies that the gains from access to new goods more than outweigh the reduction in the gains from specialization that occurs because not all countries are available as sourcing locations for all goods. These similar aggregate numbers hide important differences in the distribution of the gains across countries between the two models. In the size-proportional case, the smallest countries benefit most from access to new goods. This leads to a negative and significant relationship between country size and the increase in the gains from trade relative to the EK model. In the symmetric case, the gains from new goods are more evenly distributed across countries. The relationship between size and the increase in the gains from trade is insignificant here.

A decomposition of the gains from trade into those derived from specialization on comparative advantage goods and those derived from access to new goods and their optimal sourcing reveals a strong positive relationship between country size and the gains from specialization in the size-proportional case. This stems from the fact that larger countries are also able to produce more goods. For the largest country, gains from specialization on own comparative advantage goods account for 12% of total gains. In the symmetric case, the relationship is weaker and negatively signed reflecting the more even distribution of producible goods across countries.

This paper relates to the debate over the size of the gains from trade started by Arkolakis, Costinot, and Rodríguez-Clare (2012). Melitz and Redding (2015) show that small deviations from the restrictions imposed by ACR lead to variable trade elasticities and substantial deviations from ACR for the predicted effects of various trade liberalization scenarios in the heterogeneous firms model. Costinot and Rodríguez-Clare (2014) and Ossa (2015) show that the consideration of varying trade elasticities across industries can significantly increase the predicted gains from trade. Sampson (2016) considers a dynamic version of the heterogeneous firms model with productivity spillovers from incumbent to newly entering firms and finds substantial increases in the gains from trade based on dynamic selection. Arkolakis, Costinot, Donaldson, and Rodríguez-Clare (2018) extend the ACR formula to the case with variable mark-ups using various demand systems. They consider only those demands that conform with the macro restrictions imposed by ACR. They find that the gains from trade implied by the addition of pro-competitive effects are roughly identical to those predicted by CES models. In contrast to these contributions my argument is based on a static, single sector model with CES preferences and without intermediate goods, in which the gains from trade increase because the two standard sources of gains from new goods and reallocation gains interact.

Other contributions introduce additional sources of gains from trade by considering cases in which the ACR restrictions are not satisfied. Head, Mayer, and Thoenig (2014) analyze the effect of a log-normal distribution of productivity. Feenstra (2018) considers a truncated Pareto distribution and QMOR preferences to re-introduce variety and pro-competitive gains into the Melitz-model. He finds that the truncated productivity distribution reduces the gains from resource reallocation so much that the net effect on the gains from trade is negative compared to the unbounded Pareto benchmark without the variety and pro-competitive channels. Relative to these papers, my model is based on a Ricardian framework with heterogeneous producers. The reallocation gains from trade derive from the specialization of countries on their comparative advantage goods instead of expansion of high productivity firms. By abstracting from entry and exit, the gains from new goods in my model are conceptually more similar to Krugman or Armington-type models than to models featuring endogenous selection. However, the possibility to choose the sourcing location for newly available goods introduces a previously unstudied interaction of new goods and reallocation gains from trade. While my model also deviates from one ACR restriction because it does not feature a CES import demand system, the model remains tractable because CES preferences and unbounded (Fréchet) distributions can continue to be used.

This paper also relates to a recent literature that extends the EK model in various directions and applies it in quantitative work, e.g. Alvarez and Lucas, Jr. (2007), Fieler (2011), Shikher (2011), Caliendo and Parro (2015), and Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016). Ramondo and Rodríguez-Clare (2013) consider an extension of the EK model to multinational production and its interaction with goods trade to assess the gains from openness. Their contribution is related to this paper in the sense that they also add an additional channel through which countries gain from openness in a Ricardian model beyond the standard specialization gains. Most closely related is the paper by Somale (2017), who considers the interaction of directed research and comparative advantage. To my knowledge it is the only other work based on EK that modifies the innovation process underlying the Fréchet distribution of productivity. In contrast to Somale (2017), the focus of my work is not on the interaction of research, innovation and comparative advantage, but on the interaction of access to new goods and specialization in determining the magnitude of the gains from trade.

The remainder of the paper is organized as follows. Section III.2 develops the theoretical model. In Section III.3 the quantitative exercise is described and results are presented. Section III.4 concludes.

III.2 A Ricardian Trade Model with Gains from New Goods

In this section I outline a Ricardian model of trade based on EK in which countries produce different sets of goods in autarky. When they open up to trade, consumers can buy previously consumed goods from the lowest-cost supplier and in addition get access to new goods.

To do so, I modify the innovation process that underlies the productivity distribution in the EK model. While the Fréchet distribution of productivity is assumed to be exogenous in EK, Eaton and Kortum (2001) provide a microfoundation of this distribution based on an innovation process that delivers the Fréchet distribution as the technology frontier at some point in time. The innovation process is particularly simple in their model because of the assumption that the continuum of producible goods is identical across countries and has unit measure. I modify this assumption to introduce gains from new goods.

III.2.1 The Technology Frontier

There is a continuum J of goods that is potentially producible. Each country i out of the set $C = \{1, \ldots, N\}$ of countries randomly draws a measure $S_i \subset J$ of goods for which it then possesses a production technology.[3] This model therefore features two randomization stages. First, each country randomly draws a measure of goods S_i. Second, and conditional on this set of goods, the productivities are drawn.

As is shown in Appendix C.1.1, the modified technology frontier is then given by

$$F_i(z, S_i) = Pr\left[Z_i \leq z\right] = \frac{S_i}{J} \exp\left\{-\frac{T_i}{S_i} z^{-\theta}\right\} + \frac{J - S_i}{J}. \tag{III.1}$$

For the fraction of goods $\frac{S_i}{J}$, which i is able to produce, productivity is distributed according to a scaled Fréchet distribution.[4] The goods for which i does not possess the technology have zero productivity, so the probability of having a productivity lower than z is unity.

[3] Without loss of generality, J can be normalized to unity so that S_i is the share of goods producible by country i. I stick to J here for clarity of exposition. However, in the calibration exercise I will assume that S_i is proportional to country size L_i and set J to the sum of all country sizes. This is then equivalent to normalizing J to unity and letting each country produce a share of goods that is proportional to their share of "world" population.

[4] The scaling is consistent with the generalization of the technology frontier noted in Eaton, Kortum, and Kramarz (2011), footnote 11.

III.2.2 Setup of the Model

While utility and pricing are identical to the original model proposed by EK, the interaction of technology frontiers across countries generates new price distributions as I show below.

III.2.2.1 Utility and Pricing

Utility of a representative consumer is identical across countries and is given by the CES aggregate

$$U = \left[\int_0^J q(j)^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}}, \tag{III.2}$$

with $\sigma > 1$. Goods are substitutes and consumers have love of variety. There is perfect competition so that the price offered by country i to n for variety j is

$$p_{ni}(j) = \frac{w_i}{z_i(j)} d_{ni}.^5 \tag{III.3}$$

If j cannot be produced by i, $z_i(j) = 0$ and accordingly the price offered to n goes to infinity. Each country buys from the cheapest source, so that

$$p_n(j) = \min \{ p_{ni}(j), i = 1, \ldots, N \}.$$

III.2.2.2 Technology in the Open Economy

To fix ideas about the way in which the country-specific measures of goods interact in this Ricardian model, consider a world with two countries, i.e. $N = 2$ and $C = \{1, 2\}$. Due to the randomly drawn technologies, the knowledge to produce a good j could be in the possession of each subset of C including C itself. This is the power set of C,

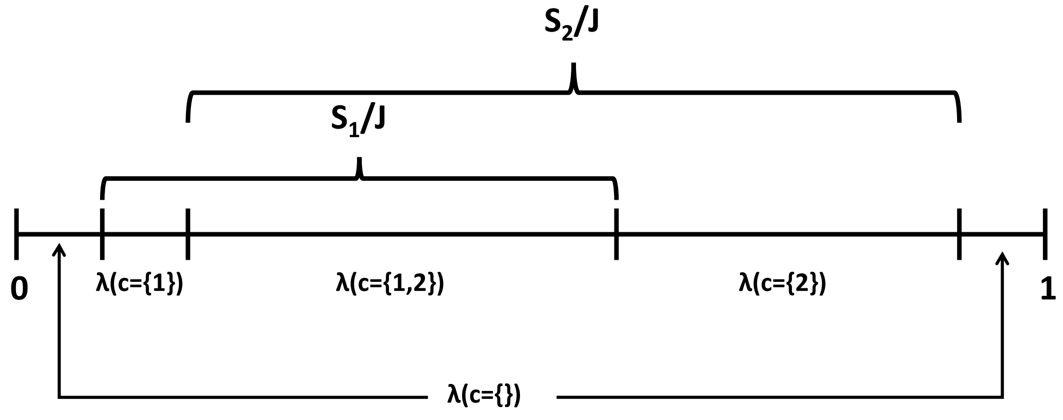
$$\mathcal{P}(C) = \{\{\}, \{1\}, \{2\}, \{1, 2\}\}$$

with cardinality $|\mathcal{P}(C)| = 4 = 2^N$. For what follows, it is useful to define each element $c \in \mathcal{P}(C)$ as a *producer set.*

To be able to work with the producer sets, it is important to determine which goods are produced by which set. Figure III.1 shows a possible distribution of technologies across the two countries for a normalized measure of existing goods. Each country i knows how to produce a fraction S_i/J of all goods. Each producer set is now attached to a range on

[5] The assumption that labor is the only factor of production and that intermediate inputs are not used is made in order to focus on the new mechanism. It can be relaxed easily.

Figure III.1: Technology in the Open Economy



the goods line, whose length is labeled $\lambda(c)$. Intuitively, it must hold that $\sum_c \lambda(c) = 1$ and $\sum_{c:i\in c} \lambda(c) = S_i/J$.[6] This will be shown formally below.

Figure III.1 also shows how specialization and gains from new goods interact in this model. For the goods in $\lambda\left(c = \{1, 2\}\right)$ that are produced by both countries, country 1 can choose whether to source those goods domestically or from abroad, benefiting from lower prices abroad for some goods. The goods in $\lambda\left(c = \{2\}\right)$ are not available for consumption in autarky. These are new goods that introduce gains from new goods for consumers in country 1. Consumers derive no gains from trade for the goods produced only by country 1 in $\lambda\left(c = \{1\}\right)$. They are consumed as in autarky. However, because country 1 is the sole provider of these goods on the world market it will capture full world demand for these just as country 2 captures full world demand for the goods in $\lambda\left(c = \{2\}\right)$. In more complex settings with N countries, country 1 does not only have one foreign country to source from. For most of the new goods, there will be several potential suppliers. Country 1 consumers will therefore benefit from access to these new goods and the fact that they can buy from the lowest-cost producer of each of the new goods. Finally, there is a range of goods $\lambda\left(c = \{\}\right)$ that are not produced at all - no country possesses the technology to produce these goods.

III.2.2.3 The Distribution of Prices

Returning to the full model with N countries, the prices each country offers are determined using equation (III.3) in the technology frontier (III.1). It follows directly that the fraction

[6]The second sum reads as the sum over all producer sets c in which i is an element.

of goods for which i offers a price lower than p to n is

$$\frac{S_i}{J} G_{ni}(p) = \frac{S_i}{J} \left(1 - \exp\left\{-\frac{T_i}{S_i} \left(d_{ni} w_i\right)^{-\theta} p^{\theta}\right\}\right), \tag{III.4}$$

while the fraction of goods for which i offers a *finite* price larger than p to n is

$$\frac{S_i}{J} \left[1 - G_{ni}(p)\right].$$

Because goods are drawn randomly and independently across countries, the fraction of goods for which all countries jointly charge a *finite* price larger than p in n is

$$\prod_{i=1}^{N} \frac{S_i}{J} \left[1 - G_{ni}(p)\right] = \lambda(C) \exp\left\{-p^{\theta} \Phi_n(C)\right\},$$

with $\lambda(C) = \prod_{i=1}^{N} \frac{S_i}{J}$ and $\Phi_n(C) = \sum_{i=1}^{N} \frac{T_i}{S_i} \left(d_{ni} w_i\right)^{-\theta}$. Analogously, for any other producer set $c \neq C$, the fraction of goods for which all *producing* countries jointly charge a finite price larger than p while all non-producing countries have zero productivity for these goods and therefore charge $p \to \infty$ (i.e. their probability of charging a price greater than p is unity) is

$$\prod_{i \in c} \frac{S_i}{J} \left[1 - G_{ni}(p)\right] \prod_{i \notin c} \frac{J - S_i}{J} \cdot 1 = \lambda(c) \exp\left\{-p^{\theta} \Phi_n(c)\right\},$$

with $\lambda(c) = \prod_{i \in c} \frac{S_i}{J} \prod_{i \notin c} \frac{J - S_i}{J}$ and $\Phi_n(c) = \sum_{i \in c} \frac{T_i}{S_i} \left(d_{ni} w_i\right)^{-\theta}$. These expressions reflect the two randomization stages of the model. First, countries randomly draw a set S_i of goods they know how to produce. From the definition above it becomes clear that $\lambda(c)$ is the probability that a good is produced jointly by the countries in c (and only by them). This is then also the share of goods that is offered jointly by the countries in c. The term summarizes the weight attached to each producer set on the goods line. Second, and conditional on this goods share, the exponential summarizes the distribution of prices that are offered to n by the countries in c. $\Phi_n(c)$ then depends on c, because in each producer set different (numbers of) producer countries generate different price distributions in n. The fraction of goods produced by the countries in c and for which the producers jointly charge a price *smaller* than p in n is then given by $\lambda(c) \left(1 - \exp\left\{-p^{\theta} \Phi_n(c)\right\}\right)$. The price distribution in n is then the fraction of *all* goods for which the price p_n that n actually pays is lower than p. Aggregating over producer sets,

$$G_n(p) = Pr\left[p_n < p\right] = 1 - \sum_{c} \lambda(c) \exp\left\{-p^{\theta} \Phi_n(c)\right\}, \tag{III.5}$$

where $\sum_c \lambda(c) = 1$.[7] Equation (III.5) nicely shows how the model nests the EK model as a special case. In EK, all countries produce all goods so that $S_i = J \; \forall \; i$ and therefore $\lambda(C) = 1$ and $\lambda(c) = 0 \; \forall \; c \neq C$. The following lemma summarizes this result.

Lemma III.1 *The $\lambda(c)$ appropriately weight the aggregation across producer sets. In particular it holds that $\sum_c \lambda(c) = 1$ and $\sum_{c:i\in c} \lambda(c) = \frac{S_i}{J}$. Equation* (III.5) *is therefore the aggregate price distribution.*
Proof: *See Appendix C.1.2.*

III.2.3 Goods Shares and the Price Index

Because the aggregation across producer sets is so parsimonious in this model, the standard EK algebra can be applied to derive goods shares and the country-level price index. As is shown in Appendix C.1.3, the fraction of goods that country n buys from i is given by

$$\bar{\pi}_{ni} = \sum_{c:i\in c} \lambda(c) \frac{T_i \left(d_{ni} w_i\right)^{-\theta}}{S_i \Phi_n(c)} = \sum_{c:i\in c} \lambda(c) \pi_{ni}(c). \tag{III.6}$$

At the producer set level, the share of goods bought by n from i depends negatively on trade and production costs and positively on country-level productivity T_i/S_i relative to the corresponding variables of all other competitors, summarized in the $\Phi_n(c)$-term. The dependence of $\Phi_n(c)$ on the producer set is again crucial because (the number of) competitors differ across producer sets. For example, in a set with very few competitors, a country will provide a larger fraction of goods to n simply because there are only few potential suppliers available.[8] These goods shares at the producer set level are then aggregated with the appropriate weight of the producer set on the goods line to the aggregate share of goods bought by n from i. In other words, $\bar{\pi}_{ni}$ denotes the probability that a randomly picked good j is bought in n from i. The answer reflects again the two randomization stages. First, what is the probability that the good is produced by the producer set c and second, conditional on the producer set, what is the probability that the price charged by country i is the lowest price available?[9]

Using similar techniques, the result from equation (III.5) can be applied to derive the CES price index that is dual to the utility function (III.2). As is shown in Appendix

[7] This summation includes the producer set that is the empty set. This set has the weight $\lambda\left(c = \{\}\right) = \prod_{i=1}^{N} \frac{J - S_i}{J}$ and the probability that the price offered to n is larger than p is unity. One way to see this is to recognize that $\Phi_n(c = \{\}) = \sum_{i\in c} \frac{T_i}{S_i} \left(d_{ni} w_i\right)^{-\theta} = 0$ because the sum has no elements.

[8] By construction there is a producer set for each country, in which that country is the sole supplier of a particular range of goods. Because this model assumes perfect competition, this does not have an effect on mark-ups and countries do not exploit their "monopoly".

[9] The derivation in Appendix C.1.3 formally deals with the case in which country i is not an element of a particular producer set.

C.1.4,

$$P_n^{1-\sigma} = \sum_c P_n(c)^{1-\sigma} = \gamma^{1-\sigma} \sum_c \lambda(c) \Phi_n(c)^{\frac{\sigma-1}{\theta}}, \tag{III.7}$$

where γ is a constant and I impose $\theta > \sigma - 1$ in order to obtain a well-defined price index. Also here do the $\lambda(c)$-terms provide the appropriate weighting of the different competitive environments in the individual producer sets as given by the $\Phi_n(c)$-terms. The model collapses again to the EK case when $S_i = J \; \forall \; i$.

III.2.4 Expenditure Shares

In addition to the goods shares and the price index, a third property of the Fréchet distribution is important for the functioning of the model. EK show that the distribution of prices in a country is independent of the location from which goods are sourced. In other words, there is no intensive margin adjustment: when a sourcing location becomes cheaper, the importing country increases the range of goods that are sourced from this location - adding increasingly expensive goods - until the price distribution is again identical to that of the goods that are sourced from other locations. This property allows EK to treat goods shares also as expenditure shares.

That is the case in this model only at the level of each producer set. Conditional on the set of producer countries, goods shares are chosen such that the price distributions equalize across producer countries within the producer set. Therefore $\pi_{ni}(c)$ is the fraction of goods bought from i by n in producer set c and also the fraction of expenditure allocated to country i out of the expenditure *spent on producer set c*.

The fact that different countries produce different (measures of) goods prevents price distributions from being equalized conditional on a sourcing location. Therefore, $\bar{\pi}_{ni}$ is not the share of expenditure allocated by n to goods from i. To arrive at the proper expenditure share, producer set level expenditure shares $\pi_{ni}(c)$ need to be weighted with the share of total expenditure allocated to a particular producer set.

With CES preferences, these expenditure shares are parsimonious. Producer set goods shares need to be weighted simply with the relative size of the producer set's price index,

$$\pi_{ni} = \sum_{c:i \in c} \left(\frac{P_n(c)}{P_n} \right)^{1-\sigma} \pi_{ni}(c). \tag{III.8}$$

Because $1 - \sigma < 0$, producer sets in which prices are low relative to the overall price index receive larger expenditure shares and vice versa. $P_n(c)$ is small when $\Phi_n(c)$ is large. In the model, $\Phi_n(c)$ can be large for two reasons. First, if the producer set contains many countries, the longer sum raises $\Phi_n(c)$. Intuitively, the more countries are active in a producer set, the more numerous are the sourcing options country n faces. The more competitors there are, the more are supplier countries squeezed to selling only their most productive goods, thereby lowering the price index at the producer set level. Second, aggregate productivity, wages and trade costs determine the size of $\Phi_n(c)$. Two producer sets with the same number of competitors can differ in the price indeces they imply if the countries in one of them are much more productive than the ones in the other. Trade costs and wages have similar effects. The price index implied by a producer set with three close countries will - everything else equal - be lower than the price index of a producer set with the identical number of countries that are more distant. The following lemma summarizes these results.

Lemma III.2 *At the producer set level, price distributions are independent of the sourcing location. Because different countries produce different (measures of) goods, this independence result does not hold in the aggregate. Equation* (III.6) *only represents aggregate goods shares. Consumers shift expenditure towards cheaper producer sets so that expenditure shares π_{ni} are given by equation* (III.8).
Proof: *See Appendix C.1.5.*

III.2.5 Bilateral Trade Flows and the Gravity Equation

With expenditure shares properly defined, bilateral trade flows X_{ni} can be written as

$$X_{ni} = \sum_{c:i\in c} \left(\frac{P_n(c)}{P_n}\right)^{1-\sigma} \pi_{ni}(c) X_n, \tag{III.9}$$

where X_n is aggregate expenditure in country n. I show in Appendix C.1.6 that these trade flows satisfy a gravity equation of the form

$$X_{ni} = \frac{\left(\frac{d_{ni}}{P_n}\right)^{-\theta} \Lambda_n}{\sum_{m=1}^{N} \left(\frac{d_{mi}}{P_m}\right)^{-\theta} X_m \Lambda_m} X_n Q_i, \tag{III.10}$$

where $\Lambda_n = \sum_{c:i\in c} \lambda(c)^{\frac{\theta}{\sigma-1}} \left(\frac{P_n(c)}{P_n}\right)^{\theta+1-\sigma}$ is an additional term that reflects the measure of goods produced by the exporting country and the expenditure shares allocated to it by the importing country. It takes the value of 1 in the EK model. As Λ_n sums over all producer sets in which a given exporter is active, this model implies that a country will export a lot if it has a large economic mass Q_i and if it is able to produce many goods. However, Λ_n has no consequences for the (partial equilibrium) elasticity of trade with respect to trade costs because it is monadic. When equation (III.10) is log-linearized, Λ_n is captured by the importer fixed effect. The Λ_m-terms disappear in the exporter fixed effect. The fact that different countries produce different measures of goods has thus only an effect on the *level* of trade flows, but not on (partial equilibrium) percentage *changes* following changes in trade costs.

III.2.6 Equilibrium

The model is closed by two conditions. First, labor markets must clear. With labor as the only factor of production in the economy, labor income in i equals total worldwide sales of a country,

$$w_i L_i = \sum_n \pi_{ni} X_n. \tag{III.11}$$

Second, goods markets clear so that aggregate expenditure is equal to aggregate income,

$$w_i L_i = X_i. \tag{III.12}$$

Taken together, and eliminating domestic sales on both sides of the equation, equations (III.11) and (III.12) imply balanced trade so that total imports equal total exports in each country,

$$\sum_{n \neq i} \pi_{in} X_i = \sum_{n \neq i} \pi_{ni} X_n. \tag{III.13}$$

III.2.7 Autarky and the Gains from Trade

The expression for the gains from trade is the key object to study the interaction of gains from specialization and gains from new goods. I adopt the real wage w_i/P_i as the welfare measure. As shown in Appendix C.1.7, the real wage in the open economy can be written as

$$\left(\frac{w_i}{P_i}\right)_T = \left(\frac{T_i}{S_i \pi_{ii}}\right)^{\frac{1}{\theta}} \gamma^{-1} \left[\sum_{c:i \in c} \lambda(c)^{\frac{\theta}{\sigma-1}} \left(\frac{P_i(c)}{P_i}\right)^{\theta+1-\sigma}\right]^{\frac{1}{\theta}}. \tag{III.14}$$

The autarky real wage $(w_i/P_i)_A$ can be obtained by setting $\pi_{ii} = 1$ and noting that in autarky country i only consumes the fraction S_i/J of goods i it produces itself. Because the prices for all other goods are infinity, the expression in parentheses collapses to $(S_i/J)^{\frac{1}{\sigma-1}}$ and the autarky real wage is

$$\left(\frac{w_i}{P_i}\right)_A = \left(\frac{T_i}{S_i}\right)^{\frac{1}{\theta}} \gamma^{-1} \left(\frac{S_i}{J}\right)^{\frac{1}{\sigma-1}}. \tag{III.15}$$

When countries produce different sets of goods, it is not only country-level productivity T_i that matters for welfare. Because $\theta > \sigma - 1$ and $\sigma > 1$ by assumption, the elasticity of the autarky real wage with respect to the measure S_i of goods producible in the economy is $\frac{1}{\sigma-1} - \frac{1}{\theta} > 0$. In addition to higher productivity, countries that are able to produce more goods are richer in per-capita terms due to love of variety $(1/(\sigma-1))$ despite the fact that the number of available ideas T_i is spread over a larger set of goods $(-1/\theta)$.

Dividing equation (III.14) by equation (III.15), the gains from trade are given by

$$GT_i = \pi_{ii}^{-\frac{1}{\theta}} \left[\sum_{c:i\in c} \left[\frac{\lambda(c)}{(S_i/J)} \right]^{\frac{\theta}{\sigma-1}} \left(\frac{P_i(c)}{P_i} \right)^{\theta+1-\sigma} \right]^{\frac{1}{\theta}}. \tag{III.16}$$

In addition to the well-known inverse of the domestic expenditure share π_{ii}, GT_i contains a second term that reflects how expenditure is spread across producer sets as foreign sourcing locations as well as new goods become available. Recall that $\sum_{c:i\in c} \lambda(c) = S_i/J$ so that the first brackets after the summation simply reflect how the fraction of goods produced by i in autarky is now split up into different producer sets with different (numbers of) competitors. The term in parentheses accounts for the expenditure shares that are allocated to these producer sets. It is important to keep in mind that the price index P_i also contains goods that were unattainable for country i in autarky. The expenditure shares $P_i(c)/P_i$ therefore reflect the gains from new goods indirectly: the larger the measure of new goods available under trade and the cheaper these are, the lower is P_i relative to previously consumable goods in $P_i(c)$ and therefore also the fraction of aggregate expenditure allocated to the previously available goods.

The distinction between the gains from specialization and those from the access to new goods is more easily visible in the following decomposition of the gains from trade. As is shown in Appendix C.1.8, they can be written as

$$GT_i = \underbrace{\left[\sum_{c:i\in c} \frac{\lambda(c)}{S_i/J} \pi_{ii}(c)^{-\frac{\sigma-1}{\theta}} \right]^{\frac{1}{\sigma-1}}}_{GT_{i,SP}} \underbrace{\left(\frac{P_{i,SP}}{P_{i,T}} \right)}_{GT_{i,NG}}, \tag{III.17}$$

where $P_{i,T}$ is the price index in country i with trade and $P_{i,SP}$ is the price index of goods for which gains arise from specialization only, that is, those that i can also produce in autarky: $P_{i,SP}^{1-\sigma} = \sum_{c:i\in c} P_i(c)^{1-\sigma}$. The first term shows how the fraction S_i/J of goods producible in autarky is divided into producer sets with weights $\lambda(c)$ on the goods line and a fraction $\pi_{ii}(c)$ of expenditure allocated to producer set c that is spent on domestic goods. I label those gains *specialization gains* $GT_{i,SP}$. These are gains from trade that stem purely from sourcing some of the autarky goods from other countries at cheaper prices. The second factor measures the relative size of the overall price index to the price index of the goods producible at home *under trade*. Due to love of variety, each new good with a finite price lowers $P_{i,T}$ relative to $P_{i,SP}$. The more new goods there are for country i (i.e. the smaller S_i), the larger is the ratio in parentheses. Therefore, $GT_{i,NG}$

measures the *gains from new goods* that cannot be produced in autarky. These gains also include gains from specialization because the price index of goods sourced from abroad is already optimized with respect to the sourcing locations. This means that the price index $P_{i,T}$ already contains the optimized sourcing decisions of country i for the newly available goods and thus also reflects the specialization of the producer countries.[10] The following proposition summarizes these results.

Proposition III.1 *When countries produce different sets of goods, the gains from trade are given by equation* (III.17)*. The first term measures the gains derived from importing previously producible goods from abroad at lower prices. The second term measures the gains derived from the fall in the price index due to the availability of previously unconsumed goods.*
Proof: *See Appendix C.1.8.*

What can be said about the size of the gains from trade based on equation (III.17)? It is not clear ex-ante whether the overall gains from trade are larger than in the EK model. While the gains from new goods are clearly a new source of gains that is absent in the standard model, the gains from specialization are *reduced* relative to EK, where there are N sourcing options for each good. In this model, the great majority of goods can only be sourced from a subset of all countries. This reduces the gains from specialization as measured by the first part of equation (III.17) and the specialization component that is embedded in the 'New Goods' part of the gains from trade. I assess the relative size of those two forces in the following quantitative exercise.

III.3 Quantitative Exercise

The key new variable in this model is the share of goods produced by each country S_i/J. In the quantitative analysis, I consider two instructive ways of calibrating this variable which are described in detail below.[11] In both cases I follow the theoretical result from Eaton and Kortum (2001) and the calibration exercises conducted by Ramondo and Rodríguez-Clare (2013) and Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016) in calibrating the ratio T_i/L_i proportional to the research intensity μ_i. For clarity of the theoretical effects of this choice, I include this formulation in the following exposition of the two cases before describing the data these variables are matched to.

[10] It seems difficult to disentangle specialization and gains from new goods further because it is unclear what the right counterfactual is. Countries produce different sets of goods, so it is not possible to construct a benchmark price index in which i buys all new goods from one particular country, for example.

[11] I discuss alternative approaches to the one presented here in Section III.3.5.

III.3.1 The Size-Proportional Case

In this first case, I let theory be my guide in the choice of S_i/J. Reflecting the free entry result from Krugman (1980), I assume that the measure of goods produced by a country is proportional to the size of its labor force, so that $S_i = L_i$. The fraction of goods produced by each country is then equal to its share of the world population, $S_i/J = L_i/\sum_k L_k$. This is observationally equivalent to normalizing J to unity (as in EK) and letting countries produce measures of goods proportional to their share in the world population.

The real wage in autarky is then given by

$$\left(\frac{w_i}{P_i}\right)_A = \gamma^{-1}\left(\frac{T_i}{L_i}\right)^{\frac{1}{\theta}}\left(\frac{L_i}{\sum_k L_k}\right)^{\frac{1}{\sigma-1}} = \gamma^{-1}\mu_i^{\frac{1}{\theta}}\left(\frac{L_i}{\sum_k L_k}\right)^{\frac{1}{\sigma-1}}. \tag{III.18}$$

This case is interesting because it highlights a link of this model to the monopolistic competition models of trade. In the standard EK model, $L_i = J = 1$ so that there is a *technological* scale effect. Larger countries have higher aggregate productivity T_i and therefore enjoy a higher real wage in autarky. The theory-consistent choice of the parameterization of the measure of producible goods $S_i = L_i$ exactly cancels this technological scale effect and replaces it with a love of variety scale effect present in the monopolistic competition trade models. Larger countries do produce more ideas but they are absorbed by the larger measure of goods they apply to. Instead, consumers enjoy a higher real wage in autarky through the larger measure of varieties available for consumption and captured by the term $(L_i/\sum_k L_k)^{\frac{1}{\sigma-1}}$.[12]

The gains from trade then become

$$GT_i = \left[\sum_{c:i\in c}\frac{\lambda(c)}{L_i/\sum_k L_k}\pi_{ii}(c)^{\frac{1-\sigma}{\theta}}\right]^{-\frac{1}{1-\sigma}}\left(\frac{P_{i,SP}}{P_{i,T}}\right). \tag{III.19}$$

Because smaller countries produce fewer goods in autarky, gains from new goods decrease in country size. While there are fewer goods that a large country cannot produce in autarky, small countries face a large expansion in the set of consumable goods when they open up to trade. The smaller the country, the larger $P_{i,SP}/P_{i,T}$. The new goods gains from trade are thus of particular benefit to small countries. The size-proportionality of the measure of goods also implies via the gravity equation (III.10) that large countries do not only export a lot because of their economic mass, but also because they have more goods to offer.

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[12] In Krugman (1980), autarky welfare can be written as $P_K^{-1} = \frac{\sigma-1}{\sigma}\varphi\left(\frac{L}{\sigma f}\right)^{\frac{1}{\sigma-1}}$ and in Melitz (2003), autarky welfare is $P_M^{-1} = \frac{\sigma-1}{\sigma}\tilde{\varphi}\left(\frac{L}{\sigma(\bar{\pi}+f)}\right)^{\frac{1}{\sigma-1}}$.

III.3.2 The Symmetric Case

Because the first case creates a strong bias in gains from new goods towards small countries, the concern arises that an increase in the gains from trade relative to the standard EK model may be driven by this assumption. To alleviate this concern, I consider a second, symmetric case in which countries produce equally sized but - due to the random draw - different sets of goods of measure $S_i = 1/N$ with $J = 1$ and N being the number of countries in the model.[13]

In this case, the autarky real wage is given by

$$\left(\frac{w_i}{P_i}\right)_A = \gamma^{-1}\left(\frac{T_i}{S_i}\right)^{\frac{1}{\theta}}\left(\frac{S_i}{J}\right)^{\frac{1}{\sigma-1}} = \gamma^{-1}\left(\mu_i L_i\right)^{\frac{1}{\theta}}\left(\frac{1}{N}\right)^{\frac{1}{\sigma-1}-\frac{1}{\theta}}. \tag{III.20}$$

With this specification, all countries profit from access to new goods to the same extent and the results reflect the interaction of these new goods gains with the country-specific gains from specialization. The gains from trade are here given by

$$GT_i = \left[\sum_{c:i\in c}\lambda(c)N\pi_{ii}(c)^{\frac{1-\sigma}{\theta}}\right]^{-\frac{1}{1-\sigma}}\left(\frac{P_{i,SP}}{P_{i,T}}\right). \tag{III.21}$$

As in the general case, the first term in brackets reflects how consumption spending over the measure $1/N$ of goods that were available in autarky is now spread over other producing countries. In contrast to the size-proportional case above, there is no systematic bias towards small countries in the term reflecting the new goods gains from trade. Each country gets access to an equally-sized measure of new goods.

III.3.3 Calibration

I calibrate the model to match aggregate trade data from 26 OECD countries to assess the effect of the interaction of new goods gains with specialization on the magnitude of the gains from trade.

I use the dataset provided by Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016). Structural parameters to be calibrated are θ and σ, in addition to country sizes L_i, research intensities μ_i, and the matrix d_{ni} of bilateral trade costs.

[13] Note that $1/N$ is chosen only for convenience. I discuss the effect of choosing different constants in Section III.3.4.3.

III.3.3.1 Parameters and Data

The model outlined in Section III.2 implies a log-linear gravity equation. It is therefore model-consistent to turn to the trade literature for estimates of θ. Head and Mayer (2014) find a mean estimate of 3.78 for structural gravity estimates and Simonovska and Waugh (2014) find a value of θ between 4 and 5. I set $\theta = 4$.

In contrast to the EK model, the value of the elasticity of substitution σ matters for the gains from trade in this model. The larger σ, the larger is the elasticity of substitution between goods. This reduces the utility gains from new goods. I follow established estimates in the literature, e.g. Broda and Weinstein (2006), and choose $\sigma = 4$, which is also consistent with the parameter restriction needed for a finite price index, $\theta > \sigma - 1$.

Following Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016), country sizes L_i are set to the measures of equipped labor from Klenow and Rodríguez-Clare (2005). This measure corrects for differences in physical and human capital per worker. They are also used to construct the producible goods measures in the size-proportional case, with $S_i = L_i$ and $J = \sum_i L_i$. It is important to stress that although the producible goods shares add up to unity, producible goods shares of different countries overlap because of the random draw. As a consequence there is also a fraction of the unit measure of goods that is not produced at all as indicated in Figure III.1.

I follow Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016) in setting the research intensity μ_i proportional to the share of country-level R&D-employment. These shares are taken from the World Development Indicators and are averaged over the 1990s. With the assumption that $T_i = \mu_i L_i$, this produces a calibration of technology levels as in Ramondo and Rodríguez-Clare (2013) and Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016).

In principle any cross-section of trade data can be matched perfectly when trade costs are treated as free parameters. It is therefore important to discipline them as a function of known core determinants. To keep things simple, bilateral trade costs are defined as

$$d_{ni} = \exp\{\beta_1\}\, dist_{ni}^{\beta_2} \text{ for } i \neq n,$$

where $dist_{ni}$ is the distance between the most populated cities of countries n and i from *CEPII.* I target a distance elasticity of -1.05, which is well in line with estimates from the literature. See Head and Mayer (2014) for a survey. With $\theta = 4$, this implies a value of $\beta_2 = 0.2625$. β_1 is then calibrated to produce trade flows whose average matches the average bilateral trade in manufacturing in the data. Bilateral trade flows X_{ni} are averaged over 1996-2001 from OECD STAN. The average bilateral trade share in the data is 0.0155.[14]

III.3.3.2 Calibration Procedure

The wage updating function at the heart of the code follows Alvarez and Lucas, Jr. (2007). Given exogenous parameters θ, σ, country sizes L_i and technology levels $T_i = \mu_i L_i$, as well as the matrix of trade costs d_{ni} and an initial wage guess, model outcomes are calculated using the equilibrium expressions for trade shares and price indeces. Aggregate exports and imports of each country are evaluated using an excess demand function. The nominal wages of countries that export more than they import are raised, the others lowered. With the updated wage, new excess demand functions are calculated. This algorithm is repeated until the percentage change in wages falls below some threshold level.

In extending the basic code to allow for different measures of produced goods across countries, the main challenge is the introduction of producer sets. With $N = 26$ countries, there are $2^N = 67108864$ producer sets to be considered. I keep track of them by converting the numbers from 0 to $2^{26} - 1$ into binary numbers, each with 26 places. The permutations of ones and zeros then reflect all possible permutations of producer combinations, where the ones indicate membership of a country in a producer set. For example, the producer set corresponding to the number 67108863 consists of $N = 26$ ones in the binary system and represents the producer set in which all countries are members. The producer set matrix is then an $N \times 2^N$ matrix.

Next, I use the matrix of producible goods measures S_i and $J - S_i$ together with the producer set matrix to calculate the $\lambda(c)$s for each producer set. The producer set matrix is then applied to calculate the $N \times 2^N$ matrix of $\Phi_n(c)$-terms - each country i consumes goods from all producer sets, which differ in their composition. Given the matrix of $\Phi_n(c)$s, application of equation (III.7) first gives the matrix of producer set level price indeces $P_n(c)$ and subsequent summation gives the vector of price indeces P_n consistent with the initial wage guess.

With $\Phi_n(c)$, $P_n(c)$, and P_n in hand, the $N \times N \times 2^N$ matrix of trade shares $\pi_{ni}(c)$ at the producer set level can be constructed. Using equation (III.8) they are then summed over the third dimension to give the $N \times N$ aggregate expenditure trade shares π_{ni} from which aggregate trade flows X_{ni} can be constructed to evaluate the balanced trade condition (III.13).

Due to the large number of producer sets the matrices take up a lot of memory, I divide the producer set matrix into several parts and let the computer calculate each part in turn before summing up to the aggregate total.

[14]Country-level absorption is calculated from the same data as production minus exports plus imports from the sample countries in manufacturing.

Table III.1: Model Overview

model	goods measures	R-squared	β_1	avg GT	median GT
Eaton-Kortum	$S_i/J = 1$	0.9361	0.8206	16.45%	10.95%
New Goods, size-prop.	$S_i/J = L_i/\sum_i L_i$	0.9303	1.1034	23.42%	13.42%
New Goods, symmetric	$S_i/J = 1/N$	0.9379	1.0773	21.88%	14.41%

Note: The column R-squared contains the goodness of fit between the actual bilateral trade flows between 26 OECD countries and those predicted by the model. β_1 is a global trade cost shifter chosen so that the model produces trade flows whose average matches the average trade share in the data.

For the calibration of the parameter β_1 I add an upper level loop over the algorithm calculating the equilibrium that evaluates the average trade share produced by the model after each round. If the average trade share is larger than the targeted value of 0.0155 from the data, β_1 is increased in proportion to the difference between the target and the actual value in the next round until the model outcome equals the target exactly and vice versa.

III.3.4 Results

In this section, the quantitative implications of the model are evaluated. I first consider the size-proportional case in which the measure of goods produced by each country is proportional to the size of its labor force so that there are scale effects as in monopolistic competition models of trade. To analyze the extent to which the results are driven by the fact that this assumption disproportionately allocates large gains from new goods to smaller countries I then continue to examine the symmetric case, in which each country is able to produce an equally-sized share of all goods.

I compare both versions of the New Goods model to the standard EK model. To discipline the models, each of them is calibrated to match the average trade share found in the data so that the calibrated values of β_1 differ between them. Table III.1 summarizes the model characteristics.

While all models match the data well, the value of β_1 that is needed to match the average trade share is higher in the New Goods models than in the standard EK model. This implies that the New Goods models predict higher trade flows for a given level of trade costs, which is a consequence of the fact that countries produce different sets of goods. For each country there is some measure of goods for which home production is not an option. Hence, the fraction of expenditure that is allocated to goods produced at home is lower than in the standard EK model, in which home production is an option for all goods. The need to buy new goods from abroad therefore increases overall trade flows.

This effect can also be seen in the modified gravity equation (III.10). In the proportional case larger countries export more for two reasons. First, because their aggregate expenditure is higher. This is a standard gravity feature. Second, larger countries produce more goods and therefore face more demand for their goods from all over the world. Seen from the importer's perspective, trade flows are now skewed towards large exporter countries beyond the standard gravity effect, because they are a sourcing option for a larger fraction of the goods that are consumed.

In the symmetric case, the calibrated value of β_1 is lower than in the proportional case but still larger than in the standard model. This shows that the larger trade flows are not driven by the proportionality assumption, but arise because domestic sourcing is not an option for all goods. The fact that larger countries are able to produce more goods only strengthens this effect.

In both cases, the gains from trade are larger in the New Goods model than in the standard EK model both on average as well as at the median. These aggregate numbers already provide an important result of the quantitative exercise. The increase in the gains from trade through access to new goods is larger than the loss that comes from a reduced number of sourcing options for many of the consumed goods. There is a net increase in the gains from trade relative to the standard model. Because these numbers mask a lot of heterogeneity, I now turn to analyzing the results in more detail.

III.3.4.1 The Gains from Trade

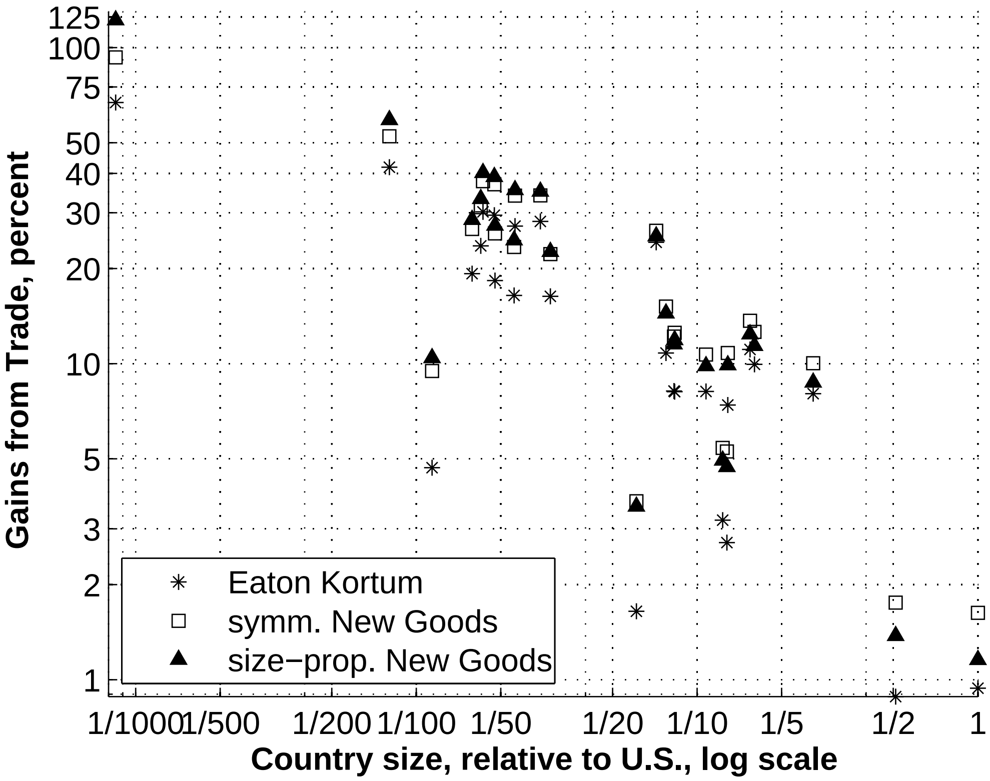
Figure III.2 plots the gains from trade in the standard EK model and the New Goods models as a function of relative country size.[15] The stars show that smaller countries gain more from trade than large ones even when all countries produce all goods. This effect is well established and stems from the fact that small countries face a disproportionate increase in demand for their comparative advantage goods when they open up to trade. In addition, this relationship is reinforced by the way technology levels are calibrated. Because technology is proportional to country size, larger countries are also more productive and will have higher domestic expenditure shares.

The triangles show the gains from trade in the case in which the measure of goods is proportional to country size. All triangles lie above the stars, indicating that across all country sizes the gains from trade in the size-proportional New Goods model are larger than in the EK model. This is also true for the squares, which show the gains from trade in the symmetric case of the New Goods model.

While the increase in the gains from trade from access to new goods outweighs the losses due to the reduced specialization gains for all countries and in both model speci-

[15]I document the numbers corresponding to the data points in all graphs of this section in Appendix C.2.

Figure III.2: Country Size and the Gains from Trade



fications, the assumptions about the relationship between country size and the measure of producible goods matter for the distribution of the additional gains from trade across countries. As the relative position of the triangles and the squares indicates, large countries gain more in the symmetric case than in the size-proportional case because the measure of new goods is larger for them in the symmetric case. Small countries gain more when gains from new goods are particularly strong for them in the size-proportional case.

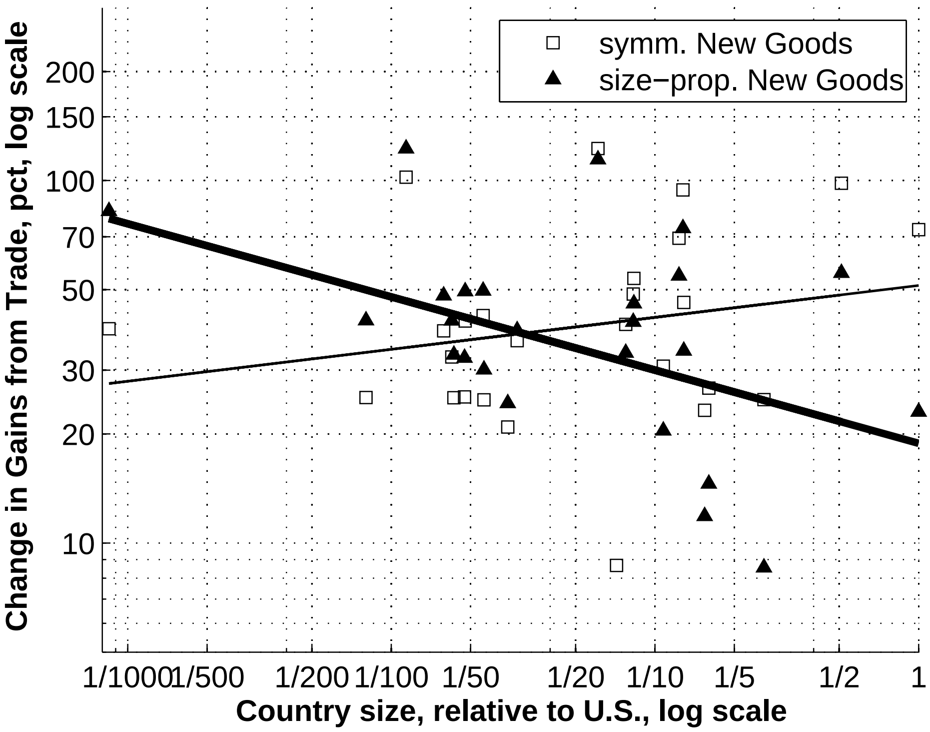
III.3.4.2 The Change in the Gains from Trade

Having established that the interaction of gains from new goods with Ricardian specialization unambiguously increases the gains from trade relative to the standard model, Figure III.3 assesses the *relative* change in the gains from trade compared to the EK model across countries and assumptions about the distribution of producible goods measures.

For example, the data points on the very right-hand side of the graph show the U.S., whose gains from trade are about 23% higher compared to the standard model in the size-proportional case, while those of Iceland, the smallest country, increase by 82%. In the symmetric case, the relationship is reversed. The U.S. gains from trade increase by about 73%, while those of Iceland only increase by about 39%.

More generally, the plot shows that the smallest countries attain the largest percentage

Figure III.3: Country Size and the Change in Gains from Trade



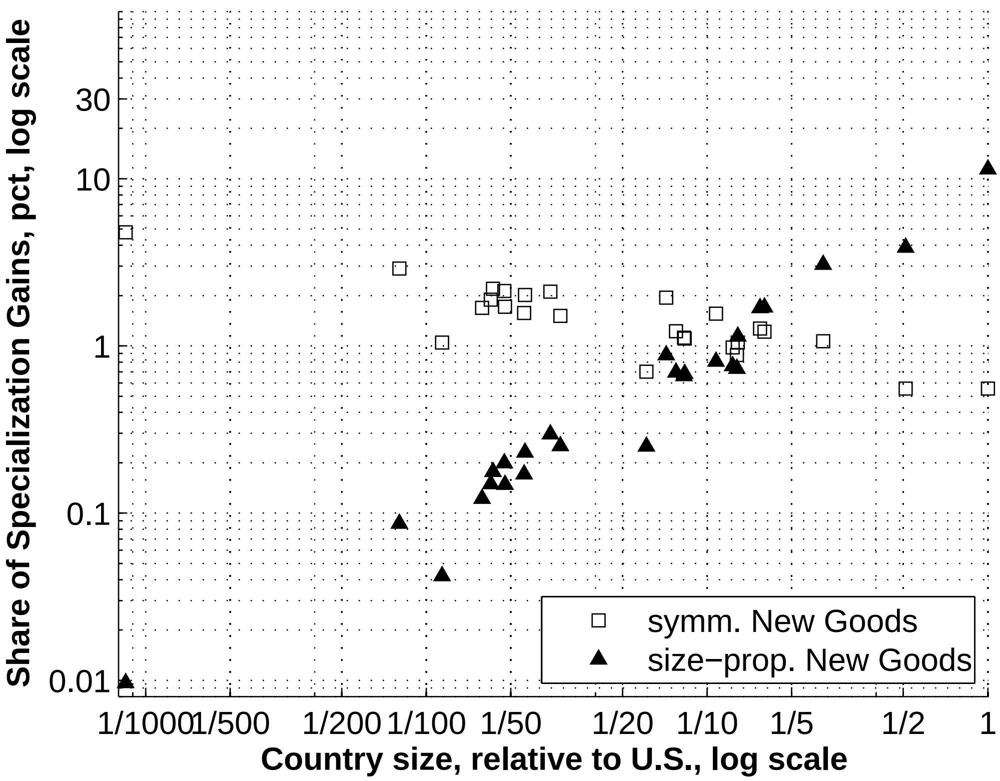
Note: The bold line is fitted to the triangles and the thin line is fitted to the squares.

increases in their gains from trade relative to the EK model in the size-proportional case, when the gains from new goods are largest for them. The elasticity of the relative increase in the gains from trade with respect to country size for the size-proportional case is −0.2022 and is significant at the 5%-level.

In the symmetric case, on the other hand, the relationship between the relative increase in the gains from trade and country size is slightly positive with an elasticity of 0.0881 but insignificant (p-value 0.29). This reflects the fact that the gains from new goods are distributed more evenly across countries in the symmetric case.

Despite the fact that underlying assumptions matter for the distribution of the gains from new goods across countries, on average the increase in the gains from trade relative to the EK model is quite similar in both models. In the size-proportional case the gains from trade increase by 43.42% on average and by 39.71% at the median, while the average increase in the gains from trade in the symmetric case is 46.69% and an increase by 38.77% at the median. The increase in the gains from trade relative to the standard model seems to be quite robust.

Figure III.4: Decomposition of the Gains from Trade



III.3.4.3 Gains from Trade Decomposition

Finally, it is of interest to decompose the contributions of gains from specialization and gains from new goods in this model. Figure III.4 plots the share of gains from trade that are derived from pure specialization (i.e. from sourcing autarky-consumed goods from abroad) against the log of relative country size following the decomposition in equation (III.17).

The share of the gains from specialization in total gains is strongly correlated with country size in the size-proportional case. The elasticity is 1.0023 and significant at the 1%-level. The source of this strong positive relationship is the proportionality of the measure of producible goods with country size. With this assumption, the fraction of goods for which standard Ricardian specialization is possible increases directly with country size, thereby also increasing the share this type of gains accounts for in overall gains from trade. To see this, note that following equation (III.17), it is possible to write the share of the gains from trade derived from specialization on comparative advantage goods as

$$\left(\frac{GT_{i,SP}}{GT_i}\right)_{prop.} = \left(\frac{P_{i,T}}{P_{i,SP}}\right)_{prop.}.$$

From this equation it is clear that the price index of the producible goods under trade $P_{i,SP}$

is smaller for larger countries simply because it contains the prices of a larger measure of goods. Love of variety in preferences causes this effect. It follows that the price index $P_{i,SP}$ is already relatively close to the (even smaller) full price index $P_{i,T}$ so that the share of the gains from trade accounted for by standard specialization is relatively large.

In the symmetric case, the relationship between country size and the share of specialization gains from trade is reversed. The elasticity is -0.2830 and significant at the 1%-level as well. The absolute value of the slope is reduced by more than two thirds compared to the size-proportional case reflecting the even distribution of producible goods across countries. Still, the share of total gains from trade derived from specialization on comparative advantage goods is smaller for larger countries. To understand this relationship, express the share of total gains attributable to specialization gains as unity minus the share of gains from trade coming from new goods. It is then possible to write

$$\left(\frac{GT_{i,SP}}{GT_i}\right)_{symm.} = 1 - \left[\sum_{c:i\in c} \lambda(c) N \pi_{ii}(c)^{\frac{1-\sigma}{\theta}}\right]^{\frac{1}{1-\sigma}},$$

where it is understood that the right-hand side variables $\lambda(c)$ and $\pi_{ii}(c)$ generally differ from their counterparts in the size-proportional case. Because all countries produce equally-sized measures of goods, the only source of variation in the shares of specialization gains across countries are the domestic production shares

$$\pi_{ii}(c) = \frac{\frac{\mu_i L_i}{1/N} w_i^{-\theta}}{\Phi_i(c)}.$$

In contrast to the size-proportional case, the symmetric case features the technological scale effect implied by the microfoundation in Eaton and Kortum (2001) and used in the calibration instead of the love of variety scale effect as in the symmetric case. Larger countries therefore enjoy a higher average productivity. This means that the attractiveness of domestic production increases in country size. Higher $\pi_{ii}(c)$ then reduce the gains from specialization for larger (and hence more productive) countries and also the share of total gains derived from it.

In this model the share of specialization gains as measured by the decomposition formula (III.17) lie below 10% of total gains. It is important to keep in mind that the remaining 90% or more that are allocated to the 'new goods' bin by the formula also contain gains from the possibility to buy the new goods from the cheapest producer, measuring not only 'pure' new goods gains, but also their interaction with Ricardian specialization.

It is also important to note that this ratio is in part driven by the choice of the goods share each country is able to produce. With the share $1/N$ of goods produced by each country, the total measure of consumable goods in the economy is given by $1 - \prod_i \left(1 - \frac{1}{N}\right) = 0.64$ with $N = 26$ under analysis here.[16] If each country were able to produce a fraction $1/10$ of all goods, say, the measure of consumable goods would be $1 - \prod_i \left(1 - \frac{1}{10}\right) = 0.94$. In the standard EK model the value of this exogenous constant does not matter for the gains from trade. Results are identical whether the measure of producible goods is unity as in EK or some other number as it would simply cancel out. In this model, however, this exogenous constant matters because it influences the share of 'pure' specialization gains, i.e. the gains derived from buying goods that are producible at home from a cheaper supplier from abroad. In the case analyzed above, each country is able to produce 6.01% of all *producible* goods. In the example just above, this percentage is at 10.64%. The share of producible goods each country contributes increases in the overall measure of producible goods. This implies that also the share of the gains from trade that is derived from pure specialization is increasing in the measure of producible goods. Intuitively, in the limit, when all countries produce all goods, the model returns to the EK case in which 100% of the gains from trade come from pure specialization. As a consequence there is a decreasing share of goods left to which the interaction of gains from new goods and specialization gains applies. In the limit, the gains from trade therefore also fall back to the level predicted by EK.

III.3.5 Discussion

A key issue of the model is the missing data counterpart for the measure S_i of producible goods for each country. In this paper, I deal with the issue by considering two instructive cases of the model. First, taking guidance from theory, I assume that the measure of producible goods is proportional to country size as given by the free entry result in Krugman (1980). To assess the effect of this strong skewness in the distribution of new goods gains towards small countries I consider a symmetric case in which all countries produce an equally-sized measure of (randomly drawn) goods.

I present three further options that can be considered in future work. The first approach would be to look at highly detailed product-level production data to assess the extent to which various products are produced across countries. This would give a direct data counterpart to this new variable. I have probed this possibility by looking into trade data at the HS6-level from Comtrade (not reported). In these data, all OECD economies under study export at least one unit of an HS6 code to at least one destination for more than 90% of all possible HS6 codes. The coverage rate at the production level is probably

[16]The formula takes the size of the unit continuum of goods and subtracts the share of goods that is not produced by any country, i.e. the probability that no country is able to produce a given good.

higher. This implies that production-level data at even finer levels would be needed to get a sensible measure of S_i. To my knowledge, such detailed product-level *production* data are not widely available. An exception are the 10-digit HS10 codes used by Broda and Weinstein (2006). Additionally, even if such data existed, the number of detailed products produced in each economy is already endogenous to trade.

The second approach borrows a strategy to avoid having to estimate the technology parameters T_i from Fieler (2011). In her paper, she matches the wages to observed wage levels around the world and lets the computer choose appropriate values for T_i to match the calibration target. In principle, it is possible to extend this approach to identify the *adjusted* technology parameter $\frac{T_i}{S_i}$ in the calibration given observed wages. The disadvantage is that both parameters can only be identified jointly, which creates a difficulty in updating the goods shares $\lambda(c)$ as the algorithm searches for a solution because those do not depend on T_i.

A third way forward would be a microfoundation of S_i through some augmented process of research and innovation as in Eaton and Kortum (2001). Though I have adapted the microfoundation of the Fréchet distribution, S_i is exogenous in this model.

III.4 Conclusion

In this paper I developed a quantitative Ricardian trade model that interacts two important sources of gains from trade: gains from the reallocation of resources to the most efficient producers and gains from access to new goods. I introduced gains from new goods into the standard quantitative Ricardian model of trade by letting countries produce randomly drawn and potentially differently sized measures of goods. In the model, goods are then produced by different producer sets. When opening up to trade, consumers in each country gain from the possibility to buy previously consumed goods from low-cost suppliers abroad. In addition, they gain access to new goods that they were not able to consume in autarky. Gains from new goods and from specialization interact because consumers are able to choose the lowest-cost supplier for each new good.

Two forces affect the size of the gains from trade relative to the standard model. First, gains from trade increase because consumers get access to new goods when a country opens up to trade. This channel is absent in the standard model. Second, because countries produce different measures of goods, not all countries are available as a sourcing option for each good. That reduces the gains from Ricardian specialization.

In the quantitative exercise, I calibrated the model to match aggregate trade flows between 26 OECD economies. I considered two cases of the model. In the size-proportional case, smaller countries benefit more from access to new goods because they are only able to produce few goods in autarky. In the symmetric case, gains from new goods are more evenly distributed as countries produce different but equally-sized measures of goods. While these assumptions affect the distribution of the gains from trade across countries, both models predict similarly sized and considerable increases in the gains from trade relative to the standard model.

Chapter A

Appendix Chapter I

A.1 Theory Appendix

A.1.1 Proof of Proposition I.1

Derivation of the supplier cutoff For unethical production to be preferred, we need the total cost savings from unethical production ΔC to be larger than the expected ethical revenue premium $E\left[\Delta R_S\right]$.

$$\begin{aligned}
\Delta C &> E\left[\Delta R_S\right] \\
\left(c_m^e - c_m^u\right) m(\omega)_k^e &> \left(1-\phi_k\right)\left(R(\omega)_k^e - E\left[R(\omega)_k^u\right]\right) \\
\left(c_m^e - c_m^u\right) m(\omega)_k^e &> \left(1-\phi_k\right)\left(1-\gamma\right) R(\omega)_k^e \\
\left(c_m^e - c_m^u\right)\left(1-\beta\right) A\alpha^{\frac{1}{1-\alpha}} \frac{1-\phi_k}{c_m^e} \left[\left(\frac{c_h}{\phi_k}\right)^{\beta}\left(\frac{c_m^e}{1-\phi_k}\right)^{1-\beta}\right]^{-\frac{\alpha}{1-\alpha}} & \\
> \left(1-\gamma\right)\left(1-\phi_k\right) A\alpha^{\frac{\alpha}{1-\alpha}} \left[\left(\frac{c_h}{\phi_k}\right)^{\beta}\left(\frac{c_m^e}{1-\phi_k}\right)^{1-\beta}\right]^{-\frac{\alpha}{1-\alpha}} & \\
\frac{c_m^e - c_m^u}{c_m^e}\left(1-\beta\right)\alpha &> 1-\gamma
\end{aligned}$$

Solving for β using the fact that $c_m^u = \mu c_m^e$ gives that when

$$\beta < \beta_S = 1 - \frac{1-\gamma}{\left(1-\mu\right)\alpha}, \tag{A.1}$$

the supplier will prefer unethical production.

A.1.1.1 Comparative statics

Differentiating w.r.t. $1-\mu$, $1-\gamma$, and $\frac{1}{\alpha}$ delivers

$$\frac{\partial \beta_S}{\partial (1-\mu)} = \frac{1-\gamma}{\alpha (1-\mu)^2} > 0. \tag{A.2}$$

$$\frac{\partial \beta_S}{\partial (1-\gamma)} = -\frac{1}{\alpha (1-\mu)} < 0. \tag{A.3}$$

$$\frac{\partial \beta_S}{\partial \frac{1}{\alpha}} = -\frac{1-\gamma}{(1-\mu)} < 0. \tag{A.4}$$

A.1.2 Proof of Proposition I.2

The cutoff β_l is the value of β that solves

$$\Theta^l(\beta_l) = \left[\left(\frac{\phi_V}{\phi_O}\right)^{\beta_l}\left(\frac{1-\phi_V}{1-\phi_O}\right)^{1-\beta_l}\right]^{\frac{\alpha}{1-\alpha}} \frac{\gamma-\alpha(1-\beta_l)\mu+\phi_V\alpha[\mu-\beta_l(1+\mu)]}{\gamma-\alpha(1-\beta_l)\mu+\phi_O\alpha[\mu-\beta_l(1+\mu)]} = 1 \tag{A.5}$$

with $\gamma, \mu \in (0,1)$ delivering the unethical cutoff β_u. In the corner case of $\gamma = \mu = 1$, the β that solves the equation is β_e.

A.1.2.1 Existence

To show existence of the two cutoffs, we will derive conditions under which the corner cases $\Theta^l(\beta = 1) > 1$ and $\Theta^l(\beta = 0) < 1$ are true, implying that there exists some β_e for which $\Theta^e(\beta_e) = 1$ and some β_u for which $\Theta^u(\beta_u) = 1$.

Case 1: $\beta = 0$ $\quad\Theta^l(\beta)$ reduces to

$$\left(\frac{1-\phi_V}{1-\phi_O}\right)^{\frac{\alpha}{1-\alpha}}\left[\frac{\gamma-\alpha\mu(1-\phi_V)}{\gamma-\alpha\mu(1-\phi_O)}\right]. \tag{A.5'}$$

Case 2: $\beta = 1$ $\quad\Theta^l(\beta)$ becomes

$$\left(\frac{\phi_V}{\phi_O}\right)^{\frac{\alpha}{1-\alpha}}\frac{\gamma-\phi_V\alpha}{\gamma-\phi_O\alpha}. \tag{A.5''}$$

Here, again, $\gamma, \mu \in (0,1)$ deliver Θ^u and $\gamma = \mu = 1$ deliver Θ^e.

Numerator and denominator of each of the two cases differ only in the value of ϕ_k. Substituting x for $1-\phi_k$ in (A.5') and for ϕ_k in (A.5") and recalling that $\frac{1}{2} < \phi_k < 1$, the two cases only differ in the value of μ. Numerator and denominator of any of the two cases can be expressed in general form as

$$x^{\frac{\alpha}{1-\alpha}}\left(\gamma - \alpha\mu x\right). \tag{A.6}$$

Because $\phi_V > \phi_O$ (and thus $1-\phi_V < 1-\phi_O$), conditions that ensure that equation (A.6) has a positive slope in x also ensure that $\Theta^l(\beta=0) < 1$ and $\Theta^l(\beta=1) > 1$.

$$\frac{\partial}{\partial x} x^{\frac{\alpha}{1-\alpha}}\left(\gamma - \alpha\mu x\right) = \frac{\alpha}{1-\alpha} x^{\frac{\alpha}{1-\alpha}}\left(\frac{\gamma}{x} - \mu\right)$$

Because $x \in (0,1)$ and $\alpha \in (0,1)$, the last factor determines the sign of the derivative. We must cover four cases, each of Cases 1 and 2 from above for ethical ($\gamma = \mu = 1$) and unethical production, i.e. with $\gamma, \mu \in (0,1)$.

$$\left.\begin{array}{r}\text{ethical production, } \beta = 0\text{: } \dfrac{1}{x} - 1 \\ \text{ethical production, } \beta = 1\text{: } \dfrac{1}{x} - 1 \\ \text{unethical production, } \beta = 0\text{: } \dfrac{\gamma}{x} - \mu \\ \text{unethical production, } \beta = 1\text{: } \dfrac{\gamma}{x} - 1\end{array}\right\} \overset{!}{>} 0 \tag{A.7}$$

For ethical production, the condition always holds because $\frac{1}{x} > 1$ in both cases. To ensure existence of β_u, both conditions under unethical production must hold, i.e. we must have $\gamma > \mu(1-\phi_O)$ and $\gamma > \phi_V$. As $\gamma > \phi_V$ is the stricter condition, it is also a sufficient condition for existence.

Therefore, with ethical production, $\Theta^e(\beta = 1) > 1$ and $\Theta^e(\beta = 0) < 1$, and hence, β^e exists. With unethical production, if $\gamma > \phi_V$, then $\Theta^u(\beta = 1) > 1$ and $\Theta^u(\beta = 0) < 1$, therefore β^u exists. QED.

A.1.2.2 Uniqueness

To establish uniqueness, we show under which conditions the derivative of $\Theta^l(\beta)$ with respect to β is larger than zero for all $\beta \in [0,1]$. The proof follows the structure of Appendix 2 in Antràs (2003).

Recall that $\phi_V = \phi_O + \delta^\alpha(1-\phi_O)$, where δ is the share of the intermediate the headquarter can continue to use in an integrated firm in case bargaining breaks down.

Using this relationship, $\Theta^l(\beta)$ can be written as

$$\Theta^l(\beta) = \underbrace{\left[1+\frac{\delta^\alpha}{\phi_O\left(1-\delta^\alpha\right)}\right]^{\frac{\alpha\beta}{1-\alpha}}\left(1-\delta^\alpha\right)^{\frac{\alpha}{1-\alpha}}}_{=F_1}\cdot\underbrace{\left[1+\frac{\alpha\delta^\alpha\left(1-\phi_O\right)\left[\mu-\beta\left(1+\mu\right)\right]}{\gamma-\alpha\left(1-\beta\right)\mu+\phi_O\alpha\left[\mu-\beta\left(1+\mu\right)\right]}\right]}_{=F_2}.$$

As before, $\gamma,\mu\in(0,1)$ deliver Θ^u and $\gamma=\mu=1$ deliver Θ^e. The derivative of $\Theta^l(\beta)$ with respect to β is positive if

$$\Theta^{l\prime}(\beta)=\frac{\partial F_1}{\partial\beta}F_2+\frac{\partial F_2}{\partial\beta}F_1>0,$$

with

$$\begin{aligned}
\frac{\partial F_1}{\partial\beta} =& \left(1-\delta^\alpha\right)^{\frac{\alpha}{1-\alpha}}\ln\left(1+\frac{\delta^\alpha}{\phi_O\left(1-\delta^\alpha\right)}\right)\frac{\alpha}{1-\alpha}\left[1+\frac{\delta^\alpha}{\phi_O\left(1-\delta^\alpha\right)}\right]^{\frac{\alpha\beta}{1-\alpha}}\\
\frac{\partial F_2}{\partial\beta} =& \frac{-\alpha\delta^\alpha\left(1-\phi_O\right)\left(1+\mu\right)\left[\gamma-\alpha\left(1-\beta\right)\mu+\phi_O\alpha\left[\mu-\beta\left(1+\mu\right)\right]\right]}{\left(\gamma-\alpha\left(1-\beta\right)\mu+\phi_O\alpha\left[\mu-\beta\left(1+\mu\right)\right]\right)^2}\\
&-\frac{\alpha\delta^\alpha\left(1-\phi_O\right)\left[\mu-\beta\left(1+\mu\right)\right]\left[\alpha\mu-\phi_O\alpha\left(1+\mu\right)\right]}{\left(\gamma-\alpha\left(1-\beta\right)\mu+\phi_O\alpha\left[\mu-\beta\left(1+\mu\right)\right]\right)^2}.
\end{aligned}$$

$\Theta^{l\prime}(\beta)>0$ can be simplified to give

$$\ln\left(1+\frac{\delta^\alpha}{\phi_O\left(1-\delta^\alpha\right)}\right)\Omega\left(\beta,\mu,\gamma\right)>\left[\gamma\left(1+\mu\right)-\alpha\mu\right]\left(1-\alpha\right)\left(1-\phi_O\right)\delta^\alpha$$

where

$$\begin{aligned}
\Omega\left(\beta,\mu,\gamma\right)=&\underbrace{\left[\gamma-\alpha\mu\left(1-\phi_V\right)+\alpha\beta\left[\mu-\left(1+\mu\right)\phi_V\right]\right]}_{\tau_V}\\
&\cdot\underbrace{\left[\gamma-\alpha\mu\left(1-\phi_O\right)+\alpha\beta\left[\mu-\left(1+\mu\right)\phi_O\right]\right]}_{\tau_O}.
\end{aligned}$$

The strategy is now to show that Ω strictly decreases in β and then to plug in the minimum value $\Omega\left(\beta=1,\mu,\gamma\right)$ and show that the relationship still holds at this point. The two multiplicative terms τ_V and τ_O in Ω are symmetric except for the bargaining power parameter ϕ_k, so that

$$\frac{\partial\tau_k}{\partial\beta}=\alpha\left[\mu-\left(1+\mu\right)\phi_k\right]<0,\ k\ \in\ \{V,O\}.$$

To see this note that $\frac{\partial(\mu-(1+\mu)\phi_k)}{\partial\mu}=1-\phi_k>0$. The term therefore reaches its maximum at $\mu=1$, where it becomes $1-2\phi_k$, which is negative because $\phi_k>\frac{1}{2}$ by assumption. To determine the sign of $\frac{\partial\Omega}{\partial\beta}$, we need to determine the sign of τ_k, which can be rewritten as

$$\tau_k = \gamma - \alpha\left[\beta\phi_k + (1-\beta)\,\mu\,(1-\phi_k)\right].$$

The term in brackets can be shown to be smaller than ϕ_k because $\phi_k > \frac{1}{2}$. Therefore the assumption that $\gamma > \phi_V$ from the existence proof is sufficient to ensure a positive τ_k. Maintaining $\gamma > \phi_V$, it follows that under both ethical and unethical production, τ_k is positive. This implies that

$$\frac{\partial\Omega\left(\beta,\mu,\gamma\right)}{\partial\beta} = \frac{\partial\tau_V}{\partial\beta}\tau_O + \frac{\partial\tau_O}{\partial\beta}\tau_V < 0.$$

It follows that Ω attains its smallest value within the admissible range of β at $\beta = 1$. Plugging in $\beta = 1$ into Ω eliminates μ from the function and yields

$$\Omega\left(\beta=1,\gamma\right) = \left(\gamma-\alpha\phi_V\right)\left(\gamma-\alpha\phi_O\right).$$

Note that the assumption $\gamma > \phi_V$ ensures that both factors are positive because $\phi_O < \phi_V$. Expressing ϕ_V in terms of ϕ_O and inserting this for Ω in $\Theta^l(\beta)$ and rearranging then yields

$$\vartheta(\delta) = \ln\left(1+\frac{\delta^\alpha}{\left(1-\delta^\alpha\right)\phi_O}\right) - \frac{\left[\gamma\left(1+\mu\right)-\alpha\mu\right]\left(1-\alpha\right)\left(1-\phi_O\right)\delta^\alpha}{\underbrace{\left[\gamma-\alpha\left(\phi_O+\delta^\alpha\left(1-\phi_O\right)\right)\right]\left(\gamma-\alpha\phi_O\right)}_{=\Omega(\beta=1,\gamma)}} \overset{!}{>} 0.$$

To show that $\vartheta(\delta) > 0$ for all $\delta \in (0,1)$, note that $\vartheta(\delta=0) = 0$ so that $\vartheta(\delta) > 0$ if $\vartheta'(\delta) > 0$. The first derivative of ϑ with respect to δ can be expressed as

$$\begin{aligned}\frac{\partial\vartheta}{\partial\delta} =& \frac{\alpha\delta^{\alpha-1}}{\left(1-\delta^\alpha\right)\left[\delta^\alpha+\phi_O\left(1-\delta^\alpha\right)\right]} - \frac{\left[\gamma\left(1+\mu\right)-\alpha\mu\right]\left(1-\alpha\right)\left(1-\phi_O\right)}{\left(\gamma-\alpha\phi_O\right)\left[\gamma-\alpha\left(\phi_O+\delta^\alpha\left(1-\phi_O\right)\right)\right]^2}\\ &\cdot\left(\alpha\delta^{\alpha-1}\right)\left\{\left[\gamma-\alpha\left(\phi_O+\delta^\alpha\left(1-\phi_O\right)\right)\right]+\alpha\delta^\alpha\left(1-\phi_O\right)\right\} \overset{!}{>} 0.\end{aligned}$$

This can be simplified further to give

$$\left(\gamma-\alpha\phi_V\right)^2 \overset{!}{>} \left[\gamma\left(1+\mu\right)-\mu\alpha\right]\left(1-\alpha\right)\left(1-\phi_V\right)\phi_V \equiv M(\mu).$$

Now note that $\frac{\partial M}{\partial\mu} = \left(\gamma-\alpha\right)\left(1-\alpha\right)\left(1-\phi_V\right)\phi_V$. The sign of the derivative depends on the relationship between γ and α.

Case 1 Consider case 1 where $\gamma < \alpha$ and so $\frac{\partial M}{\partial\mu} < 0$. This implies that for $\mu \in (0,1)$, $M(\mu)$ attains a maximum in the corner case of $\mu = 0$. For the inequality above to hold it is therefore sufficient to prove that

$$(\gamma - \alpha\phi_V)^2 > \gamma(1-\alpha)(1-\phi_V)\phi_V. \tag{A.8}$$

Simplifying and solving for α equivalently gives

$$\alpha^2\phi_V^2 - \alpha\gamma\phi_V(1+\phi_V) + \gamma[\gamma - (1-\phi_V)\phi_V] > 0.$$

The discriminant term of this quadratic equation is given by

$$(1+\phi_V)^2\phi_V^2\gamma^2 - 4\phi_V^2\gamma[\gamma - \phi_V(1-\phi_V)].$$

Simplification shows that the discriminant term is negative if $\gamma > \frac{4\phi_V}{3+\phi_V}$ so that (A.8) has no roots and is thus always positive. Because $\frac{4\phi_V}{3+\phi_V} > \phi_V \ \forall \ \phi_V \in (0,1)$, the inequality (A.8) holds for all $\alpha \in (0,1)$ when $\gamma > \frac{4\phi_V}{3+\phi_V} > \phi_V$ and $\gamma < \alpha$.

We have previously imposed $\gamma > \phi_V$ to guarantee existence of β_u. Now consider values of γ between ϕ_V and $\frac{4\phi_V}{3+\phi_V}$. (A.8) has roots in this parameter range. For (A.8) to hold for all α for some $\gamma < \frac{4\phi_V}{3+\phi_V}$, we would need the smaller of the two roots of (A.8) to be larger than 1, which requires

$$\gamma(1+\phi_V) - 2\phi_V > \sqrt{(1+\phi_V)^2\gamma^2 - 4\gamma[\gamma - (1-\phi_V)\phi_V]}. \tag{A.9}$$

The right-hand side is the discriminant term and is positive because we consider values of $\gamma < \frac{4\phi_V}{3+\phi_V}$. The left-hand side is only positive if $\gamma > \frac{2\phi_V}{1+\phi_V}$, which is larger than $\frac{4\phi_V}{3+\phi_V}$. This implies that in the range of values of γ we consider here, the left-hand side is always negative and so (A.9) never holds for these values. In the rest of the proof, we must therefore impose the stricter condition $\gamma > \frac{4\phi_V}{3+\phi_V}$.

Case 2 Consider case 2 where $\gamma > \alpha$ and so $\frac{\partial M}{\partial \mu} > 0$. This implies that for $\mu \in (0,1)$, $M(\mu)$ attains a maximum at the corner case $\mu = 1$. The relationship to be shown now is

$$(\gamma - \alpha\phi_V)^2 - (2\gamma - \alpha)(1-\alpha)(1-\phi_V)\phi_V > 0. \tag{A.10}$$

Note first that for the left-hand side to be increasing in γ, it has to hold that $\gamma > \phi_V[1 - \phi_V(1-\alpha)]$. Because the term in brackets is smaller than 1, this is true for all $\gamma > \frac{4\phi_V}{3+\phi_V} \geq \phi_V$. It is therefore sufficient to show that (A.10) holds at the minimum level of γ. In this case we assume $\gamma > \alpha$ and impose $\gamma > \frac{4\phi_V}{3+\phi_V} > \phi_V$. Three sub-cases have to be covered.

Case 2a: $\gamma > \alpha > \frac{4\phi_V}{3+\phi_V}$ The minimum value γ can take here is α. Plugging in α for γ in (A.10) and simplifying gives that (A.10) holds when $\alpha > \phi_V$, which is true in this sub-case because $\frac{4\phi_V}{3+\phi_V} > \phi_V$.

Case 2b: $\gamma > \frac{4\phi_V}{3+\phi_V} > \alpha > \phi_V$ The minimum value γ can take here is $\frac{4\phi_V}{3+\phi_V}$. Case 2a has shown that if $\alpha > \phi_V$, (A.10) holds for $\gamma > \alpha$ which also holds in this case.

Case 2c: $\gamma > \frac{4\phi_V}{3+\phi_V} > \phi_V > \alpha$ Plugging in ϕ_V for γ in (A.10) results in the necessary condition of $\alpha < \phi_V$ for (A.10) to hold, which is true here. (A.10) therefore holds for $\gamma > \phi_V$ when $\phi_V > \alpha$. This includes $\frac{4\phi_V}{3+\phi_V} > \phi_V$. QED.

A.1.2.3 Relative Size of the Two Integration Cutoffs

We prove that $\beta_u > \beta_e$ by showing that (1) $\frac{\partial \beta_u}{\partial \mu} < 0$ for all $\mu \in (0,1]$ and $\gamma \in \left(\frac{4\phi_V}{3+\phi_V}, 1\right]$ and that (2) $\frac{\partial \beta_u}{\partial \gamma} < 0$ for all $\mu \in (0,1]$ and $\gamma \in \left(\frac{4\phi_V}{3+\phi_V}, 1\right]$. This includes the corner case of $\mu = \gamma = 1$, in which $\beta_u = \beta_e$. This implies that starting from the case $\beta_u = \beta_e$, any marginal decrease in either μ or γ increases β_u and continues to do so over the admissible range of the two parameters. We prove this using implicit differentiation of

$$\begin{aligned}\Theta^u(\beta_u) = F_1 \cdot F_2 = &\left[1 + \frac{\delta^\alpha}{\phi_O (1-\delta^\alpha)}\right]^{\frac{\alpha\beta_u}{1-\alpha}} (1-\delta^\alpha)^{\frac{\alpha}{1-\alpha}} \\ &\cdot \left[1 + \frac{\alpha\delta^\alpha (1-\phi_O) [\mu - \beta_u (1+\mu)]}{\gamma - \alpha (1-\beta_u) \mu + \phi_O \alpha [\mu - \beta_u (1+\mu)]}\right] = 1\end{aligned}$$

with respect to μ and γ.

Derivative of β_u with respect to μ First note that

$$\frac{\partial F_1}{\partial \mu} = (1-\delta^\alpha)^{\frac{\alpha}{1-\alpha}} \ln\left(1 + \frac{\delta^\alpha}{\phi_O (1-\delta^\alpha)}\right) \left[1 + \frac{\delta^\alpha}{\phi_O (1-\delta^\alpha)}\right]^{\frac{\alpha\beta_u}{1-\alpha}} \frac{\alpha}{1-\alpha} \frac{\partial \beta_u}{\partial \mu},$$

$$\begin{aligned}\frac{\partial F_2}{\partial \mu} = &\frac{\alpha\delta^\alpha (1-\phi_O) \left[1 - \frac{\partial \beta_u}{\partial \mu} - \left(\beta_u + \mu\frac{\partial \beta_u}{\partial \mu}\right)\right] [\gamma - \alpha (1-\beta_u) \mu + \phi_O \alpha [\mu - \beta_u (1+\mu)]]}{\{\gamma - \alpha (1-\beta_u) \mu + \phi_O \alpha [\mu - \beta_u (1+\mu)]\}^2} \\ &- \frac{\alpha\delta^\alpha (1-\phi_O) [\mu - \beta_u (1+\mu)] \left[\alpha\left(\beta_u + \mu\frac{\partial \beta_u}{\partial \mu}\right) - \alpha + \phi_O \alpha \left[1 - \frac{\partial \beta_u}{\partial \mu} - \left(\beta_u + \mu\frac{\partial \beta_u}{\partial \mu}\right)\right]\right]}{\{\gamma - \alpha (1-\beta_u) \mu + \phi_O \alpha [\mu - \beta_u (1+\mu)]\}^2}\end{aligned}$$

and that $\frac{\partial 1}{\partial \mu} = 0$. Combining the terms to write $\frac{\partial F_1}{\partial \mu} F_2 + F_1 \frac{\partial F_2}{\partial \mu} = 0$ and simplification by multiplying through with the denominator term from $\frac{\partial F_2}{\partial \mu}$ gives that

$$\begin{aligned}
&\ln\left(1 + \frac{\delta^\alpha}{\phi_O (1 - \delta^\alpha)}\right) \Omega(\beta_u, \gamma, \mu) \frac{\partial \beta_u}{\partial \mu} = \delta^\alpha (1 - \phi_O)(1 - \alpha) \cdot \\
&\left\{ \left[\alpha \left(\beta_u + \mu \frac{\partial \beta_u}{\partial \mu} \right) - \alpha + \alpha \phi_O \left[1 - \frac{\partial \beta_u}{\partial \mu} - \left(\beta_u + \mu \frac{\partial \beta_u}{\partial \mu} \right) \right] \right] [\mu - \beta_u (1 + \mu)] \right. \\
&\left. - \left[1 - \frac{\partial \beta_u}{\partial \mu} - \left(\beta_u + \mu \frac{\partial \beta_u}{\partial \mu} \right) \right] [\gamma - \alpha (1 - \beta_u) \mu + \phi_O \alpha [\mu - \beta_u (1 + \mu)]] \right\},
\end{aligned}$$

where $\Omega(\beta_u, \gamma, \mu)$ is defined as above. The term in braces can then be simplified and the expression becomes

$$\begin{aligned}
&\ln\left(1 + \frac{\delta^\alpha}{\phi_O (1 - \delta^\alpha)}\right) \Omega(\beta_u, \gamma, \mu) \frac{\partial \beta_u}{\partial \mu} \\
=&\delta^\alpha (1 - \phi_O)(1 - \alpha) \left\{ \frac{\partial \beta_u}{\partial \mu} [\gamma (1 + \mu) - \alpha \mu] - \gamma (1 - \beta_u) - \alpha \beta_u^2 (1 - \mu) \right\},
\end{aligned}$$

which can be rearranged to

$$\begin{aligned}
&\frac{\partial \beta_u}{\partial \mu} \left[\delta^\alpha (1 - \phi_O)(1 - \alpha) [\gamma (1 + \mu) - \alpha \mu] - \ln\left(1 + \frac{\delta^\alpha}{\phi_O (1 - \delta^\alpha)}\right) \Omega(\beta_u, \gamma, \mu) \right] \\
=&\delta^\alpha (1 - \phi_O)(1 - \alpha) \left[\gamma (1 - \beta_u) + \alpha \beta_u^2 (1 - \mu) \right].
\end{aligned}$$

Notice that the term on the right-hand side is positive for the admissible ranges of the parameters. In particular, it is also positive for $\gamma, \mu \in (0, 1]$. To get $\frac{\partial \beta_u}{\partial \mu} < 0$, we need that the term in square brackets on the left-hand side is negative, or equivalently that

$$\delta^\alpha (1 - \phi_O)(1 - \alpha) [\gamma (1 + \mu) - \alpha \mu] < \ln\left(1 + \frac{\delta^\alpha}{\phi_O (1 - \delta^\alpha)}\right) \Omega(\beta_u, \gamma, \mu).$$

Because we assume $\phi_k > \frac{1}{2}$, we know from the uniqueness proof in Section A.1.2.2 that $\Omega(\beta_u, \gamma, \mu)$ has a minimum at $\beta_u = 1$. Plugging in $\beta_u = 1$ and rearranging shows that we need

$$\ln\left(1 + \frac{\delta^\alpha}{\phi_O (1 - \delta^\alpha)}\right) - \frac{\delta^\alpha (1 - \phi_O)(1 - \alpha) [\gamma (1 + \mu) - \alpha \mu]}{\Omega(\beta_u = 1, \gamma, \mu)} \equiv \vartheta(\delta) > 0$$

to obtain $\frac{\partial \beta_u}{\partial \mu} < 0$. In the uniqueness part in Section A.1.2.2 above it has been shown that the condition above holds if $\gamma > \frac{4\phi_V}{3+\phi_V}$, and in particular this holds when $\mu = \gamma = 1$. $\frac{\partial \beta_u}{\partial \mu} < 0$ for $\mu \in (0, 1]$ and $\gamma \in \left(\frac{4\phi_V}{3+\phi_V}, 1 \right]$ implies that β_u is increasing in the unethical cost advantage $1 - \mu$ for any of these values of μ and γ.

Derivative of β_u with respect to γ First note that

$$\frac{\partial F_1}{\partial \gamma} = F_1 \ln\left(1 + \frac{\delta^\alpha}{\phi_O(1-\delta^\alpha)}\right)\frac{\alpha}{1-\alpha}\frac{\partial \beta_u}{\partial \gamma}$$

and

$$\frac{\partial F_2}{\partial \gamma} = \frac{-\alpha\delta^\alpha(1-\phi_O)[\mu - \beta_u(1+\mu)] - \alpha\delta^\alpha(1-\phi_O)[\gamma(1+\mu) - \alpha\mu]\frac{\partial \beta_u}{\partial \gamma}]}{(\gamma - \alpha(1-\beta_u)\mu + \phi_O\alpha[\mu - \beta_u(1+\mu)])^2}.$$

Combining those two derivatives in the equation $F_1\frac{\partial F_2}{\partial \gamma} + F_2\frac{\partial F_1}{\partial \gamma} = 0$ and solving for $\frac{\partial \beta_u}{\partial \gamma}$ gives

$$\frac{\partial \beta_u}{\partial \gamma} = \frac{(1-\alpha)\delta^\alpha(1-\phi_O)[\mu - \beta_u(1+\mu)]}{\ln\left(1 + \frac{\delta^\alpha}{\phi_O(1-\delta^\alpha)}\right)\Omega(\beta_u, \mu, \gamma) - \delta^\alpha(1-\phi_O)(1-\alpha)[\gamma(1+\mu) - \alpha\mu]}.$$

The sign of the derivative is ambiguous. The denominator is positive, including the case of $\mu = \gamma = 1$, as can be seen from the uniqueness proof in Section A.1.2.2. The numerator is only negative if $\beta_u > \frac{\mu}{1+\mu}$, where $\frac{\mu}{1+\mu}$ reaches its maximum of $\frac{1}{2}$ at $\mu = 1$. Therefore, $\frac{\partial \beta_u}{\partial \gamma} < 0$ iff $\beta_u > \frac{1}{2}$.

The strategy is now to show that $\beta_e > \frac{1}{2}$. This will then imply that when $\mu = \gamma = 1$ and thus $\beta_u = \beta_e$, the numerator is negative and thus $\frac{\partial \beta_u}{\partial \gamma} < 0$. This then proves that starting from $\beta_u = \beta_e$, any decrease in γ increases β_u and does so for the whole range of admissible parameter values, i.e. $\mu \in (0, 1]$ and $\gamma \in \left(\frac{4\phi_V}{3+\phi_V}, 1\right]$. To see this, consider the parameter condition needed to produce $\beta_e = \frac{1}{2}$ as the ethical integration cutoff. $\Theta^e\left(\beta_e = \frac{1}{2}\right) = 1$ after some algebra simplifies considerably to

$$\phi_O = D(\delta) \equiv \frac{1-\delta^\alpha}{2-\delta^\alpha}.$$

As $\delta, \alpha \in (0, 1)$, $D(\delta)$ reaches its maximum of $\frac{1}{2}$ as $\delta \to 0$. This means that to have $\beta_e = \frac{1}{2}$, we need $\phi_O = D(\delta)$ with $D(\delta) < \frac{1}{2}$. This is ruled out by the initial assumption that $\phi_O > \frac{1}{2}$, which we carry over from Antràs (2003). We have now merely shown that $\beta_e = \frac{1}{2}$ is impossible under the imposed parameter restrictions. The proof is only complete if we show that any $\beta_e < \frac{1}{2}$ requires a value of ϕ_O whose maximum also lies below $\frac{1}{2}$. Therefore, we show that $\frac{\partial \beta_e}{\partial \phi_O} > 0$, implying that a decrease in β_e requires a reduction in ϕ_O, c.p. Implicit differentiation yields that

$$\frac{\partial \beta_e}{\partial \phi_O} = \frac{\frac{\Omega(\beta_e)\beta_e\delta^\alpha}{\phi_O[\phi_O(1-\delta^\alpha)+\delta^\alpha]} + \delta^\alpha(1-\alpha)[1-2\beta_e][1-\alpha\beta_e]}{\ln\left(1 + \frac{\delta^\alpha}{\phi_O(1-\delta^\alpha)}\right)\Omega(\beta_e) - \delta^\alpha(1-\phi_O)(1-\alpha)[2-\alpha]}.$$

The sign of the derivative is again determined by the sign of the numerator. The denominator is positive as has been shown in the uniqueness part of the proof in Section A.1.2.2. If $\beta_e \leq \frac{1}{2}$, the numerator is positive. Therefore, for $\beta_e \leq \frac{1}{2}$, a marginal decrease in β_e would require a decrease in ϕ_O. So in order to have a $\beta_e < \frac{1}{2}$ we require $\phi_O < D(\delta)$, which is ruled out by the initial assumption of $\phi_O > \frac{1}{2}$. QED.

A.1.3 Proof of Proposition I.3

For the proofs of Cases 2 and 3 note that the existence part of the proof of Proposition I.2 specifies conditions for which $\Theta^u(\beta_u)$ and $\Theta^e(\beta_e)$ are *smaller* than 1 and *larger* than 0, respectively. Therefore, as long as these conditions hold, $\beta_e \in (0,1)$ and $\beta_u \in (0,1)$. Showing that $\beta_S \leq 0$ and $\beta_S = 1$ are possible within the admissible range of the parameters determining the cutoff proves the existence of Cases 2 and 3. With these preliminaries, it is unnecessary to consider partial derivatives of β_e and β_u with respect to μ and γ, because by Proposition I.2, $\beta_e, \beta_u \in (0,1)$.

Case 3 For this case we show that as the unethical cost advantage goes to zero ($\mu \to 1$), $\beta_S \to -\infty$ so that unethical production is never chosen.

$$\lim_{\mu \to 1} \beta_S = \lim_{\mu \to 1} \left[1 - \frac{1-\gamma}{\alpha\,(1-\mu)} \right] = -\infty. \tag{A.11}$$

Case 2 For this case we show that $\beta_S \to 1$ as the threat of a consumer boycott goes to zero ($\gamma \to 1$) so that ethical production is never chosen.

$$\lim_{\gamma \to 1} \beta_S = \lim_{\gamma \to 1} \left[1 - \frac{1-\gamma}{\alpha\,(1-\mu)} \right] = 1 - \frac{0}{\alpha\,(1-\mu)} = 1. \tag{A.12}$$

Case 1 Consider some $\beta_S \in (-\infty, 1)$. Case 1 trivially exists if $\beta_e < \beta_S < \beta_u$. Case 1 also exists starting from any value of $\beta_S < \beta_e$ or $\beta_S > \beta_u$. If $\beta_S < \beta_e$, increasing $\gamma \to 1$ will necessarily move $\beta_S \to 1$, while $\beta_e, \beta_u \in (0,1)$. For some values of γ given μ and α, it must be the case that $\beta_e < \beta_S < \beta_u$. If $\beta_S > \beta_u$, increasing $\mu \to 1$ will necessarily move $\beta_S \to -\infty$, while $\beta_e, \beta_u \in (0,1)$. For some values of μ given γ and α, it must be the case that $\beta_e < \beta_S < \beta_u$. QED.

A.1.4 Proof of Proposition I.4

It has been shown in the proof of Proposition I.2 in Section A.1.2.3 that $\frac{\partial \beta_u}{\partial \mu} < 0$ for $\mu \in (0,1]$ and $\gamma \in \left(\frac{4\phi_V}{3+\phi_V}, 1\right]$. It follows directly that $\frac{\partial \beta_u}{\partial (1-\mu)} > 0$ for these parameter values. It has been shown in the proof of Proposition I.1 in Section A.1.1 that $\frac{\partial \beta_S}{\partial (1-\mu)} > 0$.

Moreover, it can be seen from equation (I.19) that β_e does not depend on μ or γ. Therefore, $\frac{\partial \beta_e}{\partial \mu} = 0$. QED.

A.1.5 Proof of Proposition I.5

The proof follows closely the proof of Proposition I.1 in terms of structure. When the headquarter can also set the technology of the match in addition to the organizational form, the key difference is that the headquarter takes the overall surplus into account when deciding between ethical and unethical production. The headquarter again compares the total cost savings from unethical production ΔC to the expected ethical revenue premium, which we now label $E[\Delta R]$, which is given by the sum of the suppliers and the headquarters revenue premium. Therefore, the term $(1-\phi_k)$ on the right-hand side, which denoted the revenue share allocated to the supplier in the proof of Proposition I.1 is now replaced by unity.

$$\begin{aligned}
\Delta C &> E[\Delta R] \\
(c_m^e - c_m^u)\, m(\omega)_k^e &> (R(\omega)_k^e - E[R(\omega)_k^u]) \\
(c_m^e - c_m^u)\, m(\omega)_k^e &> (1-\gamma)\, R(\omega)_k^e \\
(c_m^e - c_m^u)(1-\beta) A\alpha^{\frac{1}{1-\alpha}} \frac{1-\phi_k}{c_m^e} \left[\left(\frac{c_h}{\phi_k}\right)^{\beta}\left(\frac{c_m^e}{1-\phi_k}\right)^{1-\beta}\right]^{-\frac{\alpha}{1-\alpha}} & \\
> (1-\gamma) A\alpha^{\frac{\alpha}{1-\alpha}} \left[\left(\frac{c_h}{\phi_k}\right)^{\beta}\left(\frac{c_m^e}{1-\phi_k}\right)^{1-\beta}\right]^{-\frac{\alpha}{1-\alpha}} & \\
\frac{c_m^e - c_m^u}{c_m^e}(1-\phi_k)(1-\beta)\,\alpha > 1-\gamma &
\end{aligned}$$

Solving for β using the fact that $c_m^u = \mu c_m^e$ gives that when

$$\beta < \beta_{H,k} = 1 - \frac{1-\gamma}{(1-\mu)\,\alpha\,(1-\phi_k)} < \beta_S, \tag{A.13}$$

the headquarter will prefer unethical production. Note that this cutoff now depends on the organizational form of the firm. $\beta_{H,O} > \beta_{H,V}$ because $\phi_V > \phi_O$. Because $1-\phi_k < 1$, both cutoffs are smaller than β_S from the baseline model.

A.1.5.1 Existence of the described pattern

From Section A.1.3 we know that by letting $\gamma \to 1$, $\beta_S \to 1$ and by letting $\mu \to 1$, $\beta_S \to -\infty$. Because the new cutoffs $\beta_{H,k}$ with $k \in \{V, O\}$ differ from β_S only by a positive factor in the denominator, the results from Proposition I.3 can be directly applied to the cutoffs derived above. Therefore, there is a non-empty set of admissible values of γ, α and μ that ensures that for any $\phi_k > \frac{1}{2}$, there exists a range of $\beta \in (\beta_{H,O}, \beta_S) \wedge \beta \in (\beta_e, \beta_u)$. QED.

A.1.6 Proof of ambiguous effects of α and γ on $\bar{\beta}$

It has been shown in the proof of Proposition I.2 in Section A.1.2.3 that $\frac{\partial \beta_u}{\partial \gamma} < 0$ for $\mu \in (0, 1]$ and $\gamma \in \left(\frac{4\phi_V}{3+\phi_V}, 1\right]$. It follows directly that $\frac{\partial \beta_u}{\partial(1-\gamma)} > 0$ for these parameter values. It has been shown in the proof of Proposition I.1 in Section A.1.1 that $\frac{\partial \beta_S}{\partial(1-\gamma)} < 0$. Therefore, the effect of $1-\gamma$ on the outsourcing cutoff is ambiguous.

We show the ambiguity of the effect of $1/\alpha$ on the outsourcing cutoff with two numerical examples. Consider the following set of parameter values: $\phi_O = 0.6$, $\delta = 0.5$, $\alpha = 0.8$ and $\gamma = 0.88$. This implies that $\phi_V = 0.8297$. Note that $\frac{4\phi_V}{3+\phi_V} = 0.8666$ and therefore it holds that $\gamma > \frac{4\phi_V}{3+\phi_V}$. Setting $\mu = 0.3$ and using numerical solution methods implies that $\bar{\beta} = \beta_S$ and therefore $\frac{\partial \bar{\beta}}{\partial(1/\alpha)} < 0$. Changing the value of μ to $\mu = 0.5$ implies that $\bar{\beta} = \beta_c$. Using numerical solution methods, it can also be shown that an increase in $1/\alpha$ leads to an increase in $\bar{\beta}$, where β_c remains the outsourcing cutoff. Therefore, in this case, $\frac{\partial \bar{\beta}}{\partial(1/\alpha)} > 0$. QED.

A.1.7 Solving the Microfounded Model

We solve the microfounded model by backward induction. As we have seen above, in period t_5, all firms not having faced a boycott in period t_3 set the same price and generate the same revenues as in equation (I.5) of the baseline model. Bargaining takes place in period t_4 and also delivers the same outcome as in the baseline model. In period t_3 nature decides which of the unethical firms face a boycott. A fraction $1-\gamma$ of firms is investigated. The unethical firms among them are boycotted. In period t_2, production of intermediates takes place, again with the same quantities as in the baseline model.

These quantities are chosen in period $t_1(b)$ and are given by (I.9) for the headquarter and by (I.10) for the supplier. Firms who choose to produce ethically and those who would like to be unethical but only have the ethical technology available reach these investment quantities in the investment game with continuous best response functions. Firms who have the unethical technology available and whose suppliers choose to use it, optimally mimic the firms who are forced to be ethical.

In period $t_1(a)$, the supplier finds out whether it is able to use the unethical technology in the production of the variety ω it has been matched with. It then maximizes expected profits by comparing expected unethical profits of mimicking $E(\pi^u_{S,k})$ to the certain profits of ethical production $\pi^e_{S,k}$ (as well as the outcome of zero demand in case of openly unethical production, which is never optimal). This comparison is identical to the baseline model. Although only a fraction κ of firms are able to use the unethical technology, from the perspective of an unethical firm the probability of being investigated and being hit by a boycott is $1-\gamma$. Therefore, as in the baseline model, the supplier would prefer unethical production whenever $\beta < \beta_S = 1 - \frac{1-\gamma}{\alpha(1-\mu)}$. Only a fraction κ of suppliers is able to use the unethical technology, the others must choose ethical production even if $\beta < \beta_S$. Investments are then made simultaneously and non-cooperatively, where the headquarter spends $c_h h(\omega)_k^e$ on headquarter services and the supplier spends $c_m^e m(\omega)_k^e$ in case of ethical production and $c_m^u m(\omega)_k^e$ otherwise.

In period t_0, the headquarter chooses the organizational form and extracts a transfer payment before knowing whether the supplier will be able to use the unethical technology. As in the baseline model, the headquarter intensity β determines the organization of production. If $\beta > \beta_S$, the supplier will implement the ethical technology in period $t_1(a)$. The headquarter then chooses outsourcing for $\beta < \beta_e$ and integration otherwise and extracts a transfer payment amounting to the full profits of the supplier under ethical production $\pi_{S,k}^e$ given by equation (I.14) in the baseline model.

If $\beta < \beta_S$, the headquarter anticipates that the supplier will choose the unethical technology if it is able to do so and mimic ethical firms. At t_0, this happens with probability κ from the perspective of both supplier and headquarter. The headquarter therefore extracts the supplier's future expected profits, which are now different from the baseline model and given by

$$(1-\kappa)\pi_{k,S}^e + \kappa\ E(\pi_{k,S}^u),$$

where $E(\pi_{k,S}^u)$ is given by equation (I.15) in the baseline model. Accordingly, the organizational decision is now also slightly modified compared to the baseline model. Even with $\beta < \beta_S$, there is still a probability $1-\kappa$ that ethical production takes place. Therefore, the ratio of profits under integration relative to outsourcing is in this case given by

$$\tilde{\Theta}^u(\beta) = \frac{(1-\kappa)\,\Pi_V^e + \kappa E\left(\Pi_V^u\right)}{(1-\kappa)\,\Pi_O^e + \kappa E\left(\Pi_O^u\right)},$$

where Π_k^e and $E\left(\Pi_k^u\right)$ are given by equations (I.17) and (I.18) from the baseline model. Simplification yields

$$\tilde{\Theta}^u(\beta) = \left[\left(\frac{\phi_V}{\phi_O}\right)^{\beta}\left(\frac{1-\phi_V}{1-\phi_O}\right)^{1-\beta}\right]^{\frac{\alpha}{1-\alpha}} \frac{\gamma' - (1-\beta)\,\alpha\mu' + \phi_V\alpha\left[\mu' - \beta\left(1+\mu'\right)\right]}{\gamma' - (1-\beta)\,\alpha\mu' + \phi_O\alpha\left[\mu' - \beta\left(1+\mu'\right)\right]},$$

where $\gamma' \equiv 1-\kappa\,(1-\gamma)$ and $\mu' \equiv 1-\kappa\,(1-\mu)$. The integration cutoff under unethical production $\tilde{\beta}_u$ is implicitly defined by

$$\tilde{\Theta}^u(\tilde{\beta}_u) = 1. \tag{A.14}$$

Corollary 2 to Lemma I.1 summarizes the organization of production with the ethical technology in the extended model.

Corollary 2 *In the extended model, β_e is unchanged and still defined by equation* (I.19).

Proof: *This follows directly from Lemma I.1.*

For production using the unethical technology, we can state the following proposition paralleling Proposition I.2 from the baseline model.

Proposition A.2 *In the extended model, there exists a unique β_e below which the headquarter chooses outsourcing irrespective of the technology choice of the supplier. Integration is always chosen for headquarter intensities above $\tilde{\beta}_u$ and it always holds that $\beta_e < \tilde{\beta}_u$. A sufficient condition for a unique interior solution $\tilde{\beta}_u \in (\beta_e, 1)$ to exist is given by $\gamma > 1 - \frac{3(1-\phi_V)}{(3+\phi_V)\kappa}$. For any $\beta \in (\beta_e, \tilde{\beta}_u)$ the headquarter chooses integration if and only if the supplier produces ethically and chooses outsourcing if and only if unethical production is anticipated.*

Proof: *In the text.*

Setting $\kappa = 1$ reduces $\tilde{\Theta}^u(\beta)$ to $\Theta^u(\beta)$ from the baseline model. Inspection of the definitions of γ' and μ' reveals that $\frac{\partial \gamma'}{\partial \gamma} > 0$ with $0 < \gamma < \gamma' < 1$ and that $\frac{\partial \mu'}{\partial \mu} > 0$ with $0 < \mu < \mu' < 1$. This implies that the proofs we provide for existence and uniqueness of the integration cutoff β_u as well as the relative size of β_e and β_u in Appendices A.1.2.1, A.1.2.2, and A.1.2.3 continue to hold qualitatively for $\tilde{\beta}_u$. It also follows directly that $\beta_e < \tilde{\beta}_u < \beta_u$. To see this, note that β_u and $\tilde{\beta}_u$ are both decreasing in γ, and for any value of $\gamma, \kappa \in (0, 1)$ it holds that $\gamma' > \gamma$. In terms of parameter constraints, we now require $\gamma' > \frac{4\phi_V}{3+\phi_V}$ for existence and uniqueness. Inserting the definition of γ' and solving for γ gives the parameter constraint stated in Proposition A.2. It is straightforward to show that the condition is less strict on γ than the condition in the baseline model.

Next, we can state the following proposition about the different cases that may arise in the extended model paralleling Proposition I.3 from the baseline model.

Proposition A.3 *There exist three possible equilibria in the extended model characterized by $\beta_e < \beta_S < \tilde{\beta}_u$ (Case 1); $\beta_e < \tilde{\beta}_u < \beta_S$ (Case 2) and $\beta_S < \beta_e < \tilde{\beta}_u$ (Case 3). Unethical outsourcing and ethical integration are equilibrium outcomes in all three cases. Unethical integration and ethical outsourcing can also occur in equilibrium in Cases 2 and 3, respectively.*

Proof: *In the text.*

The existence of the three cases follows directly from the proof of Proposition I.3 in Appendix A.1.3 together with the parameter constraint from Proposition A.2, which ensures that $\tilde{\beta}_u \in (0,1)$.

Finally, we can state the following about the effect of unethical production on the international organization of production in the extended model. This parallels Proposition I.4. Define $\tilde{\beta}$ as the headquarter intensity above which integration actually takes place in the extended model. This cutoff is given by $\tilde{\beta} = \beta_S$ in Case 1; $\tilde{\beta} = \tilde{\beta}_u$ in Case 2; and $\tilde{\beta} = \beta_e$ in Case 3. With $\tilde{\beta}_u > \beta_e$, the integration cutoff is given by

$$\tilde{\beta} = \begin{cases} \min\{\beta_S; \tilde{\beta}_u\} & \text{if } \beta_S > \beta_e \\ \beta_e & \text{otherwise.} \end{cases} \tag{A.15}$$

Proposition A.4 *In the extended model, outsourcing is weakly increasing in the unethical cost advantage, i.e.* $\frac{\partial \tilde{\beta}}{\partial (1-\mu)} \geq 0$.
Proof: *In the text.*

It has been shown above that β_S and β_e remain unchanged in the extended model. Concerning $\tilde{\beta}_u$, Proposition A.2 implies that the Proposition I.2 can be applied in the extended model with the appropriate parameter condition. In the proof of Proposition I.2, it is shown in Appendix A.1.2.3 that β_u is increasing in $1-\mu$. Because μ' is increasing in μ, it therefore follows that also $\frac{\partial \tilde{\beta}_u}{\partial 1-\mu} > 0$.

A.2 Data Appendix

A.2.1 Robustness Checks

In this section we analyze the robustness of our main results. We add more control variables in Tables A.1 and A.2. We show the results with a constant (small) sample size in Table A.3.

A.2.1.1 Additional Control Variables

Antràs and Chor (2013) have recently documented the importance of the average relative position of an industry in production chains as a determinant of intrafirm trade. In particular, they show in their model that headquarters tend to integrate more upstream stages of production when demand is relatively inelastic and outsource downstream stages. Conversely, when demand is relatively elastic, upstream stages are outsourced and more downstream stages are integrated. We construct the measure *DUse_TUse* developed by

Antràs and Chor (2013) to account for the average relative position of an industry in production chains using the detailed BEA 2007 Input-Output Use table following the implementation laid out in their paper.[1] Of all output an industry produces for intermediate use in other industries, *DUse_TUse* is the share of that output that is used in the production of final output (direct use over total use). A larger *DUse_TUse* value therefore indicates a greater average 'downstreamness' of an industry.

Table A.1: Robustness I - Downstreamness

Dependent Variable: Intrafirm Import Share									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intensity Definition:	Total Cost	Total Cost	Total Cost	Total Sales	Total Sales	Total Sales	Payroll	Payroll	Payroll
log ECSP		-0.0223**	-0.0396***		-0.0225**	-0.0412***		-0.0235**	-0.0270**
		(0.0107)	(0.0141)		(0.0107)	(0.0139)		(0.0100)	(0.0135)
log ECSP			0.00844**			0.00868**			0.00149
X EPSI			(0.00427)			(0.00433)			(0.00408)
log other machinery intensity	0.0196*	0.0297***	0.0421***	0.0177*	0.0275***	0.0342**	0.0169*	0.0295***	0.0330**
	(0.0113)	(0.0109)	(0.0137)	(0.0102)	(0.0104)	(0.0145)	(0.00929)	(0.00978)	(0.0138)
log skill intensity	0.0426**	0.0420**	0.0639***	0.0320***	0.0327***	0.0363**	0.0481*	0.0521**	0.0415
	(0.0215)	(0.0207)	(0.0212)	(0.0117)	(0.0114)	(0.0152)	(0.0264)	(0.0254)	(0.0356)
log R&D intensity	0.0216***	0.0202***	0.0266***	0.0224***	0.0208***	0.0280***	0.0212***	0.0194***	0.0275***
	(0.00371)	(0.00371)	(0.00472)	(0.00367)	(0.00370)	(0.00483)	(0.00424)	(0.00416)	(0.00526)
log material intensity	0.0744	0.0594	0.137**	0.0287	0.0199	0.0208	-0.00216	0.00512	-0.00679
	(0.0598)	(0.0594)	(0.0551)	(0.0240)	(0.0255)	(0.0338)	(0.0113)	(0.0112)	(0.0115)
dispersion	0.0830***	0.0784***	0.0875***	0.0839***	0.0789***	0.0889***	0.0815***	0.0764***	0.0872***
	(0.0143)	(0.0135)	(0.0148)	(0.0144)	(0.0137)	(0.0156)	(0.0146)	(0.0136)	(0.0158)
log building intensity	-0.00833	-0.00683	-0.00793	-0.00854	-0.00732	-0.00885	-0.0112**	-0.00900	-0.0107
	(0.00572)	(0.00570)	(0.00730)	(0.00583)	(0.00577)	(0.00713)	(0.00566)	(0.00570)	(0.00745)
log auto intensity	-0.0116***	-0.0119***	-0.0183***	-0.0128***	-0.0127***	-0.0207***	-0.0108**	-0.0110***	-0.0191***
	(0.00435)	(0.00419)	(0.00588)	(0.00436)	(0.00421)	(0.00604)	(0.00437)	(0.00415)	(0.00615)
log computer intensity	-0.00899	-0.0121*	0.00231	-0.00808	-0.0117*	0.00305	-0.0112*	-0.0144**	0.000475
	(0.00646)	(0.00648)	(0.0100)	(0.00628)	(0.00647)	(0.0103)	(0.00638)	(0.00624)	(0.0102)
1(sigma<median)	-0.169***	-0.170***	-0.172***	-0.167***	-0.170***	-0.172***	-0.171***	-0.172***	-0.173***
X DUse_TUse	(0.0332)	(0.0318)	(0.0453)	(0.0336)	(0.0321)	(0.0465)	(0.0338)	(0.0320)	(0.0462)
1(sigma>median)	-0.122***	-0.126***	-0.137***	-0.109***	-0.119***	-0.124***	-0.118***	-0.122***	-0.134***
X DUse_TUse	(0.0291)	(0.0294)	(0.0372)	(0.0318)	(0.0312)	(0.0379)	(0.0281)	(0.0285)	(0.0367)
1(sigma>median)	-0.0348	-0.0308	-0.0196	-0.0391	-0.0333	-0.0248	-0.0390	-0.0345	-0.0220
	(0.0279)	(0.0272)	(0.0354)	(0.0282)	(0.0272)	(0.0354)	(0.0277)	(0.0267)	(0.0354)
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IO2007 industry clusters	211	211	211	211	211	211	211	211	211
Observations	130,920	130,337	35,416	130,920	130,337	35,416	130,920	130,337	35,416
R-squared	0.188	0.190	0.182	0.188	0.190	0.181	0.188	0.190	0.180

Note: Estimation by OLS with standard errors clustered at the industry level reported in parentheses. ***, **, and * denote significance the 1%, 5%, and 10% level, respectively. log ECSP is the log of expenditure on waste and hazardous materials removal over total cost, industry sales or payroll. sigma is the estimate of the import demand elasticity from Broda and Weinstein (2006). DUse_TUse measures the share of output of an industry used in production of final output relative to total demand for that industry's output as an intermediate input.

In Table A.1, we add the interaction of *DUse_TUse* with the import demand elasticity estimates from Broda and Weinstein (2006) to our baseline specification. The level effect of the dummy variable $1(sigma > median)$ already controls for the elasticity of substitution from the baseline regression in the main paper. Therefore log *sigma* is omitted in here as well as in Table A.2. In column 1, we introduce the new variables into our preferred

[1]They construct the measure from the 2002 IO table. Details on our construction are provided in Appendix A.2.2.6.

specification with total cost as the normalization variable. We then introduce our measure of the environmental cost savings potential (ECSP) in column 2 and find that our effect is negative and significant at the 5% level. The magnitude of the coefficient only changes at the fourth decimal place compared to our baseline results in Table I.1. The effects of the downstreamness interactions remain stable as well. In column 3 we add the interaction with the environmental policy stringency index (EPSI) and find a positive and significant effect as before. Compared to Table I.1 also the magnitudes do not change much. Turning to the intensity definition with total sales in columns 4 to 6, we find that our previous results continue to hold here as well when the variables from Antràs and Chor (2013) are introduced. Both the level effect of the ECSP and the interaction effect with the EPSI remain at magnitudes very similar to the ones estimated in Table I.1.

In columns 7 to 9 we report the results with the payroll normalization. Compared to Table I.1, the level effect in column 8 changes only in the fourth decimal place. When the environmental stringency index is added in column 9, the level effect continues to be significant and the interaction effect is positive and insignificant, as in Table I.1.

In Table A.2, we add additional controls that have been suggested as determinants of intrafirm trade in the literature to our preferred specification. In columns 1 and 2 we introduce the value added share in total sales, in columns 3 and 4 we add the 'importance' of an input measured as the total use of an industry's output as an intermediate input relative to total input purchases by all its buyers. Intermediation in columns 5 and 6 comes from Bernard, Jensen, Redding, and Schott (2013) and is a measure of the importance of intermediaries in the form of wholesalers in a given industry calculated from firm-level data. In columns 7 and 8 we add a measure of industry contractibility based on Nunn and Trefler (2008).[2] Finally, in columns 9 and 10, we add all of the new controls jointly.

In column 1, the value added share makes the level effect of the ECSP insignificant, but when we add the interaction with the EPSI in column 2, both the coefficients are significant and at comparable levels to our main specification in Table I.1 in terms of magnitude. In column 3, the level effect remains significant at 10% when input importance is introduced. The specification with the interaction effectively replicates the result from Table I.1. The intermediation and contractibility variables render the level effect of the unethical cost advantage insignificant. Our results return, however, when we add the interaction effect. The magnitude of the level effect is diminished and significance reduced to 10% and 5%, respectively. The interaction effect continues to be significant at the 5% level at a stable magnitude. When we add all of the additional controls in columns 9 and 10, the level effect of the unethical environmental cost advantage disappears, but the interaction effect continues to be significant.

[2]The construction of all these variables is described in the Appendix A.2.2 below.

Table A.2: Robustness II - Additional Controls - Total Cost Definition

	Dependent Variable: Intrafirm Import Share									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Intensity Definition:	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost
log ECSP	-0.0215*	-0.0386***	-0.0224**	-0.0400***	-0.0143	-0.0294**	-0.0137	-0.0261*	-0.00679	-0.0176
	(0.0112)	(0.0142)	(0.0105)	(0.0141)	(0.0102)	(0.0142)	(0.0108)	(0.0139)	(0.0112)	(0.0142)
log ECSP X EPSI		0.00846**		0.00857**		0.00875**		0.00814*		0.00844*
		(0.00427)		(0.00428)		(0.00426)		(0.00434)		(0.00434)
log other machinery intensity	0.0308***	0.0434***	0.0303***	0.0422***	0.0218**	0.0305**	0.0310***	0.0476***	0.0244**	0.0359***
	(0.0112)	(0.0141)	(0.0105)	(0.0136)	(0.0109)	(0.0131)	(0.0109)	(0.0135)	(0.0107)	(0.0132)
log skill intensity	0.0444**	0.0663***	0.0493***	0.0673***	0.0383**	0.0573***	0.0290	0.0450**	0.0315*	0.0399**
	(0.0214)	(0.0211)	(0.0165)	(0.0205)	(0.0184)	(0.0191)	(0.0214)	(0.0223)	(0.0172)	(0.0199)
log R&D intensity	0.0202***	0.0266***	0.0197***	0.0265***	0.0158***	0.0204***	0.0193***	0.0253***	0.0153***	0.0197***
	(0.00369)	(0.00471)	(0.00363)	(0.00465)	(0.00417)	(0.00467)	(0.00360)	(0.00455)	(0.00395)	(0.00447)
log material intensity	0.0498	0.127*	0.0790	0.145***	0.0489	0.119**	0.0650	0.144***	0.0686	0.132**
	(0.0627)	(0.0646)	(0.0505)	(0.0536)	(0.0551)	(0.0523)	(0.0613)	(0.0547)	(0.0537)	(0.0600)
dispersion	0.0781***	0.0873***	0.0853***	0.0916***	0.0840***	0.0996***	0.0796***	0.0890***	0.0891***	0.100***
	(0.0134)	(0.0148)	(0.0117)	(0.0148)	(0.0119)	(0.0156)	(0.0127)	(0.0143)	(0.0117)	(0.0160)
log building intensity	-0.00646	-0.00752	-0.00728	-0.00841	-0.00561	-0.00659	-0.00397	-0.00368	-0.00298	-0.00253
	(0.00570)	(0.00709)	(0.00564)	(0.00727)	(0.00547)	(0.00696)	(0.00529)	(0.00666)	(0.00514)	(0.00627)
log auto intensity	-0.0120***	-0.0186***	-0.00864**	-0.0162***	-0.00752*	-0.0114*	-0.0139***	-0.0207***	-0.00821**	-0.0140**
	(0.00421)	(0.00592)	(0.00401)	(0.00616)	(0.00408)	(0.00630)	(0.00432)	(0.00608)	(0.00414)	(0.00661)
log computer intensity	-0.0117*	0.00274	-0.0125*	0.00221	-0.0114*	0.00342	-0.0135*	-0.000120	-0.0130*	0.00117
	(0.00650)	(0.0101)	(0.00637)	(0.00998)	(0.00651)	(0.00976)	(0.00686)	(0.00991)	(0.00691)	(0.00982)
1(sigma<median) X DUse_TUse	-0.169***	-0.172***	-0.177***	-0.177***	-0.137***	-0.126***	-0.178***	-0.184***	-0.154***	-0.142***
	(0.0321)	(0.0457)	(0.0328)	(0.0458)	(0.0328)	(0.0467)	(0.0305)	(0.0422)	(0.0338)	(0.0455)
1(sigma>median) X DUse_TUse	-0.121***	-0.132***	-0.123***	-0.135***	-0.103***	-0.109***	-0.145***	-0.175***	-0.124***	-0.149***
	(0.0320)	(0.0388)	(0.0286)	(0.0368)	(0.0299)	(0.0376)	(0.0285)	(0.0363)	(0.0307)	(0.0382)
1(sigma>median)	-0.0321	-0.0213	-0.0360	-0.0233	-0.0236	-0.00844	-0.0229	-0.00151	-0.0205	0.00758
	(0.0272)	(0.0351)	(0.0275)	(0.0356)	(0.0271)	(0.0358)	(0.0265)	(0.0338)	(0.0260)	(0.0329)
value added share	-0.0380	-0.0391							-0.00244	0.0117
	(0.0908)	(0.107)							(0.0829)	(0.0900)
input importance			1.732**	1.081					1.078	0.0330
			(0.812)	(0.904)					(0.778)	(0.921)
intermediation					-0.166***	-0.241***			-0.137***	-0.218***
					(0.0488)	(0.0601)			(0.0499)	(0.0616)
contractibility							-0.0624***	-0.0927***	-0.0605***	-0.0876***
							(0.0178)	(0.0234)	(0.0178)	(0.0217)
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IO2007 industry clusters	205	205	205	205	205	205	205	205	205	205
Observations	130,337	35,416	130,337	35,416	130,337	35,416	127,484	34,547	127,484	34,547
R-squared	0.190	0.182	0.191	0.183	0.193	0.189	0.193	0.190	0.196	0.196

Note: Estimation by OLS with standard errors clustered at the industry level reported in parentheses. ***, **, and * denote significance the 1%, 5%, and 10% level, respectively. log ECSP is the log of expenditure on waste and hazardous materials removal over total cost. sigma is the estimate of the import demand elasticity from Broda and Weinstein (2006). DUse_TUse measures the share of output of an industry used in production of final output relative to total demand for that industry's output as an intermediate input.

A.2.1.2 Holding the Sample Constant

Because the OECD environmental stringency index is only available for 32 countries (excluding the U.S.) and for the period 2007 to 2012, the sample size in our main specification drops considerably when we add the interaction of the index with our measure of the environmental cost savings potential. In this section we report the specifications without the interaction effect, but with the smaller subsample. Table A.3 shows our results. Columns 3, 6, and 9 replicate the respective columns from Table I.1 in the main text. In column 2, the total cost specification, the level effect of the ECSP is negative as expected, but insignificant. The same holds for the coefficient in the total sales specification in column 5. When we normalize with payroll, the coefficient is negative and significant at the

5%-level. For our preferred specifications with total cost and total sales, the insignificant coefficients in columns 2 and 5 are consistent with our theory. In Section I.4.5 we argue that the prediction of our model holds in the specification without the interaction effect if most of the countries and territories have more lenient regulation than the U.S. Here we reduce the sample to OECD economies with similar levels of regulation to the U.S. plus six emerging economies. In light of our theoretical argument, it is therefore not surprising that we cannot find a significant level effect.

Table A.3: Robustness III - Constant Sample

	Dependent Variable: Intrafirm Import Share								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intensity Definition:	Total Cost	Total Cost	Total Cost	Total Sales	Total Sales	Total Sales	Payroll	Payroll	Payroll
log ECSP		-0.0193	-0.0401***		-0.0173	-0.0387***		-0.0229**	-0.0270*
		(0.0120)	(0.0143)		(0.0118)	(0.0143)		(0.0115)	(0.0140)
log ECSP			0.00892**			0.00917**			0.00174
X EPSI			(0.00429)			(0.00435)			(0.00410)
log sigma		-0.00236	-0.00232		-0.000150	-0.000124		-0.00194	-0.00194
		(0.00888)	(0.00889)		(0.00865)	(0.00865)		(0.00907)	(0.00907)
log other machinery intensity	0.0466***	0.0559***	0.0558***	0.0417***	0.0504***	0.0503***	0.0358***	0.0490***	0.0490***
	(0.0131)	(0.0140)	(0.0140)	(0.0131)	(0.0143)	(0.0144)	(0.0129)	(0.0138)	(0.0138)
log skill intensity	0.0606***	0.0578***	0.0578***	0.0379**	0.0375**	0.0375**	0.0468	0.0489	0.0490
	(0.0214)	(0.0209)	(0.0210)	(0.0152)	(0.0152)	(0.0152)	(0.0382)	(0.0373)	(0.0373)
log R&D intensity	0.0277***	0.0267***	0.0267***	0.0288***	0.0279***	0.0278***	0.0283***	0.0269***	0.0269***
	(0.00478)	(0.00483)	(0.00483)	(0.00493)	(0.00496)	(0.00496)	(0.00548)	(0.00544)	(0.00544)
log materials intensity	0.141**	0.131**	0.131**	0.0497	0.0452	0.0455	-0.0179	-0.00950	-0.00949
	(0.0589)	(0.0581)	(0.0582)	(0.0313)	(0.0328)	(0.0328)	(0.0119)	(0.0118)	(0.0118)
dispersion	0.0898***	0.0858***	0.0858***	0.0904***	0.0871***	0.0871***	0.0894***	0.0846***	0.0846***
	(0.0141)	(0.0141)	(0.0141)	(0.0147)	(0.0148)	(0.0148)	(0.0151)	(0.0149)	(0.0149)
log building intensity	-0.0130*	-0.0114	-0.0114	-0.0110	-0.0103	-0.0103	-0.0167**	-0.0146*	-0.0146*
	(0.00778)	(0.00776)	(0.00776)	(0.00743)	(0.00745)	(0.00746)	(0.00773)	(0.00780)	(0.00780)
log auto intensity	-0.0184***	-0.0180***	-0.0181***	-0.0217***	-0.0210***	-0.0211***	-0.0188***	-0.0181***	-0.0181***
	(0.00614)	(0.00594)	(0.00594)	(0.00625)	(0.00614)	(0.00614)	(0.00654)	(0.00626)	(0.00626)
log computer intensity	0.00339	0.000705	0.000841	0.00615	0.00322	0.00338	0.000983	-0.00230	-0.00229
	(0.0105)	(0.0106)	(0.0106)	(0.0106)	(0.0108)	(0.0108)	(0.0110)	(0.0109)	(0.0109)
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IO2007 industry clusters	212	212	212	212	212	212	212	212	212
Observations	35,434	35,434	35,434	35,434	35,434	35,434	35,434	35,434	35,434
R-squared	0.167	0.169	0.169	0.168	0.169	0.169	0.165	0.167	0.167

Note: Estimation by OLS with standard errors clustered at the industry level reported in parentheses. ***, **, and * denote significance the 1%, 5%, and 10% level, respectively. log ECSP is the log of expenditure on waste and hazardous materials removal over total cost, total sales, or payroll. sigma is the estimate of the import demand elasticity from Broda and Weinstein (2006).

A.2.2 Data Sources

In this section we provide more details about our measure of the environmental cost savings potential (ECSP). We also describe our data sources and cleaning procedures.

A.2.2.1 Industries with Highest and Lowest Environmental Cost Saving Potential

Table A.4 documents the sectors with the lowest and the highest ECSP based on the payroll definition in the left panel and based on the total cost definition on the right. Our measures generate rankings of industries that are arguably in line with common preconceptions about environmentally 'dirty' industries, such as the chemical or textile industries. On the other end of the spectrum our measures put industries that are mainly involved in assembling parts and thus do not produce a lot of (hazardous) waste.

Table A.4: Lowest to Highest ECSP

Industry	IO2007 code	Payroll Definition	Industry	IO2007 code	Cost Definition
334517	Irradiation apparatus manufacturing	0.0027	334517	Irradiation apparatus manufacturing	0.00055
333313	Office machinery manufacturing	0.0036	333112	Lawn and garden equipment manufacturing	0.00060
339116	Dental laboratories	0.0039	336112	Light truck and utility vehicle manufacturing	0.00070
336411	Aircraft manufacturing	0.0041	336411	Aircraft manufacturing	0.00076
333993	Packaging machinery manufacturing	0.0044	333313	Office machinery manufacturing	0.00081
335314	Relay and industrial control manufacturing	0.0045	336120	Heavy duty truck manufacturing	0.00083
334220	Broadcast and wireless communications equipment	0.0047	336360	Motor vehicle seating and interior trim manufacturing	0.00084
33451A	Watch, clock, and other measuring and controlling device manufacturing	0.0050	336213	Motor home manufacturing	0.00086
336414	Guided missile and space vehicle manufacturing	0.0052	311119	Other animal food manufacturing	0.00090
333511	Industrial mold manufacturing	0.0053	334210	Telephone apparatus manufacturing	0.00093
⋮	⋮	⋮	⋮	⋮	⋮
312120	Breweries	0.0877	313300	Textile and fabric finishing and fabric coating mills	0.00892
325211	Plastics material and resin manufacturing	0.0890	325180	Other basic inorganic chemical manufacturing	0.00944
325320	Pesticide and other agricultural chemical manufacturing	0.0923	312120	Breweries	0.00954
31122A	Soybean and other oilseed processing	0.1042	325130	Synthetic dye and pigment manufacturing	0.00957
331314	Secondary smelting and alloying of aluminum	0.1076	322130	Paperboard mills	0.00984
324110	Petroleum refineries	0.1132	327992	Ground or treated mineral and earth manufacturing	0.01041
325110	Petrochemical manufacturing	0.1337	327993	Mineral wool manufacturing	0.01334
325120	Industrial gas manufacturing	0.1683	311221	Wet corn milling	0.01339
311221	Wet corn milling	0.2657	325120	Industrial gas manufacturing	0.02160
325190	Other basic organic chemical manufacturing	0.4224	325190	Other basic organic chemical manufacturing	0.02445

Note: The ranking is based on industries for which intrafirm trade data are available. They are ranked by their ECSP measured as expenditure on hazardous waste removal over payroll in the left panel, and measured as expenditure on hazardous waste removal over total cost in the right panel. Each industry value is an average over 2007-2014.

A.2.2.2 Intrafirm Trade

Data on intrafirm trade flows cover the years 2007 to 2014. Up to and including the year 2012, the data are coded in NAICS 2007 industry codes. The other two years are coded in NAICS 2012. We use the NAICS 2007 concordance with IO2007 industry provided by the BEA with its Input-Output tables and the NAICS 2007 to NAICS 2012 concordance from the U.S. Census Bureau to recode the import flows.

A.2.2.3 Industry Characteristics

Data used to construct the ECSP measure, capital intensity and its components, skill intensity and material intensity come from from the Annual Survey of Manufactures (ASM). We use data from 2007 to 2014 and exploit variation across industries and over time. The ASM data are slightly more aggregated than 6-digit NAICS 2007 codes for the years 2007 to 2011 and are coded as NAICS 2012 in the remaining three years. We use the concordance between IO2007 and NAICS 2007 provided by the BEA with its 2007

Input-Output tables as well as the NAICS 2012 to NAICS 2007 concordance provided by the U.S. Census Bureau to achieve a consistent aggregation.

Within-industry dispersion is taken from the dataset provided by Antràs and Chor (2013) who in turn take the data from Nunn and Trefler (2008), who constructed dispersion as the standard deviation of the HS10 log exports within each HS6 code across U.S. port locations and destination countries from the year 2000. The aggregation of these original estimates to IO2002 codes is described in Antràs and Chor (2013), Appendix B, p. 2201. We take their data and convert them to IO2007 codes.

R&D data come from Compustat. We downloaded information on sales and R&D expenditure of listed U.S. firms available in Compustat for the years 2007 to 2014. Each firm-year was provided with the NAICS 2007 industry in which the firm operates. The firm-level observations were aggregated at the NAICS 2007 level and then recoded to IO2007 using the concordance from the BEA Input-Output table.

A.2.2.4 Import Demand Elasticities

For the construction of the IO2007-level import demand elasticities we follow the Antràs and Chor (2013) methodology. First, we combine the original estimates at the HS10-level with a full list of HS10 industry codes from Pierce and Schott (2012). We then employ HS10-level US imports summed over the years 2007 to 2014 from Schott (2008) to generate trade-weighted elasticities for HS10 codes that do not have an estimate. In the first round, we use HS10 codes that share the same first nine digits to generate the missing elasticities. We repeat the procedure using the first eight digits, then seven, up until two digits to fill in as many elasticities as possible. Because there are two different estimates for the same HS10 code 2103204020, we drop the observation. We then use a concordance table built from the BEA IO2002-HS10 concordance and a IO2002-IO2007 crosswalk to aggregate the HS10 codes to IO2007 industries, again using total imports from 2007 to 2014 as weights. We are left with three IO2007 codes without an assigned elasticity: 112120, 323120, and 333295. Those are assigned the values of the nearest neighbors $1121A0$, 323110, and $33329A$.

A.2.2.5 Environmental Policy Stringency Index

We downloaded the data from the OECD.stat website from 2007 up to the most recent year for which all countries were assigned an index value, which was 2012 at the time of the download. The data are available from `/https://stats.oecd.org/Index.aspx?DataSetCode=EPS`.

A.2.2.6 Data Used for Robustness Checks

DUse_TUse *DUse_TUse* measures the share of industry output used as intermediates that is used in final good production. In the construction of this variable we follow closely the description of the implementation in Antràs and Chor (2013), pp. 2160 and 2161, who construct the measure from the 2002 IO Use Table. We use the 2007 IO Use Table from the BEA to make the data compatible with our observation period. Regressing the data provided by Antràs and Chor (2013) on our self-constructed values of *DUse_TUse*, we find an R-squared of 76.8%, a constant term of -0.02689 and slope coefficient of 0.96902. Because we expect the vertical relationships within an economy to be relatively slow moving over time, these values make us confident about the correctness of our own implementation of the construction.

Other Controls We calculate **input importance** from the detailed BEA IO Use Tables after redefinitions. We first isolate intermediate sales to all other industries and intermediate purchases from all other industries for each industry. Next we construct an IO matrix of zeros and ones, where a one indicates a vertical relationship between two industries. By associating the intermediate sales and purchases with this IO matrix, we can recover total intermediate purchases of the industries a particular industry is selling to (its buyer industries). Dividing total intermediate sales of a selling industry by total intermediate purchases of its buyer industries thus gives us a measure of how important the selling industry's output is as an input.

Contractibility is a measure of industry contractibility suggested by Nunn and Trefler (2008). We follow Antràs and Chor (2013) and Nunn (2007) in the construction of this measure. We download the original Rauch (1999) data in SITC rev. 2 codes and associate the product classification of the 4-digit codes with HS10 codes from Pierce and Schott (2012). These HS10 codes are then mapped to IO2007 industries via the IO2002-HS10 concordance provided by the BEA and the NAICS 2002 to NAICS 2007 concordances from the U.S. Census Bureau. For each IO2007 industry, we then calculate the share of HS10 codes within each IO2007 code that are classified as neither reference-priced nor traded on an organized exchange (the 'liberal' classification). Contractibility is defined as 1 minus this share.

The **value added share** in industry sales was calculated directly from the Annual Survey of Manufactures. The data contain a variable giving the dollar value of value added in an industry-year. We divide this value by industry sales measured by total value of shipments in the ASM data.

The **intermediation** variable was taken from the Antràs and Chor (2013) dataset who in turn took their data from Bernard, Jensen, Redding, and Schott (2013). They measure the importance of wholesalers as intermediaries in 1997 at the industry level from establishment-level data on wholesale employment shares. Antràs and Chor (2013) describe how they map the data from the original HS2 level to IO2002 industries in their paper in Appendix B, p. 2202. We take their data off the shelf and convert the IO2002 industries to IO2007 industries using the Input-Output tables from the BEA and NAICS 2002 to NAICS 2007 concordances provided by the U.S. Census Bureau.

Chapter B

Appendix Chapter II

B.1 Theory Appendix

B.1.1 Derivation of equation (II.4)

Starting from

$$\bar{U}_i = \int_0^{\infty} U dG_i(U) = \int_0^{\infty} -U^{-\epsilon}\epsilon\Psi_i \exp\left\{-U^{-\epsilon}\Psi_i\right\} dU,$$

using the change of variable $y = \Psi_i U^{-\epsilon}$ so that $dy = -\Psi_i \epsilon U^{-(\epsilon+1)} dU$ and $U = \left(\frac{y}{\Psi_i}\right)^{-\frac{1}{\epsilon}}$ in evaluating the integral gives equation (II.4)

$$\bar{U}_i = \int_0^{\infty} \Psi_i^{\frac{1}{\epsilon}} y^{-\frac{1}{\epsilon}} \exp\left\{y\right\} dy = \delta\Psi_i^{\frac{1}{\epsilon}},$$

where $\delta = \Gamma\left(\frac{\epsilon-1}{\epsilon}\right)$, $\Gamma(\cdot)$ is the Gamma function and $\Psi_i = \sum_n B_n \kappa_{ni}^{-\epsilon}\left(\frac{\nu_n}{P_n^{\alpha} R_n^{1-\alpha}}\right)^{\epsilon}$.

B.1.2 Derivation of equation (II.5)

Starting from

$$\lambda_{ni} = Pr\left[U_{ni} \geq \max\left\{U_{ki}\right\} \ \forall\ k\right] = \int_0^{\infty} \prod_{k \neq n} G_{ki}(U) dG_{ni}(U),$$

across the distribution of bilateral utility $G_{ni}(U)$, the integral evaluates the probability that all countries other than n jointly offer a lower utility than U, so that it is country n that is chosen as the utility maximizing migration destination. Simplification yields

$$\lambda_{ni} = \int_0^\infty \exp\left\{-U^{-\epsilon}\Psi_i\right\} \epsilon U^{-(1+\epsilon)}\Psi_{ni} dU.$$

Using again the change of variable $y = \Psi_i U^{-\epsilon}$ so that $dy = -\Psi_i \epsilon U^{-(\epsilon+1)} dU$ and noting that the integration limits switch because of the inverse relationship between y and U

$$\lambda_{ni} = \int_\infty^0 -\exp\{-y\} \frac{\Psi_{ni}}{\Psi_i} dy = \int_0^\infty \exp\{-y\} \frac{\Psi_{ni}}{\Psi_i} dy$$

gives equation (II.5) as

$$\lambda_{ni} = \frac{\Psi_{ni}}{\Psi_i} = \frac{B_n \kappa_{ni}^{-\epsilon} \left(\frac{\nu_n}{P_n^\alpha R_n^{1-\alpha}}\right)^\epsilon}{\sum_k B_k \kappa_{ki}^{-\epsilon} \left(\frac{\nu_k}{P_k^\alpha R_k^{1-\alpha}}\right)^\epsilon}.$$

B.1.3 Derivation of equation (II.14)

Starting from equation (II.5), inserting equation (II.10) for R_n and R_k in the denominator, respectively, and simplifying gives

$$\lambda_{ni} = \frac{B_n \kappa_{ni}^{-\epsilon} \left(\frac{\nu_n}{P_n}\right)^{\alpha\epsilon} \left(\frac{H_n}{L_n}\right)^{(1-\alpha)\epsilon}}{\sum_k B_k \kappa_{ki}^{-\epsilon} \left(\frac{\nu_k}{P_k}\right)^{\alpha\epsilon} \left(\frac{H_k}{L_k}\right)^{(1-\alpha)\epsilon}}.$$

Now note that $\nu_n = w_n + t_n = w_n + \frac{T_n}{L_n}$. Using goods market clearing (II.11), $T_n = X_n - w_n L_n$ gives that $\nu = \frac{X_n}{L_n}$ so that, using (II.12),

$$\nu_n = \frac{w_n}{\sum_i \frac{\pi_{ni}}{1+\tau_{ni}}}.$$

It follows directly that

$$\frac{\nu_n}{P_n} = \frac{w_n}{P_n} \left(\sum_k \frac{\pi_{nk}}{1+\tau_{nk}}\right)^{-1}.$$

Using standard methods from Eaton and Kortum (2002) the real wage in terms of goods can be expressed as a function of the domestic expenditure share so that equation (II.14) is given by

$$\lambda_{ni} = \frac{B_n \kappa_{ni}^{-\epsilon} \left(\frac{\mu_n L_n^{\beta}}{\pi_{nn}}\right)^{\frac{\alpha\epsilon}{\theta}} \left(\frac{H_n}{L_n}\right)^{(1-\alpha)\epsilon} \left(\sum_k \frac{\pi_{nk}}{1+\tau_{nk}}\right)^{-\alpha\epsilon}}{\sum_l B_l \kappa_{li}^{-\epsilon} \left(\frac{\mu_l L_l^{\beta}}{\pi_{ll}}\right)^{\frac{\alpha\epsilon}{\theta}} \left(\frac{H_l}{L_l}\right)^{(1-\alpha)\epsilon} \left(\sum_m \frac{\pi_{lm}}{1+\tau_{lm}}\right)^{-\alpha\epsilon}}.$$

B.1.4 Derivation of equation (II.26)

Median utility of workers from country i is defined as

$$\tilde{U}_i = G_i^{-1}\left(\frac{1}{2}\right),$$

where G_i^{-1} is the inverse function of the distribution of maximum utility of workers from i. The median of this distribution is the value $\tilde{U}_i$, for which exactly half of country i's citizens have utility less than that value. Starting from

$$G_i(U) = \exp\left\{-\Psi_i U^{-\epsilon}\right\}$$

with $\Psi_i = \sum_n B_n \kappa_{ni}^{-\epsilon} \left(\frac{\nu_n}{P_n^{\alpha} R_n^{1-\alpha}}\right)^{\epsilon}$, taking the natural log on both sides and solving for U gives

$$U = -\left(\frac{\Psi_i}{\ln G_i(U)}\right)^{\frac{1}{\epsilon}}.$$

Setting $G_i(U) = \frac{1}{2}$ implies that the left-hand side of the equation above becomes the median $\tilde{U}_i$. Simplification gives equation (II.26) as

$$\tilde{U}_i = \delta' \left[\sum_n B_n \kappa_{ni}^{-\epsilon} \left(\frac{\nu_n}{P_n^{\alpha} R_n^{1-\alpha}}\right)^{\epsilon}\right]^{\frac{1}{\epsilon}},$$

where $\delta' = (\ln 2)^{-\frac{1}{\epsilon}}$. Because $\tilde{U}_i$ differs from $\bar{U}_i$ only in the constant term δ' (as opposed to δ for mean utility), it follows directly that both statistics predict identical welfare changes in percentage terms in response to a trade or migration policy shock.

B.2 Data Appendix

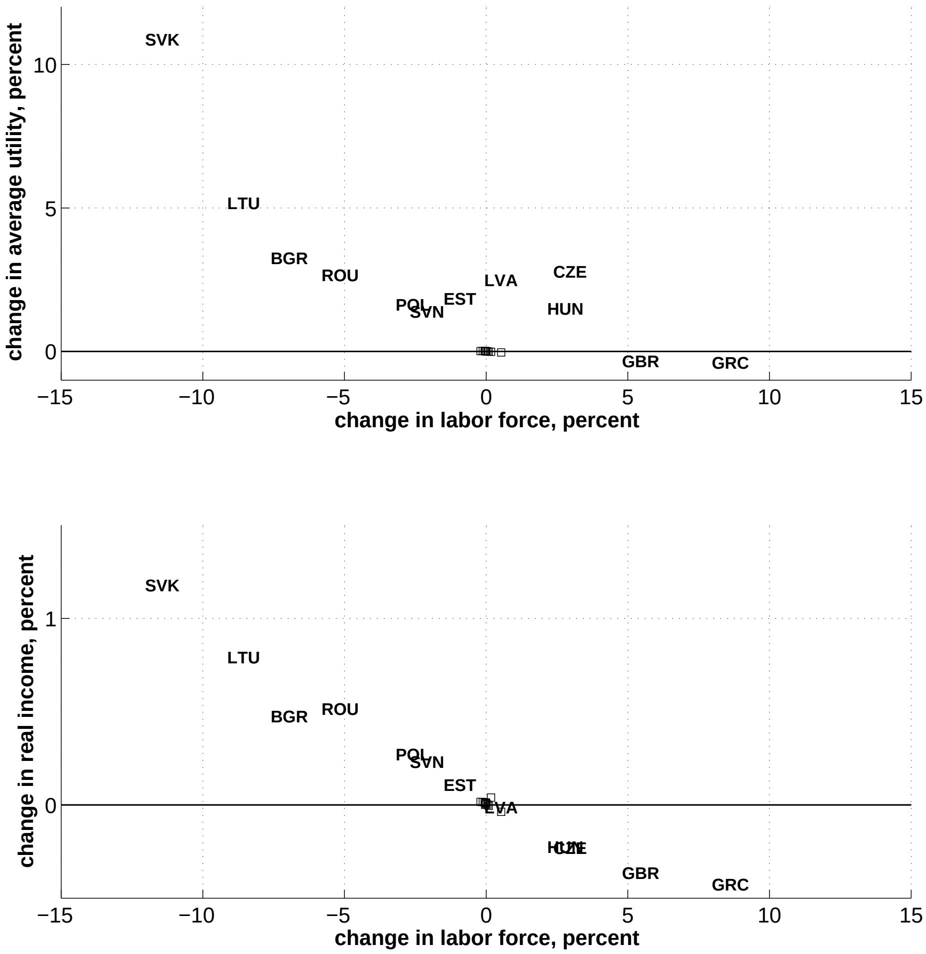
B.2.1 Migration Data

The OECD DIOC-E dataset for the reference year 2000/2001 contains several missing values. Instead of replacing them with zeros, I employ several strategies to impute values. First, I aggregate Belgium, Luxembourg and the Netherlands into one country (BNL). I then fill the numbers based on migration shares of similar countries. For example, I lack information for the number of Estonians and Latvians living in Spain in the reference year. I compute the share of Lithuanians living there and impute a number for Estonia and Latvia that produces the same migration share as for Lithuanians. Other "similar" country groups for which I employ this strategy are Portugal and Spain, Slovenia, Slovakia and Croatia, as well as Ireland and the U.K.

For citizens of Finland, Denmark and Sweden, I am missing the numbers of those who live in Germany. I replace their values with numbers generating a migration share that is equal to the average share of citizens living in Germany for all other countries. I employ the same strategy for fill up information for numbers of citizens of Spain, Portugal, the Baltic and Skandinavian countries living in Romania. Finally, I calculate migration shares and renormalize by their sum to correct for totals above or below unity and convert them back to numbers. I take the size of the worldwide labor force from World Bank development indicators and impute it for the number of workers from ROW working and living in ROW after accounting for the other countries in the sample.

B.2.2 Robustness Checks - Simple Average Tariffs

Figure B.1: Eastern Enlargement - Migration Liberalization Only



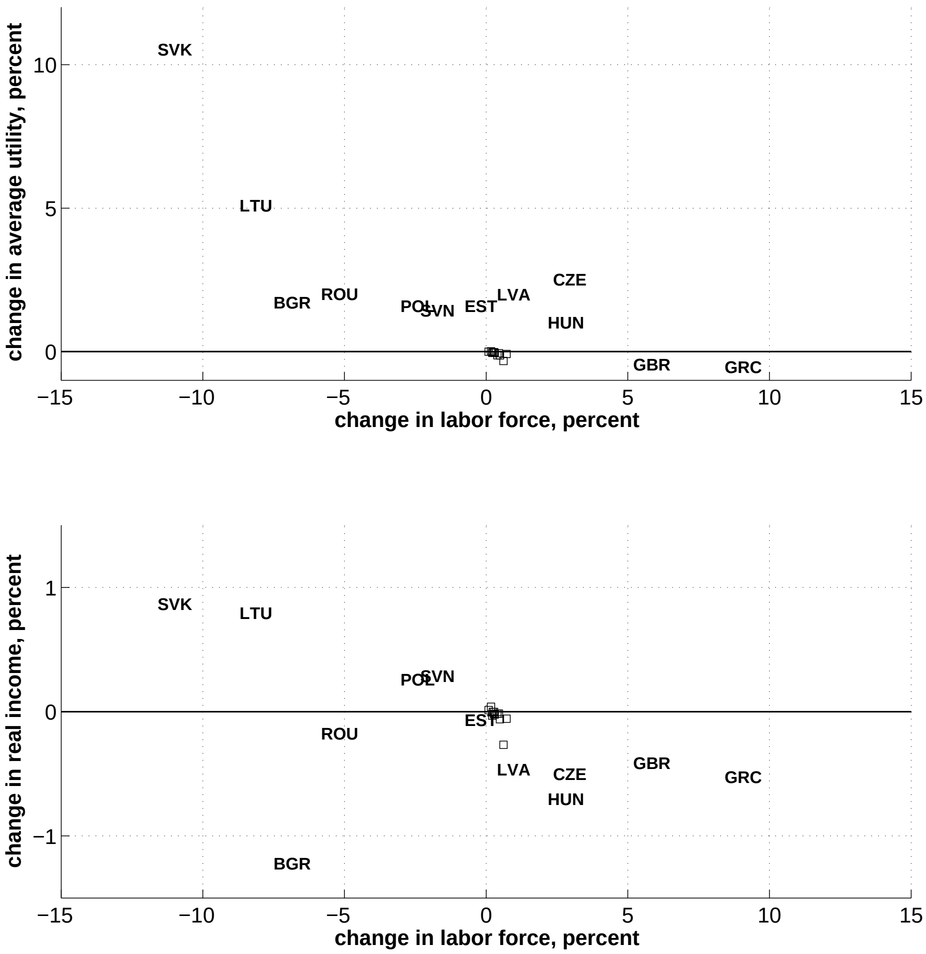
Note: The countries plotted as squares are Austria, Benelux, Germany, Denmark, Spain, Finland, France, Croatia, Ireland, Italy, Portugal, and Sweden. Rest of the World is not plotted.

Table B.1: Eastern Enlargement - Migration Liberalization Only

Country	Code	Avg. Utility	Real Income	Labor Force	EU Weight
		——— change in percent ———			pct. pts.
Austria	AUT	0.015	0.016	-0.196	0
Bulgaria	BGR	3.255	0.475	-7.602	0
Benelux	BNL	0.011	0.013	0.000	0
Czech Rep.	CZE	2.789	-0.230	2.369	0
Germany	DEU	0.013	0.015	-0.118	0
Denmark	DNK	0.009	0.011	-0.019	0
Spain	ESP	0.002	0.002	0.041	0
Estonia	EST	1.850	0.108	-1.501	0
Finland	FIN	0.009	0.010	-0.012	0
France	FRA	0.006	0.007	-0.007	0
U.K.	GBR	-0.336	-0.363	4.800	36.94
Greece	GRC	-0.394	-0.426	7.966	40.75
Croatia	HRV	0.004	0.000	-0.036	-
Hungary	HUN	1.495	-0.226	2.156	0
Ireland	IRL	-0.013	0.039	0.173	2.13
Italy	ITA	-0.036	-0.037	0.533	5.84
Lithuania	LTU	5.171	0.791	-9.135	0
Latvia	LVA	2.480	-0.012	-0.066	0
Poland	POL	1.630	0.270	-3.192	0
Portugal	PRT	-0.004	-0.005	0.093	0.74
Romania	ROU	2.666	0.516	-5.807	0
Rest of World	ROW	0.003	0.004	-0.004	-
Slovakia	SVK	10.867	1.178	-12.037	0
Slovenia	SVN	1.392	0.231	-2.695	0
Sweden	SWE	0.012	0.014	-0.052	0

Note: The table shows the percent changes in average utility, real income, the size of the labor force as well as the implied pro-European welfare weight of the government objective function for each country in the sample.

Figure B.2: Eastern Enlargement - Migration and Trade Liberalization



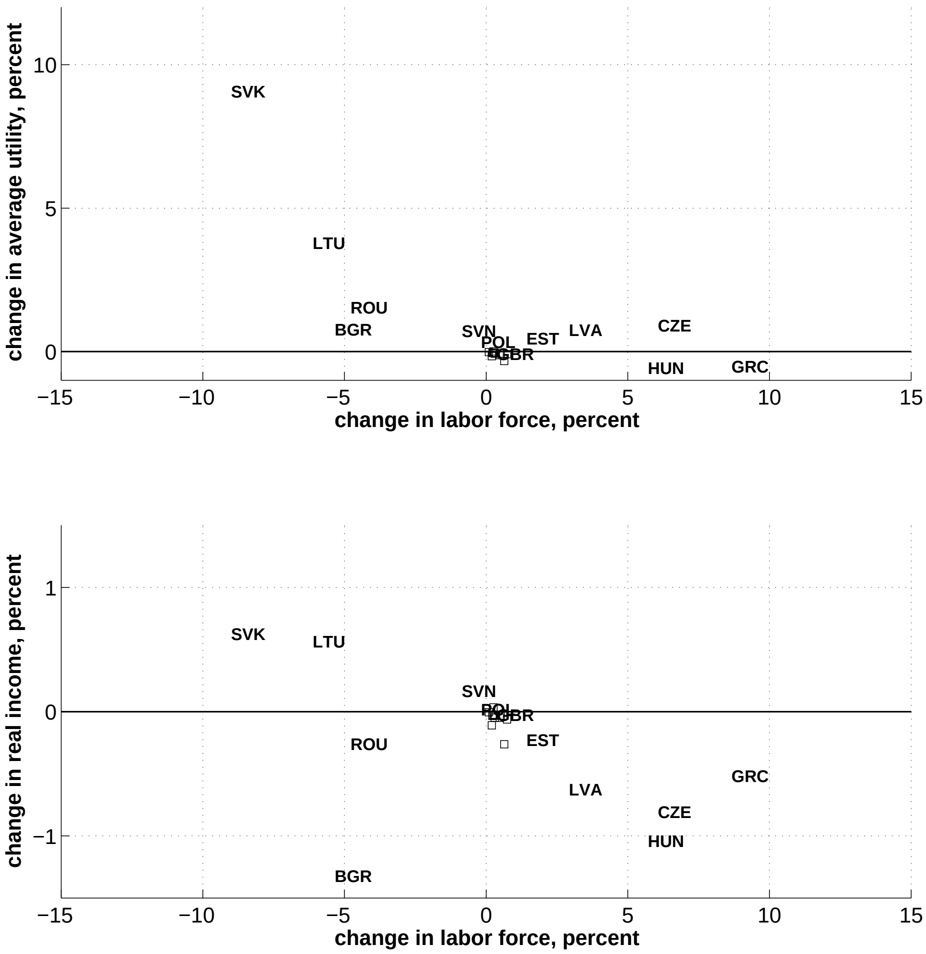
Note: The countries plotted as squares are Austria, Benelux, Germany, Denmark, Spain, Finland, France, Croatia, Ireland, Italy, Portugal, and Sweden. Rest of the World is not plotted.

Table B.2: Eastern Enlargement - Migration and Trade Liberalization

Country	Code	Avg. Utility	Real Income	Labor Force	EU Weight
		——— change in percent ———			pct. pts.
Austria	AUT	0.008	0.040	0.173	0
Bulgaria	BGR	1.714	-1.220	-7.500	0
Benelux	BNL	-0.045	-0.024	0.303	9.48
Czech Rep.	CZE	2.517	-0.499	2.362	0
Germany	DEU	-0.056	-0.016	0.453	11.44
Denmark	DNK	-0.026	0.003	0.236	5.74
Spain	ESP	-0.045	-0.032	0.218	9.40
Estonia	EST	1.592	-0.068	-0.758	0
Finland	FIN	-0.003	0.013	0.090	0.74
France	FRA	-0.034	-0.021	0.279	7.23
U.K.	GBR	-0.446	-0.414	5.195	50.72
Greece	GRC	-0.536	-0.527	8.422	55.29
Croatia	HRV	-0.330	-0.267	0.613	-
Hungary	HUN	1.025	-0.701	2.179	0
Ireland	IRL	-0.129	-0.016	0.396	22.91
Italy	ITA	-0.083	-0.057	0.719	16.02
Lithuania	LTU	5.101	0.793	-8.697	0
Latvia	LVA	1.991	-0.464	0.386	0
Poland	POL	1.592	0.260	-3.023	0
Portugal	PRT	-0.134	-0.061	0.488	23.55
Romania	ROU	2.006	-0.175	-5.828	0
Rest of World	ROW	-1.048	-1.057	-0.042	-
Slovakia	SVK	10.543	0.869	-11.592	0
Slovenia	SVN	1.427	0.289	-2.321	0
Sweden	SWE	-0.023	-0.003	0.281	5.09

Note: The table shows the percent changes in average utility, real income, the size of the labor force as well as the implied pro-European welfare weight of the government objective function for each country in the sample.

Figure B.3: Eastern Enlargement and U.K. Single Market Exit



Note: The countries plotted as squares are Austria, Benelux, Germany, Denmark, Spain, Finland, France, Croatia, Ireland, Italy, Portugal, and Sweden. Rest of the World is not plotted.

Table B.3: Eastern Enlargement and U.K. Single Market Exit

Country	Code	Avg. Utility	Real Income	Labor Force	Diff. to Scen. 2
		——— change in percent ———			pct. pt. change
Austria	AUT	0.003	0.035	0.258	-0.005
Bulgaria	BGR	0.781	-1.322	-5.340	-0.933
Benelux	BNL	-0.069	-0.049	0.301	-0.024
Czech Rep.	CZE	0.912	-0.808	6.061	-1.605
Germany	DEU	-0.071	-0.032	0.519	-0.015
Denmark	DNK	-0.049	-0.028	0.242	-0.022
Spain	ESP	-0.046	-0.034	0.222	-0.001
Estonia	EST	0.467	-0.226	1.424	-1.125
Finland	FIN	-0.020	0.005	0.095	-0.016
France	FRA	-0.043	-0.031	0.281	-0.009
U.K.	GBR	-0.086	-0.025	0.374	0.360
Greece	GRC	-0.525	-0.516	8.660	0.011
Croatia	HRV	-0.329	-0.262	0.639	0.001
Hungary	HUN	-0.563	-1.042	5.712	-1.588
Ireland	IRL	-0.158	-0.110	0.199	-0.029
Italy	ITA	-0.088	-0.063	0.737	-0.006
Lithuania	LTU	3.782	0.566	-6.124	-1.319
Latvia	LVA	0.755	-0.626	2.925	-1.236
Poland	POL	0.342	0.019	-0.184	-1.251
Portugal	PRT	-0.124	-0.050	0.483	0.010
Romania	ROU	1.549	-0.261	-4.783	-0.466
Rest of World	ROW	-1.050	-1.059	-0.041	-0.001
Slovakia	SVK	9.065	0.627	-9.003	-1.478
Slovenia	SVN	0.727	0.169	-0.859	-0.699
Sweden	SWE	-0.043	-0.024	0.312	-0.020

Note: The table shows the percent changes in average utility, real income, the size of the labor force and the difference in the change in average utility relative to Scenario 2 in percentage points.

Chapter C

Appendix Chapter III

C.1 Theory Appendix

C.1.1 The Technology Frontier

Appealing to a partial equilibrium version of the research and innovation process from Eaton and Kortum (2001), I show how the technology frontier in equation (III.1) can be microfounded.

As in Eaton and Kortum (2001), I assume that time is continuous and that at time t there are R_{it} researchers who draw ideas about how to produce the set of available goods at a Poisson rate α_i. Each idea that is drawn applies to some good $j \in S_i$ and has an efficiency $z(j)$ attached to it. The good j to which the efficiency applies is drawn from a uniform distribution over S_i, while the efficiency is drawn from a Pareto distribution $H(z) = 1 - z^{-\theta}$. The stock of ideas at time t is then defined as $T_{it} = \alpha_i \int_0^t R_{is} ds$.

The key departure from Eaton and Kortum (2001) is that this stock of ideas T_{it} does not apply to a continuum of unit measure but to the randomly drawn measure S_{it} of goods. In expectation, there are $\frac{T_{it}}{S_{it}}$ ideas per variety at time t. With ideas arriving at rate α_i, the probability if having k ideas for variety j in country i by date t is

$$\left(\frac{T_{it}}{S_{it}}\right)^k \exp\left\{-\frac{T_{it}}{S_{it}}\right\} /k!.$$

Having k ideas and independent draws, the probability that the best idea has an efficiency below z is $H(z)^k$. Summing over all possible numbers of ideas gives the technology frontier in country i at time t: the probability that a good j is produced with an efficiency below z.

$$\tilde{F}_{it}(z) = \exp\left\{-\frac{T_{it}}{S_i}\right\}\left[\sum_{k=0}^{\infty}\frac{\left[(T_{it}/S_i)\, H(z)\right]^k}{k!}\right]$$

Using the power series definition of the exponential function and inserting $H(k)$ yields

$$\tilde{F}_{it}(z) = \exp\left\{-\frac{T_{it}}{S_i}z^{-\theta}\right\}, \ z \geq 1.^1 \tag{C.1}$$

$F_{it}(z)$ is the probability that a good j producible in i at time t has a productivity of less than z. In the remainder of the paper, I will analyze the static model at some point in time so that the time subscript is dropped from here on.

While $\tilde{F}_{it}(z)$ is the distribution of productivity for goods *producible* in i, the goods for which i does not possess the technology, have productivity zero, so the probability of having a productivity lower than z is unity. Applying this gives equation (III.1) in the main part of the paper.

C.1.2 Proof of Lemma III.1

Because productivity draws for producible goods are random and there is a continuum of goods, the bilateral price distributions can be arbitrarily compressed and will still contain all possible prices due to the law of large numbers.

To show that $\sum_c \lambda(c) = 1$ and $\sum_{c:i\in c}\lambda(c) = \frac{S_i}{J}$ I proceed in two steps. First, I show three useful properties of the summation over producer set weights. Second, I use the these properties to show $\sum_c \lambda(c) = 1$ and $\sum_{c:i\in c}\lambda(c) = \frac{S_i}{J}$.

Recall that the set of all countries is $C = \{1,\ldots,N\}$ and there are $|\mathcal{P}(C)| = 2^N$ producer sets, where c indexes the elements of $\mathcal{P}(C)$.

C.1.2.1 Properties of the Summation

Decomposition Without loss of generality, it is possible to decompose the sum over all producer set weights into two sums, those in which country 1 is active and those in which it is not.

$$\sum_c \lambda(c) = \sum_{c:1\in c}\lambda(c) + \sum_{c:1\notin c}\lambda(c). \tag{C.2}$$

It follows from the properties of the power set that both summations on the right-hand side of equation (C.2) each have $2^N/2$ elements.

[1]The exponential function can be defined as $\exp(x) = \sum_{k=0}^{\infty}\frac{x^k}{k!}$.

Extraction From each of the two summations on the right-hand side of (C.2) the term containing the fraction of goods produced by country 1 can be extracted, so that

$$\sum_{c:1\in c} \lambda(c) = \sum_{c:1\in c} \frac{S_1}{J}\lambda_{-1}(c) = \frac{S_1}{J}\sum_{c:1\in c} \lambda_{-1}(c)$$
$$\sum_{c:1\notin c} \lambda(c) = \sum_{c:1\notin c} \frac{J-S_1}{J}\lambda_{-1}(c) = \frac{J-S_1}{J}\sum_{c:1\notin c} \lambda_{-1}(c),$$

where $\lambda_{-1}(c)$ denotes the usual $\lambda(c)$ without the factor containing S_1. Note that the elements of a power set can be matched in pairs such that the two paired elements differ only in the presence of one element of the original set. For example, the power set of the set $\{1, 2, 3\}$ can be sorted as

$$\begin{gathered} \{\}\,, \{1\} \\ \{2\}\,, \{1,2\} \\ \{3\}\,, \{1,3\} \\ \{2,3\}\,, \{1,2,3\}\,. \end{gathered}$$

Therefore, after the factors accounting for e.g. country 1 have been taken out, the two summations from above are equivalent, in particular

$$\sum_{c:1\in c} \lambda_{-1}(c) = \sum_{c:1\notin c} \lambda_{-1}(c). \tag{C.3}$$

Compression A third useful property is the fact that $\sum_{c:1\notin c} \lambda_{-1}(c)$ is itself a summation over *all* weights of elements of the power set of a set of countries $C_1 = \{2, \ldots, N\}$, which has 2^{N-1} elements, indexed by c_1, i.e.

$$\sum_{c:1\notin c} \lambda_{-1}(c) = \sum_{c_1} \lambda(c_1). \tag{C.4}$$

C.1.2.2 Proof that $\sum_c \lambda(c) = 1$

Using equation (C.2), it is possible to write w.l.o.g.

$$\sum_{c} \lambda(c) = \frac{S_1}{J}\sum_{c:1\in c} \lambda_{-1}(c) + \frac{J-S_1}{J}\sum_{c:1\notin c} \lambda_{-1}(c)$$
$$\sum_{c} \lambda(c) = \frac{S_1}{J}\left(\sum_{c:1\in c} \lambda_{-1}(c) - \sum_{c:1\notin c} \lambda_{-1}(c)\right) + \sum_{c:1\notin c} \lambda_{-1}(c).$$

Using the extraction property (C.3), this gives

$$\sum_{c} \lambda(c) = \sum_{c:1 \notin c} \lambda_{-1}(c) = \sum_{c_1} \lambda(c_1),$$

where the second equality follows from (C.4) and c_1 indexes the elements of $C_1 = \{2, \ldots, N\}$.

Applying decomposition (C.2), extraction (C.3), and compression (C.4) on $\sum_{c_1} \lambda(c_1)$ using country 2 gives that

$$\sum_{c_1} \lambda(c_1) = \sum_{c_2} \lambda(c_2)$$

with c_2 indexing $C_2 = \{3, \ldots, N\}$. This procedure can be applied iteratively so that with $C_{N-1} = \{N\}$,

$$\sum_{c} \lambda(c) = \sum_{c_{N-1}} \lambda(c_{N-1}) = \frac{S_N}{J} + \frac{J - S_N}{J} = 1. \tag{C.5}$$

C.1.2.3 Proof that $\sum_{c:i \in c} \lambda(c) = S_i/J$

Considering again country 1 w.l.o.g.

$$\sum_{c:1 \in c} \lambda(c) = \frac{S_1}{J} \sum_{c:1 \in c} \lambda_{-1}(c).$$

Using compression (C.4) once to arrive at $\sum_{c_2} \lambda(c_2)$ and then applying decomposition, extraction and compression iteratively as above, it holds that

$$\sum_{c:1 \in c} \lambda(c) = \frac{S_1}{J} \sum_{c:1 \in c} \lambda_{-1}(c) = \frac{S_1}{J} \sum_{c_{N-1}} \lambda(c_{N-1}) = \frac{S_1}{J} \left(\frac{S_N}{J} + \frac{J - S_N}{J} \right) = \frac{S_1}{J}. \tag{C.6}$$

QED.

C.1.3 Derivation of Goods Shares $\bar{\pi}_{ni}$

The share of goods n buys from i is also the probability that i is the lowest-cost producer for some good j. Formally,

$$\bar{\pi}_{ni} = Pr \left[p_{ni}(j) \leq \min \left\{ p_{ns}(j) \ \forall \ s \neq i \right\} \right]. \tag{C.7}$$

This implies that I need to calculate the probability that a good j is produced by a particular producer set and that all countries $s \neq i$ charge a price greater than p while at the same time country i charges a price lower than p for all possible values of p and all producer sets c. For some particular producer set c in which country i is active, this is given by

$$\lambda(c)\pi_{ni}(c) = \int_0^\infty \prod_{s\in c, s\neq i} \frac{S_s}{J}\left[1 - G_{ns}(p)\right] \prod_{s\in c} \frac{J - S_s}{J} d\frac{S_i}{J} G_{ni}(p),$$

where $\lambda(c)$ is the probability that a randomly chosen good j is produced by the countries in c. For a producer set c' in which i is not active, $\pi_{ni}(c)$ is intuitively zero.

$$\lambda(c')\pi_{ni}(c') = \int_0^\infty \prod_{s\in c} \frac{S_s}{J}\left[1 - G_{ns}(p)\right] \prod_{s\in c, s\neq i} \frac{J - S_s}{J} d\frac{J - S_i}{J} \cdot 0 = 0,$$

because for goods that i cannot produce, the probability that it charges a price lower than p is zero as prices go to infinite for these goods. It is therefore sufficient to consider producer sets in which i is active to arrive at the aggregate goods share $\bar{\pi}_{ni}$.

$$\bar{\pi}_{ni} = \sum_{c:i\in c} \int_0^\infty \prod_{s\in c, s\neq i} \frac{S_s}{J}\left[1 - G_{ns}(p)\right] \prod_{s\in c} \frac{J - S_s}{J} d\frac{S_i}{J} G_{ni}(p).$$

Using the definition of $\lambda(c)$ together with the fact that

$$g_{ni}(p) = \frac{dG_{ni}(p)}{dp} = \left[1 - G_{ni}(p)\right]\theta p^{\theta-1}\frac{T_i}{S_i}\left(d_{ni}w_i\right)^{-\theta},$$

it is possible to write that

$$\bar{\pi}_{ni} = \sum_{c:i\in c} \lambda(c)\frac{T_i}{S_i}\left(d_{ni}w_i\right)^{-\theta} \int_0^\infty \theta p^{\theta-1} \exp\left\{-p^\theta \Phi_n(c)\right\} dp.$$

Changing variables such that $t = p^\theta \Phi_n(c)$ and thus $\theta p^{\theta-1}dp = \Phi_n(c)^{-1}dt$ and noting that the integration limits remain, the integral can be solved and simplified to give equation (III.6) in the paper,

$$\bar{\pi}_{ni} = \sum_{c:i\in c} \lambda(c)\frac{T_i\left(d_{ni}w_i\right)^{-\theta}}{\Phi_n(c)}.$$

C.1.4 Derivation of the Price Index P_n

The CES price index that is dual to the utility function from (III.2) is given by

$$P_n^{1-\sigma} = \int_0^J p_n(j)^{1-\sigma}dj.$$

Expressed in terms of country n's price distribution $G_n(p)$ it is given by

$$P_n^{1-\sigma} \int_0^\infty p^{1-\sigma}dG_n(p),$$

where $G_n(p)$ is given by equation (III.5). With

$$dG_n(p) = \sum_c \lambda(c) \exp\left\{-p^\theta \Phi_n(c)\right\} \theta p^{\theta-1} \Phi_n(c) dp$$

and substituting $u = p^\theta \Phi_n(c)$ so that $p^{1-\sigma} = (u/\Phi_n(c))^{\frac{1-\sigma}{\theta}}$ and $\theta p^{\theta-1} dp = \frac{du}{\Phi_n(c)}$ the left-hand side simplifies to

$$P_n^{1-\sigma} = \sum_c \Phi_n(c)^{\frac{\sigma-1}{\theta}} \lambda(c) \int_0^\infty u^{\frac{1-\sigma}{\theta}} \exp^{-u} du.$$

The Gamma function is given by $\Gamma(a) = \int_0^\infty x^{a-1} \exp\{-x\} dx$ so that

$$P_n^{1-\sigma} = \gamma^{1-\sigma} \sum_c \lambda(c) \Phi_n(c)^{\frac{\sigma-1}{\theta}}$$

as given in equation (III.7) with $\gamma \equiv \Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)^{\frac{1}{1-\sigma}}$.

C.1.5 Proof of Lemma III.2

First, I show that goods shares equal expenditure shares at the level of a producer set. Next, I proceed to show that this result does not obtain when the aggregate price distribution is considered. In a third step, I derive the expenditure allocated to a producer set from utility maximization.

C.1.5.1 Independence at the Producer Set Level

EK show the independence of the price distribution across sourcing locations by showing that price distributions are identical across sourcing locations after accounting for the fraction of goods that is sourced from them. Analogous to their approach I show that

$$G_n(p,c) = \frac{1}{\pi_{ni}(c)} \int_0^p \prod_{s \in c, s \neq i} \frac{S_s}{J} \left[1 - G_{ns}(p)\right] \prod_{s \notin c} \frac{S_s - J}{J} \, d\frac{S_i}{J} G_{ni}(q), \tag{C.8}$$

where $G_n(p,c) = \lambda(c) \left[1 - \exp\left\{-p^\theta \Phi_n(c)\right\}\right]$ is the distribution of prices that n pays in producer set c and I assume w.l.o.g. that $i \in c$. Note that $\frac{S_s}{J}\left[1 - G_{ns}(p)\right]$ is the appropriate bilateral price distribution to use in this context, although it covers goods that lie outside the range $\lambda(c)$ under analysis here. Because productivity draws are random and there is a continuum of goods, each bilateral distribution $\frac{S_s}{J}\left[1 - G_{ns}(p)\right]$ can be arbitrarily compressed - in this case to $\lambda(c)\left[1 - G_{ns}(p)\right]$ as will become clear below - and will still contain all possible prices.

With $g_{ni}(q) = \frac{dG_{ni}(q)}{dq} = [1 - G_{ni}(q)]\, \theta q^{\theta-1} \frac{T_i}{S_i} (d_{ni} w_i)^{-\theta}$ and using the definition of $\lambda(c)$ the integral can be written as

$$\int_0^p \lambda(c) \prod_{s \in c} [1 - G_{ns}(p)]\, \theta q^{\theta-1} \frac{T_i}{S_i} (d_{ni} w_i)^{-\theta}\, dq$$

$$= \lambda(c) \frac{T_i}{S_i} (d_{ni} w_i)^{-\theta} \int_0^p \theta q^{\theta-1} \exp\left\{ -q^\theta \sum_{s \in c} \frac{T_s}{S_s} (d_{ns} w_s)^{-\theta} \right\} dq$$

$$= \lambda(c) \frac{T_i}{S_i} (d_{ni} w_i)^{-\theta} \int_0^p \theta q^{\theta-1} \exp\left\{ -q^\theta \Phi_n(c) \right\} dq.$$

Defining the change of variables $t = q^\theta \Phi_n(c)$ so that $\theta q^{\theta-1} dq = dt \Phi_n(c)^{-1}$ and accounting for the changed limits gives

$$\lambda(c) \frac{T_i}{S_i} (d_{ni} w_i)^{-\theta} \int_0^{p^\theta \Phi_n(c)} \exp\{-t\} \frac{dt}{\Phi_n(c)},$$

which simplifies to

$$\lambda(c) \frac{T_i (d_{ni} w_i)^{-\theta}}{S_i \Phi_n(c)} \left[1 - \exp\left\{ -p^\theta \Phi_n(c) \right\} \right]. \tag{C.9}$$

Inserting (C.9) for the integral in (C.8) gives the result immediately.

C.1.5.2 No Independence in the Aggregate Price Distribution

At the aggregate level, independence of the price distribution of the country of origin would require that

$$G_n(p) = \frac{1}{\bar{\pi}_{ni}} \int_0^p \sum_{c: i \in c} \prod_{s \in c, s \neq i} \frac{S_s}{J} [1 - G_{ns}(p)] \prod_{s \notin c} \frac{J - S_s}{J}\, d\frac{S_i}{J} G_{ni}(q), \tag{C.10}$$

where $\bar{\pi}_{ni}$ is the fraction of goods bought by n from i as given by equation (III.6). Applying analogous steps to the integral as above gives

$$\int_0^p \sum_{c: i \in c} \lambda(c) \prod_{s \in c} [1 - G_{ns}(p)]\, \theta q^{\theta-1} \frac{T_i}{S_i} (d_{ni} w_i)^{-\theta}\, dq.$$

The places of the sum and the integral can be swapped and terms not depending on q can be taken out of the integral to give

$$\sum_{c: i \in c} \lambda(c) \frac{T_i}{S_i} (d_{ni} w_i)^{-\theta} \int_0^p \theta q^{\theta-1} \exp\left\{ -q^\theta \Phi_n(c) \right\} dq.$$

Using the change of variables from above and simplifying gives

$$\sum_{c:i\in c} \lambda(c)\pi_{ni}(c)\left[1-\exp\left\{-p^{\theta}\Phi_n(c)\right\}\right]. \tag{C.11}$$

Inserting this into equation (C.10) and simplifying gives

$$1-\frac{\sum_{c:i\in c}\lambda(c)\pi_{ni}(c)\exp\left\{-p^{\theta}\Phi_n(c)\right\}}{\sum_{c:i\in c}\lambda(c)\pi_{ni}(c)} \tag{C.12}$$

for the right hand side of (C.10), while $G_n(p) = 1-\sum_c \lambda(c)\exp\left\{-p^{\theta}\Phi_n(c)\right\}$. From equation (C.12) it becomes clear that the price distribution depends on characteristics of the source because countries are active in different producer sets and in particular, they are only active in a subset of them while the aggregate price distribution $G_n(p)$ naturally depends on all producer sets.

C.1.5.3 Allocation of Expenditure to Producer Sets

Because the independence result does not hold in the aggregate, expenditure shares allocated to producer sets need to be accounted for to arrive at the right country-level expenditure shares.

Defining aggregate expenditure in country n as X_n, standard utility maximization of the CES utility function (III.2) subject to the appropriate budget constraint gives variety-level expenditure as

$$p_n(j)q_n(j) = \left(\frac{p_n(j)}{P_n}\right)^{1-\sigma} X_n.$$

Denote $j \leftarrow c$ as all goods j which are produced by the countries in producer set c. Then

$$\begin{aligned}
\int_{j\leftarrow c} p_n(j)q_n(j)dj &= \frac{X_n}{P_n^{1-\sigma}}\int_{j\leftarrow c} p_n(j)^{1-\sigma}dj \\
X_n(c) &= \frac{X_n}{P_n^{1-\sigma}}\int_0^{\infty} p_n^{1-\sigma}dG_n(p,c) \\
X_n(c) &= \frac{X_n}{P_n^{1-\sigma}}\gamma^{1-\sigma}\lambda(c)\Phi_n(c)^{\frac{\sigma-1}{\theta}} \\
X_n(c) &= \left(\frac{P_n(c)}{P_n}\right)^{1-\sigma} X_n,
\end{aligned}$$

where $P_n(c)$ is the CES price index for goods produced by producer set c and $X_n(c)$ is country n's expenditure on goods produced by producer set c.

Taken together the three above results imply that $\pi_{ni} = \sum_{i\in c}\left(\frac{P_n(c)}{P_n}\right)^{1-\sigma}\pi_{ni}(c)$. QED.

C.1.6 Derivation of the Gravity Equation

Bilateral trade flows from equation (III.9) can be written as

$$X_{ni} = \frac{T_i}{S_i} (w_i d_{ni})^{-\theta} X_n \sum_{c:i\in c} \left(\frac{P_n(c)}{P_n} \right)^{1-\sigma} \Phi_n(c)^{-1}.$$

Total sales Q_i are obtained by summing over all destination countries m to get

$$Q_i = \frac{T_i}{S_i} w_i^{-\theta} \sum_{m=1}^{N} X_m d_{mi}^{-\theta} \sum_{c:i\in c} \left(\frac{P_m(c)}{P_m} \right)^{1-\sigma} \Phi_m(c)^{-1}.$$

Inserting Q_i into X_{ni} gives

$$X_{ni} = \frac{d_{ni}^{-\theta} \sum_{c:i\in c} \left(\frac{P_n(c)}{P_n} \right)^{1-\sigma} \Phi_n(c)^{-1}}{\sum_{m=1}^{N} X_m d_{mi}^{-\theta} \sum_{c:i\in c} \left(\frac{P_m(c)}{P_m} \right)^{1-\sigma} \Phi_m(c)^{-1}} X_n Q_i.$$

It follows from the definition of $P_m(c)$ that $\Phi_n(c)^{-1} = \gamma^{-\theta} P_n(c)^{\theta} \lambda(c)^{\frac{\theta}{\sigma-1}}$. Using this and multiplying the numerator by $(P_n/P_n)^{-\theta}$ and the denominator by $(P_m/P_m)^{-\theta}$ gives equation (III.10).

C.1.7 Derivation of the Real Wage

With labor as the only factor of production, the real wage in country i is given by $\frac{w_i}{P_i}$. From the model, the fraction of expenditure spent by n on goods by i is

$$\pi_{ni} = \frac{T_i}{S_i} (d_{ni} w_i)^{-\theta} P_n^{\sigma-1} \sum_{c:i\in c} \Phi_n(c)^{-1} P_n(c)^{1-\sigma}.$$

From this, the wage can be expressed as

$$w_i = d_{ni}^{-1} \left(\frac{T_i}{S_i} P_n^{\sigma-1} \pi_{ni}^{-1} \right)^{\frac{1}{\theta}} \left(\sum_{c:i\in c} \Phi_n(c)^{-1} P_n(c)^{1-\sigma} \right)^{\frac{1}{\theta}}.$$

Inserting this into the real wage and setting $n = i$ gives

$$\frac{w_i}{P_i} = P_i^{-1+\frac{\sigma-1}{\theta}} \frac{T_i}{S_i}^{\frac{1}{\theta}} \pi_{ii}^{-\frac{1}{\theta}} \left(\sum_{c:i\in c} \Phi_i(c)^{-1} P_i(c)^{1-\sigma} \right)^{\frac{1}{\theta}}.$$

Using the price index of producer set c in i, $\Phi_i(c)^{-1}$ can be written as

$$\Phi_i(c)^{-1} = \gamma^{-\theta}\lambda(c)^{-\frac{\theta}{1-\sigma}}P_i(c)^{\theta}.$$

Inserting this then gives the expression in equation (III.14)

$$\frac{w_i}{P_i} = \gamma^{-1}\left(\frac{T_i}{S_i\pi_{ii}}\right)^{\frac{1}{\theta}}\left(\sum_{c:i\in c}\lambda(c)^{\frac{\theta}{\sigma-1}}\left(\frac{P_i(c)}{P_i}\right)^{\theta+1-\sigma}\right)^{\frac{1}{\theta}}.$$

C.1.8 Proof of Proposition III.1

The gains from trade are given by the relative change in the real wage when moving from autarky to finite trade costs. Using the result for the real wage in autarky from equation (III.15), the gains from trade can be written as

$$GT_i^{\sigma-1} = \frac{(w_i/P_i)_T^{\sigma-1}}{\gamma^{1-\sigma}\mu_i^{\frac{\sigma-1}{\theta}}(S_i/J)}. \tag{C.13}$$

The price index in the trade case can be decomposed into a price index which contains the goods that i can produce by itself in autarky, $P_{i,SP}$ for specialization, and one that contains all other goods, $P_{i,NG}$ for new goods.

$$P_{i,T}^{1-\sigma} = \sum_{c:i\in c}P_i(c)^{1-\sigma} + \sum_{c:i\notin c}P_i(c)^{1-\sigma} = P_{i,SP}^{1-\sigma} + P_{i,NG}^{1-\sigma},$$

where it is understood that from now on P_i and w_i denote the price index and the nominal wage in the trade case. It follows that

$$GT_i^{\sigma-1} = \frac{P_{i,SP}^{1-\sigma} + P_{i,NG}^{1-\sigma}}{w_i^{1-\sigma}\gamma^{1-\sigma}\mu_i^{\frac{\sigma-1}{\theta}}(S_i/J)}.$$

and

$$GT_i^{\sigma-1} = \frac{\sum_{c:i\in c}\lambda(c)\Phi_i(c)^{\frac{\sigma-1}{\theta}}\mu_i^{\frac{1-\sigma}{\theta}}w_i^{\sigma-1}}{S_i/J} + \frac{P_{i,NG}^{1-\sigma}}{GT_i^{1-\sigma}P_{i,T}^{1-\sigma}}$$

It follows from equation (III.6) that $\mu_i^{\frac{1-\sigma}{\theta}}w_i^{\sigma-1} = [\pi_{ii}(c)\Phi_i(c)]^{(1-\sigma)/\theta}$ so that

$$GT_i^{\sigma-1}\left[1-\left(\frac{P_{i,NG}}{P_{i,T}}\right)^{1-\sigma}\right] = \sum_{c:i\in c}\frac{\lambda(c)}{S_i/J}\pi_{ii}(c)^{\frac{1-\sigma}{\theta}}.$$

Applying the fact that $P_{i,T}^{1-\sigma} = P_{i,SP}^{1-\sigma} + P_{i,NG}^{1-\sigma}$ and solving for GT_i gives equation (III.17). QED.

C.2 Data Appendix

In this section, I report the numbers corresponding to the data points for Figures III.2, III.3, and III.4.

Table C.1: Datapoints for Figure III.2

Country	Country Size	Eaton Kortum	New Goods symmetric	New Goods size-proportional
Australia	0.0608	1.65	3.67	3.53
Austria	0.0225	27.23	33.99	35.44
Benelux	0.0715	24.21	26.31	25.33
Canada	0.1075	8.17	10.68	9.84
Switzerland	0.0277	28.18	34.07	35.04
Denmark	0.0173	30.19	37.78	40.17
Spain	0.0827	8.19	12.18	11.53
Finland	0.0158	19.26	26.68	28.54
France	0.1543	11.09	13.67	12.41
Germany	0.2593	8.03	10.03	8.72
Greece	0.0223	16.42	23.39	24.58
Hungary	0.0189	29.47	36.93	39.03
Ireland	0.0080	41.85	52.39	59.06
Iceland	0.0008	66.95	93.07	122.13
Italy	0.1286	7.39	10.81	9.90
Japan	0.5097	0.89	1.76	1.38
Korea	0.1233	3.20	5.42	4.95
Mexico	0.1276	2.71	5.27	4.72
Norway	0.0170	23.57	31.25	33.26
New Zealand	0.0114	4.68	9.47	10.43
Poland	0.0774	10.81	15.15	14.43
Portugal	0.0190	18.32	25.82	27.39
Sweden	0.0300	16.32	22.22	22.62
Turkey	0.0832	8.15	12.52	11.88
United Kingdom	0.1601	9.94	12.60	11.39
United States	1.0000	0.94	1.62	1.16

Note: Country Size is measured as equipped labor from Klenow and Rodríguez-Clare (2005) relative to the U.S. Columns 3 to 5 report the utility gains of moving from autarky to trade in percent.

Table C.2: Datapoints for Figure III.3

Country	Country Size	New Goods symmetric	New Goods size-proportional
Australia	0.0608	122.55	114.39
Austria	0.0225	24.83	30.12
Benelux	0.0715	8.67	4.61
Canada	0.1075	30.78	20.44
Switzerland	0.0277	20.91	24.33
Denmark	0.0173	25.15	33.07
Spain	0.0827	48.63	40.77
Finland	0.0158	38.52	48.20
France	0.1543	23.23	11.86
Germany	0.2593	24.87	8.55
Greece	0.0223	42.40	49.67
Hungary	0.0189	25.29	32.44
Ireland	0.0080	25.20	41.12
Iceland	0.0008	39.02	82.42
Italy	0.1286	46.14	33.93
Japan	0.5097	98.31	55.65
Korea	0.1233	69.35	54.70
Mexico	0.1276	94.31	73.91
Norway	0.0170	32.60	41.11
New Zealand	0.0114	102.24	122.64
Poland	0.0774	40.13	33.48
Portugal	0.0190	40.97	49.51
Sweden	0.0300	36.16	38.65
Turkey	0.0832	53.75	45.82
United Kingdom	0.1601	26.76	14.59
United States	1.0000	73.27	23.03

Note: Country Size is measured as equipped labor from Klenow and Rodríguez-Clare (2005) relative to the U.S. Columns 3 and 4 report the change in the gains from trade when moving from the EK model to the respective version of the New Goods model in percent.

Table C.3: Datapoints for Figure III.4

Country	Country Size	New Goods symmetric	New Goods size-proportional
Australia	0.0608	0.70	0.25
Austria	0.0225	2.02	0.23
Benelux	0.0715	1.94	0.88
Canada	0.1075	1.56	0.81
Switzerland	0.0277	2.11	0.30
Denmark	0.0173	2.20	0.18
Spain	0.0827	1.12	0.66
Finland	0.0158	1.69	0.12
France	0.1543	1.27	1.69
Germany	0.2593	1.07	3.06
Greece	0.0223	1.57	0.17
Hungary	0.0189	2.13	0.20
Ireland	0.0080	2.90	0.09
Iceland	0.0008	4.78	0.01
Italy	0.1286	1.05	1.14
Japan	0.5097	0.56	3.89
Korea	0.1233	0.98	0.76
Mexico	0.1276	0.88	0.73
Norway	0.0170	1.89	0.15
New Zealand	0.0114	1.05	0.04
Poland	0.0774	1.23	0.69
Portugal	0.0190	1.71	0.15
Sweden	0.0300	1.51	0.25
Turkey	0.0832	1.11	0.68
United Kingdom	0.1601	1.22	1.70
United States	1.0000	0.56	11.39

Note: Country Size is measured as equipped labor from Klenow and Rodríguez-Clare (2005) relative to the U.S. Columns 3 and 4 report the share of specialization gains in total gains from trade for the respective New Goods model in percent.

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