Emerging Markets and the New Geography of Trade: The Effects of Rising Trade Barriers*

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July 18, 2019

Abstract

Over the past two decades, the rise of emerging markets (EMs) has significantly altered the landscape of global trade. As a result, trade tensions, and consequent tariff increases, are at the forefront of policy makers' concerns in these countries. Our paper serves two main purposes. First, we document several stylized facts that characterize EMs' role in the new geography of trade. We focus on differences between Advanced Economies (AEs) and EMs in production structure, trade linkages, and factor supplies. Second, guided by these facts, we build a dynamic, general equilibrium, quantitative trade model featuring multiple countries, sectors and factors of production. Each model element plays an important role in understanding the impacts of trade barriers in EMs. We use the model to estimate the long run global impacts of rising trade barriers focusing on EMs—both those directly involved in rising barriers, and those affected only through spillovers. Even though our analysis does not treat EMs fundamentally differently from AEs, large and heterogeneous effects on EMs are driven by heterogeneous exposure to trade, heterogeneity in production structures, trade linkages and factor supplies.

*The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System. We thank Charlotte Singer for excellent research assistance.

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1 Introduction

The last two decades have seen a significant reconfiguration of the global economy, as trade barriers have fallen and traditional supply chains have fragmented across borders. The rise of Emerging Markets (EMs) in world production—the most salient feature of this reshape—has been accompanied by substantial growth of EMs' role in global trade. It is in this new context that policy makers in EMs see recent increases in tariffs, and the possibility of further hikes, as a significant policy challenge for their countries. Indeed, the threat of rising trade barriers has occupied a large amount of policy discussion even though tariff increases have so far only materialized (i) for a small number of country-pairs and (ii) for a small number of goods.[1] Nevertheless, there is a fear that the role of EMs in the global economy can make them particularly vulnerable to both direct trade shocks, and the spillovers of indirect trade shocks. Understanding whether these fears can be justified quantitatively demands a framework that differs from the standard model used to study EMs.[2] Such a framework must encompass the new geography of international trade, recognizing EMs as prominent players. Building on several recent advances in the trade literature, we model a global economy featuring EMs, and use this model to quantify their role in international trade and the consequences of protectionism for these countries.

Our analysis proceeds in two steps. First, we outline a set of stylized facts characterizing the role of EMs in the new geography of international trade. Each of these facts highlights a particular aspect of EMs' role in the world economy that must be taken into account to understand the effects of rising trade barriers on EMs. Second, guided by these facts, we develop of a dynamic, multi-country, multi-sector, multi-factor general equilibrium quantitative model of international trade. Our stylized facts speak to the growth of EMs in the global economy, and, crucially, how trade patterns between Advanced Economies (AEs) and EMs have changed since the late 1990s. We also contrast the production structure of EMs and AEs. Our model, built to capture the forces underlying our facts, uses several new tools from the quantitative trade literature. We offer a framework for systematic analysis of the new geography of trade with an eye toward EMs, and the impacts of protectionism in this world. Despite the growth of powerful quantitative models in the trade literature, there has been little analysis of the global impacts of recent changes in trade barriers, especially for EMs.[3]

Turning to the facts, we document six facts that we feel are important to understanding EMs:

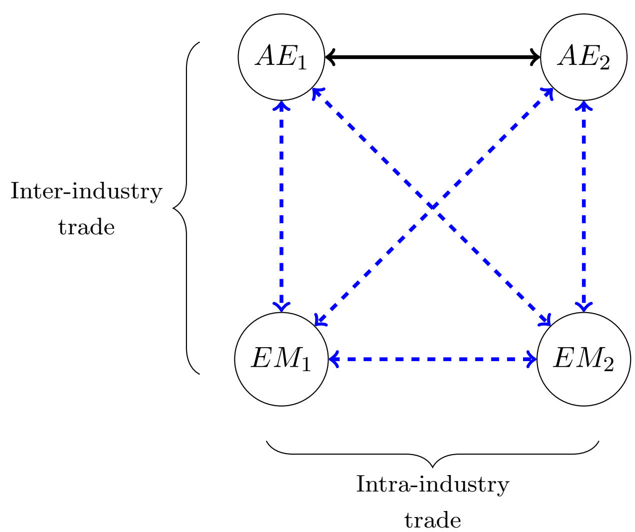
[1] For example, the majority of U.S. tariff increases have targeted Chinese goods that, in total, account for less than 10% of total U.S. imports.

[2] Végh (2013) presents and discusses the typical macroeconomic approach to studying EMs.

[3] One exception without a focus on EMs is Charbonneau and Landry (2018).

first, EMs represent a significant share of world trade, especially compared to the past; second, EMs are more open than AEs; third, not only have EMs begun to trade more, trade flows specifically between EMs and AEs now constitute half of global trade flows; fourth, EM trade amongst each other is also large, comprising half of intra-regional trade; fifth, EMs are heterogeneous in the types of goods they trade among themselves, with capital and intermediate goods playing important roles; and finally sixth, the factor content of trade differs substantially between EMs and AEs. The lesson of our exercises is mostly summarized in Figure 1. In the 1990s, before Chinese accession to the WTO, the expansion of the EU, and the rise of other BRICS countries, the world was well described by the top solid arrow. Indeed, the trade literature focused on developing theories to understand the dominance of trade between seemingly similar countries. Moreover, it was geared towards understanding the dominance of intra-industry trade in seemingly similar goods. We provide evidence of a new geography of trade, described by the dashed-blue lines in Figure 1. Interestingly, this new geography of trade suggests the view that all EMs are best modeled as small open economies (SOE) is outdated; it also relies on bridging ideas from older trade theory with the new. Specifically, on top of trade costs, multiple sectors, Ricardian comparative advantage, and input-output linkages, we highlight the role of multiple factors of production.

Figure 1: The New Geography of Trade



The quantitative exercises that we carry out in the second part of the paper shed light on how increasing trade barriers affect EMs in the long run. We use the model as a laboratory to compare steady states for two experiments. First, we do a comparison of steady states to understand the implications of a global and symmetric rise in trade barriers. Increasing trade barriers has sizable negative effects on global output and welfare, with EMs being disproportionately affected. Importantly, this result is not driven by treating EMs fundamentally differently from AEs in any way. Instead, a symmetric shock has larger and more heterogeneous effects on EMs than across AEs because of EMs' higher exposure to trade, heterogeneity in production structures, trade linkages and factor supplies. A novel channel in our analysis is the endogenous response of investment to lower returns to capital. Due to capital's importance in trade-intensive sectors, this ends up being a key channel in shaping the global response to higher trade costs. Interestingly, high trade barriers lead to a redistribution of world exports toward EMs that partially ameliorates the welfare losses for these economies. Our second experiment explores how increases in trade barriers between third-party countries spill over to EMs. Given a symmetric increase in trade barriers between AEs, these economies switch expenditure towards EMs, leading to an increase in their output. However, the lion's share of the positive GDP spillovers arises due to the endogenous adjustment in investment diverted towards EMs. Furthermore, the effects lead to an increase in inequality in EMs, as skilled-workers disproportionately reap the benefits of the spillovers.

Our empirical analysis makes important contributions to both the International Trade and International Macroeconomics literature. On international trade, we contribute to the scarce work that has focused on EMs and their role in shaping world trade flows. Hanson (2012) is one of the few papers that has focused specifically on the recent role of EMs in global trade. He studies the increase in trade among EMs, and between EMs and AEs, from the late 1990s until the Great Recession.[4] We update, expand, and extend this collection of facts, characterizing the idea of a 'new geography of international relations' put forward by UNCTAD (2004). Our finding of an increased role of EMs in trade in capital goods is particularly relevant, given that is very different to what Eaton and Kortum (2001) document. Turning to international macroeconomics, this literature has made significant progress on characterizing several features of EMs, such as business cycles.[5] We provide several trade-related facts that can serve as a starting point to reevaluate the relevance of EMs in global markets. Our facts, which touch on capital and investment goods, can play a key role in models of economic fluctuations and growth.

The second part of our paper, in which we incorporate our stylized facts into a quantitative model, contributes to the growing literature that uses large, general equilibrium models, to understand the

[4] Timmer et al. (2014) also point out some recent features of trade in value added for EMs. However, their focus is not on this set of countries in particular.

[5] For example: Neumeyer and Perri (2005); Uribe and Yue (2006); Aguiar and Gopinath (2007); Mendoza (2010); García-Cicco et al. (2010). See Montiel (2011) and Végh (2013) for overviews of Macroeconomics in EMs.

importance of new features of the global economy, and to simulate the impact of future changes to the trade environment—whether they be technological or political. Our model is closest to Parro (2013) who builds on multi-sector extensions of Eaton and Kortum (2002) with input-output linkages (Caliendo and Parro, 2015; Levchenko and Zhang, 2016) to include multiple factors of production and capital-skill complementarity.[6] To this, we add endogenous factor accumulation in physical capital and contribute to recent work by Alvarez (2017) and Ravikumar et al. (2019). The multi-factor and investment channels play a key role in shaping the response of different EMs to trade shocks, but have been absent from quantitative analyses of recent tariff hikes (e.g., Charbonneau and Landry (2018); IMF (2019)).

The rest of the paper is organized as follows. In Section 2 we carry out our empirical analysis and document six facts on EMs trade. In Section 3 we present the model and define a steady state equilibrium. Section 4 introduces the data and how we map the model to these data. Section 5 presents the quantitative results of our policy experiments and counterfactuals. Section 6 concludes.

2 Emerging Markets and the New Geography of Trade: Stylized Facts

In this section we document six stylized facts about EMs' aggregate trade patterns, focusing both on the trade relations among themselves, and with AEs. Even though our focus is on the role that EMs currently play in global trade, we document the evolution of the data to put the rapid changes in globalization in perspective. In doing so, we build on and update the work of Hanson (2012) and Timmer et al. (2014) in documenting the role of EMs in changing the global trade landscape. Our set of facts pushes for the relevance for the new geography of trade of forces driving inter-regional trade—Ricardian forces and factor differences (Heckscher-Ohlin forces)—rather than those driving intra-regional trade. We distinguish the role of three different types of goods—intermediates, commodities, and capital goods—in shaping trade patterns. To do this we combine trade data from the UN Comtrade Database, GDP data from the IMF World Economic Outlook (WEO) from 1996 to 2016, and input-output data, as well as factor data, from the World Input-Output Database (WIOD). When possible, we include 56 countries in our sample—43 AEs, 22 EMs, and an aggregate for the rest of the world. For the analysis of factors (which requires the WIOD), we focus on 20

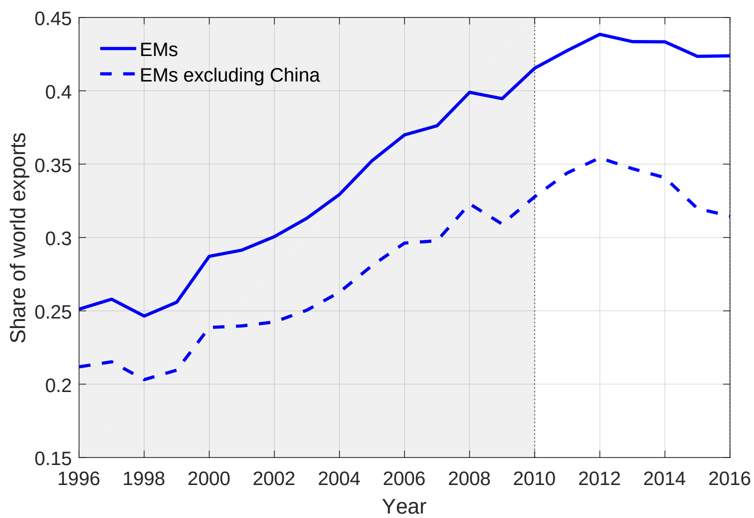
[6] The work by Cravino and Sotelo (2019) is also closely related, but they do not consider physical capital as a factor of production.

AEs, and 13 EMs.

Fact 1: Trade by EMs represents a significant share of world trade.

Figure 2 shows total EMs exports as a fraction of total world exports.[7] Clearly, EMs now (non-shaded region of figures) play a key role as global trading partners. Relative to the 1990s, the role of EMs has increased significantly. EMs exports accounted for about 25 percent of global exports in 1996, but their share expanded drastically to 42 percent in 2016. The expansion in the role of EMs has been studied in other work by Hanson (2012) and Timmer et al. (2014), who document the rise of EMs in global trade from the early 1990s until the Global Financial Crisis (GFC). Figure 2 highlights that the rise of EMs importance in global trade continued after the GFC, but has stabilized in recent years.

Figure 2: EMs Export Share (share of world exports)



Hanson (2012) points to the rise of China since the 1990s as an important driving force behind the rising share of EMs trade in global trade. To address the role of China, we compute EMs exports as a fraction of world exports excluding China as a trade partner.[8] Figure 2 shows that the rising share of EM trade in global trade is not solely driven by China. While it is true that

[7] Index countries by $i \in \mathcal{I}$, where $\mathcal{I}$ denotes the set of all countries. Define $\mathcal{A}$ as the set of AEs and $\mathcal{E}$ as the set of EMs, such that $\mathcal{A} \cup \mathcal{E} = \mathcal{I}$. We define $X_{ih,t}$ as the exports in period t from country h to country i. Total EM exports as a fraction of total world exports is computed as follows: $\frac{\sum_{h \in \mathcal{E}} \sum_{i \in \mathcal{I}} X_{ih,t}}{\sum_{h \in \mathcal{I}} \sum_{i \in \mathcal{I}} X_{ih,t}}$.

[8] Total EMs exports as a fraction of total world exports excluding China as a trading partner is computed as follows: $\frac{\sum_{h \in \mathcal{E} \setminus CHN} \sum_{i \in \mathcal{I} \setminus CHN} X_{ih,t}}{\sum_{h \in \mathcal{I} \setminus CHN} \sum_{i \in \mathcal{I} \setminus CHN} X_{ih,t}}$.

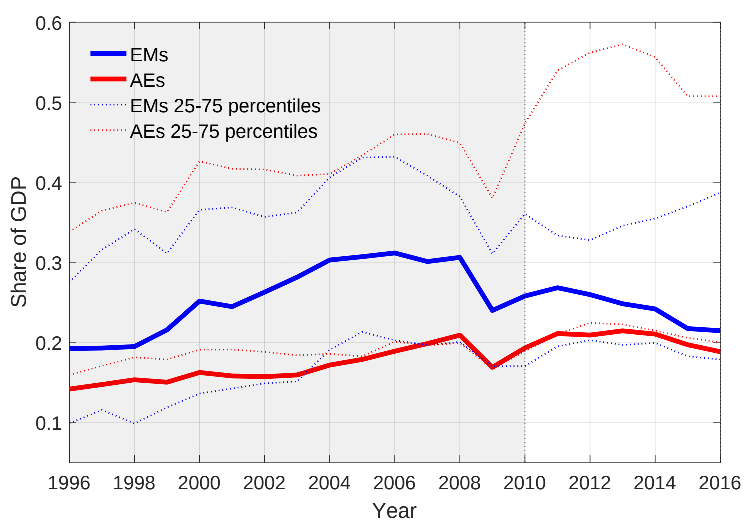
China accounts for a significant share of world exports and has been a main driver of the increasing importance of EM exports, other EM exports have also increased significantly over the last two decades, from about 21 percent to 31 percent of world exports (excluding those from and to China).

Our goal is ultimately for these facts to guide our quantitative model. To this end, we see the rise of EMs in global trade as evidence of the need to incorporate general equilibrium forces into any quantification of the effects of rising trade barriers. EMs are no longer small open economies, but countries whose actions and economic fortunes spillover onto both other EMs and AEs.

Fact 2: Emerging markets are on average more open than advanced economies, but there is great heterogeneity across countries.

Figure 3 shows how, on average, EMs are more open than AEs. We simply define a region's average trade openness as total exports by a region as a fraction of total GDP of the region.[9]. As figure 3 shows, EMs have historically had greater average trade openness than AEs, especially in the period leading up to the Great Financial Crisis (GFC). For example, in 2004, EMs average trade openness was 30 percent, which was almost twice as high as AEs trade openness of 17 percent. After the GFC, trade openness across EMs and AEs has converged somewhat, in part driven by the slower economic recovery in AEs following the GFC, but EMs remain relatively more open than AEs.

Figure 3: EMs and AEs Trade Openness (exports as a share of GDP)



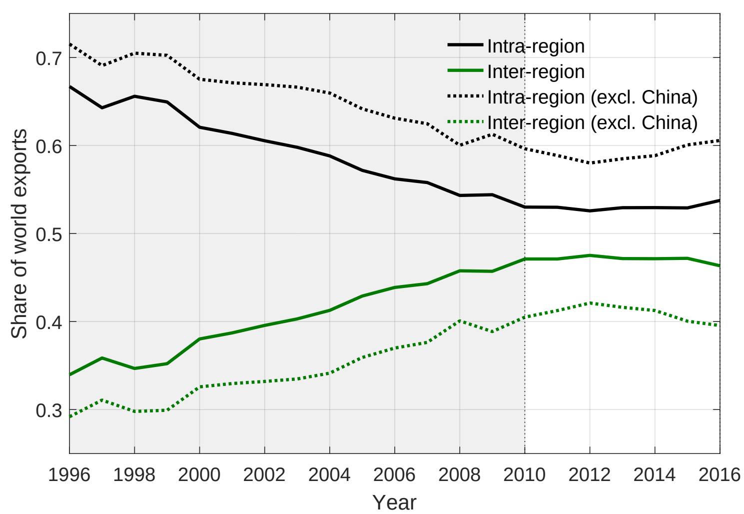
[9]Denote $Y_{h,t}$ as country h's nominal GDP in period t. EM and AE trade openness are compute as follows: $\frac{\sum_{h\in\mathcal{E}}\sum_{i\in\mathcal{I}}X_{ih,t}}{\sum_{h\in\mathcal{E}}Y_{h,t}}$ and $\frac{\sum_{h\in\mathcal{A}}\sum_{i\in\mathcal{I}}X_{ih,t}}{\sum_{h\in\mathcal{A}}Y_{h,t}}$

Even though EMs are more open on average, trade openness is very heterogeneous across countries in both regions. Figure 3 also plots the 25th and 75th percentiles of the country-specific measures of openness in EMs and AEs. Clearly, the amount of heterogeneity implies that average trade openness is not very informative about all countries in a particular region. Hence, some EMs are very similar to AEs in terms of trade openness.

Once again looking forward to our modeling choices, this fact demonstrates the need for heterogeneity in trade openness across countries. The propagation of global trade shocks to EMs will ultiamtely depend on their initial remoteness, and the barriers they face.

Fact 3: As a share of global trade, inter-regional trade has grown.

Figure 4: Intra- and Inter-region Trade Linkages (share of world exports)



Now we turn to the links that EMs form amongst themselves and with AEs. The rise of EMs is consistent with a world of multiple trading blocks, with EMs largely buying and selling to particular AEs, or with globally dense set of interconnections. We show that this latter arrangement describes modern EMs. To do this, we compute two measures of trade: (1) trade linkages among AEs and among EMs, which we define as intra-region trade; and (2) trade linkages between AEs and EMs, which we define as inter-region trade.[10] Figure 4 show that exports across regions, rather than

[10]More specifically, our measures of intra- and inter-region trade are computed as follows:

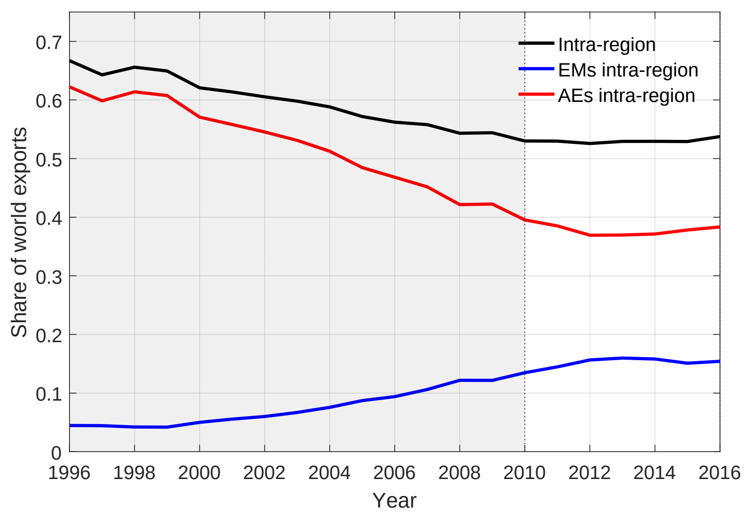
1. Intra-region trade:
$$\frac{\sum_{h\in\mathcal{A}}\sum_{i\in\mathcal{A}}X_{ih,t}+\sum_{h\in\mathcal{E}}\sum_{i\in\mathcal{E}}X_{ih,t}}{\sum_{h\in\mathcal{I}}\sum_{i\in\mathcal{I}}X_{ih,t}}.$$

within, currently accounts for nearly half of world exports—even if one ignores the meteoric rise of China. This was not always the case: prior to the early 2000s, trade between advanced economies dominated trade flows. Consequently, the trade literature focused mostly on studying so-called North-North trade. However, as the role of EMs in global trade has grown in importance, the predominance of North-North trade needs to be revisited. Today, both inter- and intra- regional trade are equally important features of the global economy.

Our major takeaway from Figure 4 is that trade patterns for EMs cannot be easily described in a North-South or North-North model. Instead, the high levels of both inter- and intra- industry trade suggest a model of differences in comparative advantage both between and within regions. Thus our model features many countries and many sectors, allowing for the kind of heterogeneity that can match modern trade patterns.

Fact 4: As a share of global trade, intra-regional trade has increased between EMs while declining, but still remaining important between AEs.

Figure 5: Intra-region Trade (share of world exports)



Next, we break down trade between patterns among EMs and AEs. We disentangle the previous measure of intra-region trade into: (1) trade among AEs; and (2) trade among EMs as a share of

2. Inter-region trade:

$$\frac{\sum_{h\in\mathcal{A}}\sum_{i\in\mathcal{E}} X_{ih,t} + \sum_{h\in\mathcal{A}}\sum_{i\in\mathcal{E}} X_{ih,t}}{\sum_{h\in\mathcal{I}}\sum_{i\in\mathcal{I}} X_{ih,t}}.$$

world trade.[11] Figure 5 plots these two measures together with the same inter-region measure as in Figure 4. Interestingly, the falling share of intra-region trade in global trade, as highlighted in Figure 4, is driven by the decline in the trade share among AEs, which fell sharply from over 60 percent of world trade in the late 1990s to just over 40 percent in 2016. In contrast, the share of EM trade has more than tripled from 4 percent of world trade in 1996 to 15 percent in 2016.[12]

Going back to the quantitative model proposed, we see the increase in intra-region trade among EMs as evidence of the relevance of incorporating heterogeneity across EMs. This heterogeneity clearly points in the direction of a model with multiple countries rather than multiple regions.

Fact 5: EMs produce and consume both intermediate and capital goods, but heterogeneously.

By now it should be clear that EMs are substantial players in the global economy—the era of trade dominated by similar countries has given way to a more completely integrated world. However, does this imply the models meant to understand trade in the latter half of the 20th century are ill-equipped for today's trade regime? In this fact we show that the answer is yes and no. EMs produce and import different goods than AEs, which militates against theories based on variety trade among similar countries. On the other hand, intra-industry trade is becoming increasingly important in these economies. This pushes for a framework that blends both classical and new trade theories. We also document an important fact that pushes us towards a dynamic model of trade: a substantial chunk of EM trade (both with AEs and amongst each other) is in capital and investment goods.

Before turning to the types of goods in which EMs trade, we turn to whether intra-industry, or inter-industry trade dominates for these economies. To this end, Figure 6 plots the evolution of the average Grubel and Lloyd (1971) index across industries for different sets of country-pairs. This index is calculated as one minus the ratio of net exports of a good to the ratio of gross trade flows of a good:

$$GL_{cc'i} = 1 - \frac{|X_{ci} - M_{ci}|}{X_{ci} + M_{ci}}.$$

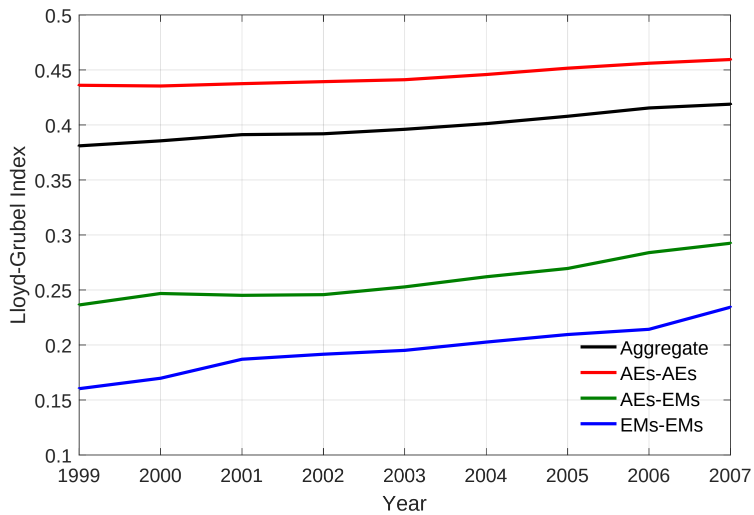
If a country exports as much of a good as it imports, the index is equal to 1, and it is evidence of high intra-industry trade. If a country either only exports or only imports a good, the index is

[11] The two measures of intra-region trade are computed as follows: $\frac{\sum_{h\in\mathcal{A}}\sum_{i\in\mathcal{A}} X_{ih,t}}{\sum_{h\in\mathcal{I}}\sum_{i\in\mathcal{I}} X_{ih,t}}$ and $\frac{\sum_{h\in\mathcal{E}}\sum_{i\in\mathcal{E}} X_{ih,t}}{\sum_{h\in\mathcal{I}}\sum_{i\in\mathcal{I}} X_{ih,t}}$.

[12] If we exclude China's economy, trade among EMs grew from 4 percent of world trade in 1996 to 9 percent in 2016.

equal to 0. We calculate this index at the HS6 level for every good and for each country's trade with all other countries. Taking the simple average yields a country (or region) level measure of intra industry trade. Figure 6 plots the evolution of this index for trade between and a cross EMs/AEs as well as the simple average across all countries.

Figure 6: Intra- and Inter-industry Trade Across and Within Regions



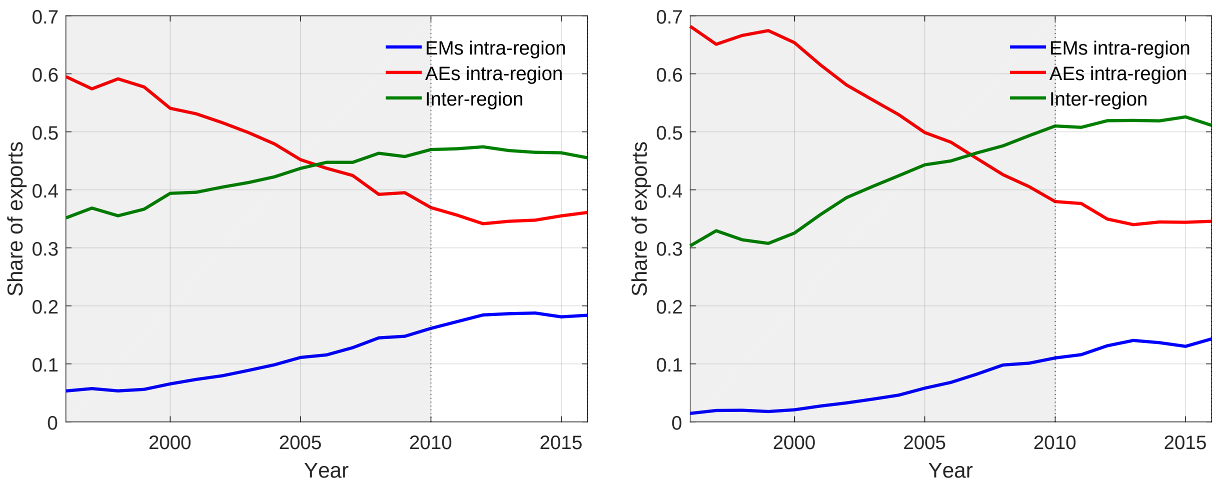
The index has been relatively high and stable for trade within AEs since the beginning of the sample. Hence, when trade within AE dominated trade flows, it is not surprising that models of inter-industry trade were unable to replicate trade patterns in the data. However, the figure shows that both trade between AEs and EMs, and trade within EMs is mostly driven by trade across industries. This points to the need for multi-industry, multi-factor models in understanding the consequences of globalization for this set of countries. On the other hand, while still low, intra-industry trade is increasing for EMs, pointing towards a role for variety effects and other elements of the new trade theory in the new geography of trade.

For the rest of this subsection we focus on what kind of goods EMEs are trading. Our motivation for doing so is the growing importance of global value chains, and the consequent rise of trade in intermediate goods (Johnson, 2014). To evaluate the role of global value chains, we disaggregate total trade among and between AEs and EMs into two types of traded goods following the Broad Economic Categories (BEC) classification: (1) trade in intermediate goods; and (2) trade in capital goods.[13]

[13]See Appendix B for the breakdown of each category. Among these two categories, intermediate goods trade accounts for more than half—56 percent in 2016— of total goods trade whereas capital goods accounts for 17 percent. The BEC classification also includes consumption goods trade as a separate category. The patterns are similar to

Figure 7: Importance of EMs in Intermediate and Capital Goods Trade

(a) Intermediate Goods (share of intermediate exports) (b) Capital Goods (share of capital exports)



The left panel in Figure 7 shows the breakdown of all the same three trade patterns as in Figure 5 for intermediate goods trade as a share of total intermediates goods trade. It highlights that the share of trade among AEs has also declined for intermediate goods trade. In contrast, the share of intermediate goods trade among EMs has increased significantly. This is consistent with the rapid expansion of China's economy, but also with the rise of global value chains, which has also pushed up the share of intermediate goods trade between EMs and AEs. This connects to the analysis of inter-industry trade, as it suggests that the inter-industry trade documented above likely reflects input-output linkages between advanced and emerging economies.

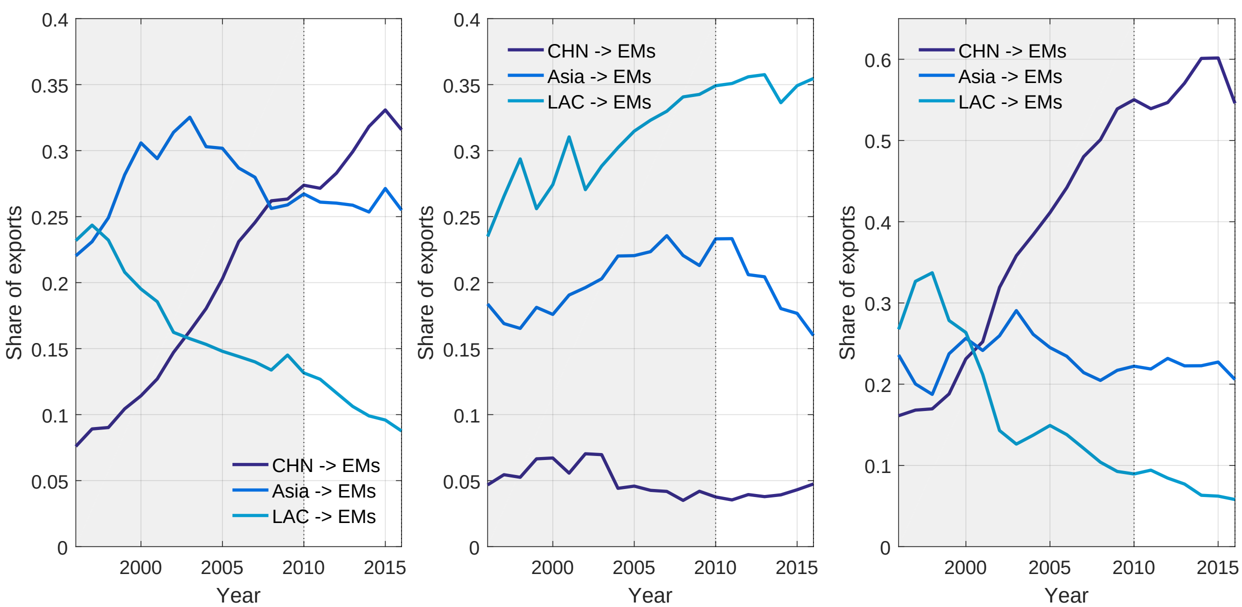
Turning to capital goods trade, the right panel in Figure 7 shows the same breakdown for all three trade patterns pairs. Interestingly, the same patterns emerge for capital goods trade as they did for intermediate goods trade. Capital goods trade between AEs as a share of global capital goods trade has declined dramatically. And EMs' trade importance in capital goods trade has soared, both with AEs and EMs. For example, capital goods trade among EMs was almost non-existent in 1996 but has risen to about 15 percent of global capital goods trade. In an influential paper, Eaton and Kortum (2001) show that in the 1990s almost all world exports of capital goods were done by only a few AEs. Figure 7 clearly shows that this common view of trade in capital goods is outdated. We see this evidence as a novel insight derived from our empirical analysis. Moreover, the growth in importance of EMs in capital goods trade points to a connection between trade and investment in

those documented for intermediate and capital goods.

these economies, and motivates our inclusion of investment decisions in the subsequent structural model.

Figure 8: Trade among EMs (share of category's exports)

(a) Intermediate Goods (b) Non-oil Commodities (c) Capital Goods



Given the increasing role of trade *among* EMs in global trade, we study regional patterns of trade. We are particularly interested in whether the growth in intermediates simply reflects a commodities boom in a few EMs. This turns out not to be the case, albeit both commodities and other intermediates matter. To illustrate this, we decompose within-EM trade into three main categories: (1) intermediate goods; (2) commodities; and (3) capital goods.[14] Figure 8 plots the share of regional trade with other EMs as a share of total EM trade in each good category. For instance, the solid black line in the left panel shows China's intermediate goods trade with other EMs as a share of total intermediate goods trade among EMs.

The left panel in Figure 8 highlights that trade in intermediate goods is dominated by China and the Asian EMs. Latin American countries represent a small share of intermediate trade. In contrast, Latin American countries account for the largest share of non-oil commodities trade to other EMs as shown in the middle panel. Finally, the right panel shows trade in capital goods. Interestingly, China's share of capital goods exports to other EMs has soared over the past two decades from just under 20 percent in 1996 to 60 percent in 2016. These patterns of trade suggest

[14]See Appendix B for the breakdown of each category.

that EMs differ among themselves in terms of comparative advantage especially between commodity exporters and exporters of manufactures. Not only does this document how EMs have integrated themselves into global value chains, but it suggests that the implications of trade shocks may be very different across EMs, at least in comparing Latin America and Asia. All told, the patterns we highlight here point towards the need for a model that allows for production heterogeneity and investment for EMs. Before showing how we can integrate these forces into a quantitative model we turn to our final fact: the stark differences in factor supplies across EMs and AEs.

Fact 6: Factor endowments are key to understand AE-EM trade.

While it is well known that EMs and AEs differ dramatically in factor supplies—and we focus on skilled and unskilled labor—it is, perhaps surprisingly, less clear how much this matters for explaining trade patterns. Much of the 1990s was spent documenting the failure of factor based models of trade, and the simultaneously low amount of trade between EMs and other countries. We do not speak to this literature directly, and instead point the reader to the recent work of Trefler and Zhu (2010) and Morrow and Trefler (2017). However, we compute the factor content of net trade for each of the countries in our sample and demonstrate that these contents are systematically different across AEs and EMs. The factor content of trade is an intuitive construct: it uses an economy's production structure to map trade in output into the implied trade in inputs (factors). We follow the method of Trefler and Zhu (2010), which allows one to construct the factor content of trade in a world of input-output links. We compute the skilled labor content of trade, FH, and unskilled labor content of trade, FL, and define the skill bias of net trade as $FH - FL$. Figure 9 displays our skill bias measure across all countries, averaged over time.

The figure's results are both intuitive and stark: advanced economies tend to export high skilled labor (or import low skilled labor), and the opposite is true for EMs. Moreover, the differences in these numbers are large. For example, Germany exports nearly as much high skilled labor as China exports low skilled labor. Indeed, the 5 largest net exporters of high skilled labor are all AEs, while only 2 of the 5 largest net exporters of low skilled labor are AEs.

The time series evidence reinforces, and actually amplifies, the cross-sectional evidence. Figure 10 plots the average skill bias of factor content for each group of countries. From the figure one can see that not only is the difference large, but it is growing over time. Hence, despite a general increase in skilled labor across the world, AEs seem to be disproportionately increasingly specialized in high skilled intensive goods.

Figure 9: Skill Bias of Net Factor Content of Trade

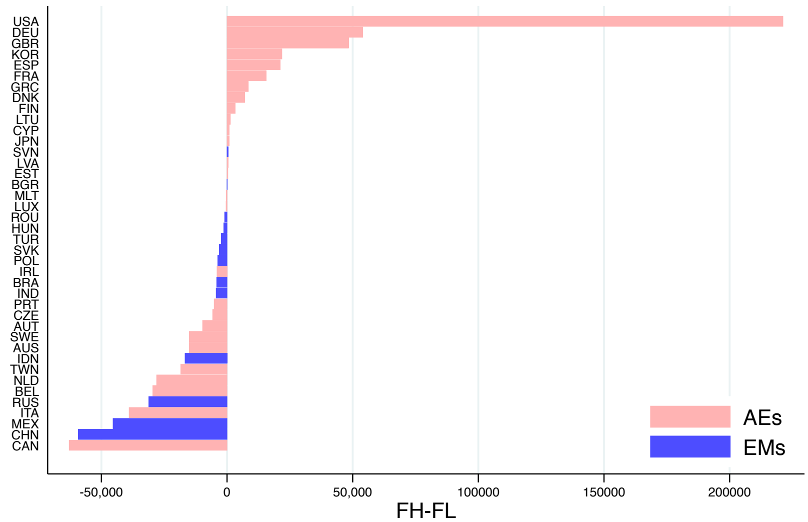
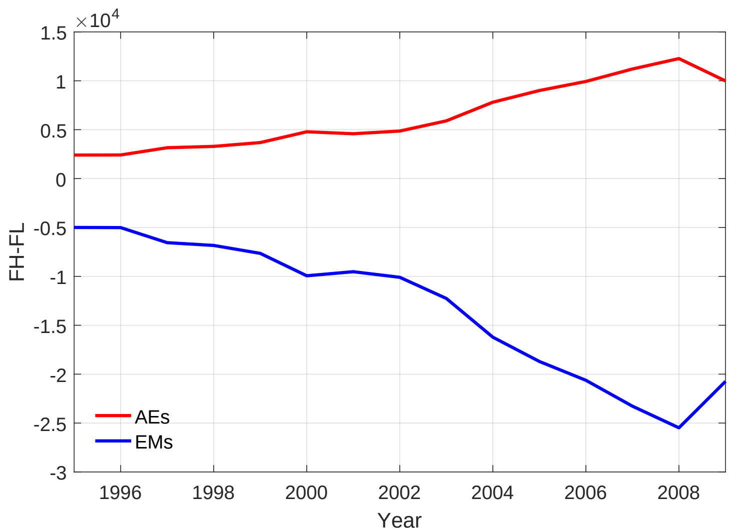


Figure 10: Evolution of Regional Skill Bias of Net Factor Content of Trade



Facts 5 and 6 call for a reevaluation of the role of Heckscher-Ohline forces—emphasizing multiple factors and sectors—in shaping trade across countries. Hanson (2012) and Timmer et al. (2014) both argue and show that changes in trade flows are consistent with EMs accumulating physical and human capital. The increase in skilled- relative to unskilled-labor is a relevant recent feature in EMs. However, EMs still produce low-skill intensive goods, consistent with them having a comparative disadvantage in such goods relative to advanced economies. This fact motivates the introduction of multiple factors of production as in Parro (2013), but also allowing for long run changes in some of these factors, specifically, physical capital.

3 The Model

In this section, we develop a quantitative model of international trade that incorporates the featrues of the new geography of trade documented in Section 2. We consider a dynamic model with multiple factors of production that encompasses Ricardian and HO types of comparative advantage. We will use this model to explore the macroeconomic effects of changes in trade barriers on EMs, as well as on the world economy overall. We first describe endowments, technologies and households' preferences and constraints, and then turn to the characterization of the optimal decisions by firms and households, as well as market clearing conditions.

3.1 Endowments, Technologies and Households

We consider an infinite horizon world economy where time is discrete and indexed by $t = 0, 1, \ldots$. The world consists of I countries indexed by i. Each country is populated by a representative household endowed with $S_{i,t}$ units of skilled labor and $U_{i,t}$ units of unskilled labor in every period t, and $K_{i,0}$ units of homogeneous physical capital in period $t = 0$. Both types of labor and capital are non-tradable across countries.

The economy of each country consists of J sectors indexed by j. Sectoral goods are non-tradable across countries, but they are produced by aggregating a continuum of sector-specific varieties that are tradable and that add value when produced. Non-tradable sectoral goods can be used for consumption, investment or as intermediate inputs in the production of sector-specific varieties.

3.1.1 Technologies: Non-tradable Sectoral Goods

Final output in each sector j is given by an aggregate of a continuum of tradable goods indexed by $\omega^j \in [0, 1]$. We assume that this aggregation takes on a constant elasticity of substitution (CES) functional form with elasticity of substitution $\eta > 0$. Denoting by $Q^j_{i,t}$ sector j's final output in country i at time t, we have that

$$Q^j_{i,t} = \left(\int_0^1 d^j_{i,t} \left(\omega^j\right)^{\frac{\eta-1}{\eta}} d\omega^j \right)^{\frac{\eta}{\eta-1}}, \tag{1}$$

where $d^j_{i,t}\left(\omega^j\right)$ denotes the use in production of intermediate good ω^j.

The demand for each intermediate good is derived from the cost minimization problem of a price-taking representative firm. Moreover, since good ω^j is tradable across countries, the firms producing $Q_{i,t}^{j}$ search across all countries for the lowest cost supplier of this good.

The final output in each sector j is non-tradable and can be used either for final consumption, investment or as an intermediate input into the production of the tradable goods. We will denote by $P_{i,t}^{j}$ the price of sectoral good j in country i at time t. Let us now focus on the technologies available to produce the tradable goods indexed by ω^{j}.

3.1.2 Technologies: Tradable Goods

Consider a particular good $\omega^{j} \in [0,1]$ and let $q_{i,t}^{j}\left(\omega^{j}\right)$ denote the production of this good in country i at time t. We consider a technology to produce each good ω^{j} flexible enough to accommodate different elasticities of substitution across factors of production.

Each good ω^{j} is produced according to

$$q_{i,t}^{j}\left(\omega^{j}\right) = x_{i,t}^{j}\left(\omega^{j}\right)\left[V_{i,t}\left(\omega^{j}\right)\right]^{\nu_i^j}\left[M_{i,t}^{j}\left(\omega^{j}\right)\right]^{1-\nu_i^j}, \tag{2}$$

where $V_{i,t}^{j}\left(\omega^{j}\right)$ is the amount value added in production of good ω^{j}, and $M_{i,t}^{j}\left(\omega^{j}\right)$ denotes the amount of intermediates used in production. Value added is in turn given by

$$V_{i,t}^{j}\left(\omega^{j}\right) = \left[\left(\gamma_i^j\right)^{\frac{1}{\sigma}} u_{i,t}\left(\omega^{j}\right)^{\frac{\sigma-1}{\sigma}} + \left(1-\gamma_i^j\right)^{\frac{1}{\sigma}} Z_{i,t}\left(\omega^{j}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{3}$$

where $Z_{i,t}$ denotes the composite factor of production that aggregates physical capital and skilled labor and is given by

$$Z_{i,t}^{j}\left(\omega^{j}\right) = \left[\left(\varphi_i^j\right)^{\frac{1}{\rho}} k_{i,t}\left(\omega^{j}\right)^{\frac{\rho-1}{\rho}} + \left(1-\varphi_i^j\right)^{\frac{1}{\rho}} s_{i,t}\left(\omega^{j}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}. \tag{4}$$

We assume that the use of intermediates in production is given by a Cobb-Douglas aggregate of non-tradable sectoral goods:

$$M_{i,t}^{j}\left(\omega^{j}\right) = \prod_{m=1}^{J} D_{i,t}^{j,m}\left(\omega^{j}\right)^{\alpha_i^{j,m}}, \tag{5}$$

where $\sum_{m=1}^{J}\alpha_i^{j,m} = 1$ for all $j = 1,\ldots,J$ and $\alpha_i^{j,m} \in (0,1)$ for all $j,m = 1,\ldots,J$. Here, $D_{i,t}^{j,m}\left(\omega^{j}\right)$ denotes the intermediate demand by producers of good ω^{j} for sectoral good m. The efficiency in the production of good ω^{j} is given by $x_{i,t}^{j}\left(\omega^{j}\right)$.

Note that the country and sector specific parameter $\nu_i^j \in (0,1)$ determines the share of value added in gross production, while $\alpha_i^{j,m}$ for all $j,m = 1,\ldots,J$ determine the input-output structure in each country.

Following Eaton and Kortum (2002), we assume that the efficiency in the production of good ω^j, $x^j_{i,t}\left(\omega^j\right)$, is given by the realization of a random variable, $x^j_{i,t} \in (0, \infty)$, distributed conditional on information in period t according to a Fréchet distribution with shape parameter θ^j and location parameter $T^j_{i,t}$,

$$F^j_{i,t}\left(x|t\right) = \Pr\left[x^j_{i,t} \leq x\right] = e^{-T^j_{i,t}x^{-\theta^j}}. \tag{6}$$

We assume that, conditional on $T^j_{i,t}$, the random variables $x^j_{i,t}$ are independently distributed across sectors and countries. In that case, the level of $T^j_{i,t}$ represents a measure of absolute advantage in the production of sector j goods, while a lower θ^j implies more dispersion across the realizations of the random variable and a higher scope for gains from comparative advantage differences through specialization.

We refer to $T^j_{i,t}$ as the sectoral productivity of country i in sector j at time t, since their values determine the level of the distribution from which producers draw their efficiencies. Notice that we are assuming that productivities can change over time, therefore implying that exogenous permanent changes in these parameters can lead the world economy to transition from one steady state to a new one.

3.1.3 Households

The dynamic dimension of the model results from the household's saving and investment decisions. We consider the benchmark case in which financial markets are frictionless, which implies that the return on international assets—denominated in a single currency— is the same for all countries.

The problem of the representative household in country i is to choose sectoral levels of consumption and investment as well as aggregate investment and savings to maximize lifetime utility. Thus, the household in country i must choose for every $t = 0, 1, \ldots$ consumption and investment levels in each sector, as well as next period's aggregate capital stock and bond holdings, $\left\{\{C^j_{i,t}\}_{j\in\mathcal{J}}, \{X^j_{i,t}\}_{j\in\mathcal{J}}, , K_{i,t+1}, B_{i,t+1}\right\}^{\infty}_{t=0}$, in order to maximize lifetime utility $\sum_{t=0}^{\infty}\beta^t \ln\left(C_{i,t}\right)$, where $C_{i,t}$ is aggregate consumption, which is a function of sectoral consumption levels, to be defined next. Bond holdings at the end of period t, $B_{i,t+1}$, are subject to portfolio adjustment costs. In particular, the cost of holding $B_{i,t+1}$ bonds is given by $\frac{\psi}{2}\left(B_{i,t+1} - \bar{B}_i\right)^2$, where $\bar{B}_i$ is exogenous.[15]

[15] These costs are modeled as in Neumeyer and Perri (2005). We choose this route to introduce trade imbalances in steady state because it introduces stationarity into the model. This feature simplifies the computation of counterfactual equilibria considerably. See Reyes-Heroles (2017) for a model without stationarity.

The choices by the representative household are subject to the budget constraint,

$$\sum_{j=1}^{J} P_{i,t}^{j}\left(C_{i,t}^{j}+X_{i,t}^{j}\right)+B_{i,t+1}+\frac{\psi}{2}\left(B_{i,t+1}-\bar{B}_{i}\right)^{2}=w_{i,t}^{U}U_{i,t}+w_{i,t}^{S}S_{i,t}+r_{i,t}K_{i,t}+R_{t}B_{i,t}+\mathcal{T}_{i,t}, \quad (7)$$

as well as to the law of motion for capital,

$$K_{i,t+1}=X_{i,t}+(1-\delta)\,K_{i,t}, \quad (8)$$

in every period $t=0,1,\ldots$, where $\mathcal{T}_{i,t}$ are tariff revenues that are rebated to households in a lump sum fashion. Aggregate consumption and investment in the representative household's problem, $C_{i,t}$ and $X_{i,t}$, are given by Cobb-Douglas aggregates of sectoral consumption and investment levels, respectively:

$$C_{i,t}=\prod_{j=1}^{J}\left(C_{i,t}^{j}\right)^{\mu_{i}^{j}} \text{ and } X_{i,t}=\xi_{i,t}\prod_{j=1}^{J}\left(X_{i,t}^{j}\right)^{\chi_{i}^{j}}, \quad (9)$$

with $\mu_{i,t}^{j},\chi_{i,t}^{j}>0$ and $\sum_{j=1}^{J}\mu_{i,t}^{j}=\sum_{j=1}^{J}\chi_{i,t}^{j}=1$ for all $i=1,\ldots,I$ and $t=0,1,\ldots$. Here, $\xi_{i,t}$ is an investment-specific efficiency shifter that we also allow to exogenously change over time.[16]

Turning to international borrowing and lending, and capital accumulation, notice that the dynamics in the household problem arise entirely through these two decisions. Here, $B_{i,t}$ is the stock of one period bonds in terms of world currency units owned by country i at the beginning of period t. In period $t=0$, these bonds exist in zero-net supply, that is, $\{R_0 B_{i,0}\}_{i=1}^{I}$ are given such that $\sum_i R_0 B_{i,0}=0$. Capital is non-tradable, so households rent it to domestic firms and must use domestic resources to invest and accumulate capital over time. All endogenous dynamics in the model arise through these two channels. In other words, decisions by firms in the model, as shown in previous subsections, are static.

3.2 Prices and Optimal Decisions

3.2.1 Firms: Trade Costs and Prices

For each sector $j=1,\ldots,J$, goods $\omega^j\in[0,1]$ can be traded across countries, but are subject to trade costs. Specifically, the cost of shipping any good $\omega^j\in[0,1]$ from country h to country i at time t consist of iceberg type trade barriers, $d_{ih,t}^{j}\geq 1$, and add valorem tariffs, $\kappa_{ih,t}^{j}\geq 0$. Hence, the total add valorem cost of shipping a good $\omega^j\in[0,1]$ from country h to country i at time t is given

[16] This shifter will be very helpful when we take the model to the data in Section 4.

by $\tau^j_{ih,t} \equiv d^j_{ih,t}\left(1+\kappa^j_{ih,t}\right) \geq 1$. This means that, in order for one unit of variety ω^j to be available in country i at time t, country h must ship $d^j_{ih,t}$ units of the good. We assume that $\tau^j_{ii,t} = 1$ for all $i = 1, \ldots, I$, that is, there are no trade costs associated with trading goods within countries. Note that these bilateral trade costs are allowed to change over time and that they are sector, but not good specific. Hence, we also allow exogenous changes in trade costs to trigger transitional dynamics in the model.

Let us now turn to the optimal decisions by firms. In particular, first consider the problem faced by the producer of good $\omega^j \in [0,1]$. Assuming perfectly competitive markets and given constant returns to scale in the production of good ω^j, the free-on-board price (before trade costs) of one unit of this good, if actually produced in country i at time t, will be equal to its marginal cost, $\frac{c^j_{i,t}}{x^j_{i,t}(\omega^j)}$, where $c^j_{i,t}$ is the cost of the input-bundle to produce one unit of ω^j. This cost is given by

$$c^j_{i,t} = \varkappa^j_i \left[\left(P^V_{i,t}\right)^{\nu^j_i} \left(\prod_{m=1}^{J} \left(P^m_{i,t}\right)^{\alpha^{j,m}_i} \right)^{1-\nu^j_i} \right], \tag{10}$$

with

$$P^V_{i,t} = \left[\gamma^j_i \left(w^U_{i,t}\right)^{1-\sigma} + \left(1-\gamma^j_i\right)\left(P^Z_{i,t}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{11}$$

and

$$P^Z_{i,t} = \left[\varphi^j_i \left(r_{i,t}\right)^{1-\rho} + \left(1-\varphi^j_i\right)\left(w^S_{i,t}\right)^{1-\rho}\right]^{\frac{1}{1-\rho}}, \tag{12}$$

where $\varkappa^j_i$ is a constant that depends on production parameters.[17]

For a particular sector j, notice that the the technologies to produce goods $\omega^j \in [0,1]$ differ only by their productivity draw, while $c^j_{i,t}$ is constant across tradable goods. Hence, we can relabel tradable goods by their efficiencies, $x^j_{i,t}$, and define $U^j_{i,t}$, $S^j_{i,t}$, $K^j_{i,t}$ and $D^{j,m}_{i,t}$ as total factor (unskilled labor, skilled labor and physical capital) usage in sector j, and intermediate input usage from each sector m in sector j.[18]

Turning to the problem faced by the non-tradable sectoral goods producers, given the price of each variety $\omega^j \in [0,1]$ that the representative firm is faced with, $p^j_{i,t}\left(\omega^j\right)$, the firm minimizes

[17] Specifically, $\varkappa^j_i = \left(\nu^j_i\right)^{-\nu^j_i}\left(\left(1-\nu^j_i\right)\prod_{m=1}^{J}(\alpha^{j,k}_i)^{\alpha^{j,m}_i}\right)\right)^{-\left(1-\nu^j_i\right)}$.

[18] Letting $\varrho^j\left(x^j|t\right)$ denote the conditional joint density of the sector specific vector of productivity draws for all countries, $x^j = \left(x^j_{1,t}, ..., x^j_{I,t}\right)$, these variables are defined for $G \in \{U,S,K\}$ and $g \in \{u,s,k\}$ as

$$F^j_{i,t} = \int_{\mathbb{R}^I_+} f^j_{i,t}\left(x^j\right)\varrho^j\left(x^j|t\right) \text{ and } D^{j,m}_{i,t} = \int_{\mathbb{R}^I_+} D^{j,m}_{i,t}\left(x^j\right)\varrho^j\left(x^j|t\right)dx^j.$$

costs, resulting in demand functions, conditional on $Q^j_{i,t}$, for each tradable good $\omega^j \in [0,1]$ given by $d^j_{i,t}\left(\omega^j\right) = \left(\frac{P^j_{i,t}}{p^j_{i,t}(\omega^j)}\right)^{\eta} Q^j_{i,t}$, where

$$p^j_{i,t}\left(\omega^j\right) = \min_h \left\{p^j_{h,t}\left(\omega^j\right)\right\} = \min_h \left\{\frac{c^j_{h,t}\tau^j_{ih,t}}{x^j_{h,t}\left(\omega^j\right)}\right\} \tag{13}$$

and $P^j_{i,t}$ denotes the price of sectoral good j, which is given by

$$P^j_{i,t} \equiv \left(\int_0^1 p^j_{i,t}\left(\omega^j\right)^{1-\eta} d\omega^j\right)^{\frac{1}{1-\eta}}. \tag{14}$$

Note that firms, by minimizing their costs, source tradable good ω^j from the lowest cost supplier after taking into account trade costs, as is implied by (13).

3.2.2 Sectoral Gravity

Given the efficiency distributions, we can derive an expression for sectoral price indices in equilibrium as functions of all sectoral prices, factor prices, and trade costs around the world. These prices are conditional on the known values of sectoral productivities, $T^j_{i,t}$, and bilateral trade costs, $\tau^j_{ih,t}$, in period t. Using (14) and the properties of the distribution of efficiencies around the world, we can derive the sectoral prices in each country i and every period t. These prices are given by

$$P^j_{i,t} = \Gamma^j \left[\Phi^j_{i,t}\right]^{-\frac{1}{\theta^j}}, \tag{15}$$

where Γ^j is a constant that only depends on η and θ^j, and

$$\Phi^j_{i,t} = \sum_{h=1}^{I} T^j_{h,t}\left(c^j_{h,t}\tau^j_{ih,t}\right)^{-\theta^j} \tag{16}$$

represents a sufficient statistic for sector j in country i of the state of technologies and trade costs around the globe.[19]

The structure of the model not only allows for closed form solutions of sectoral price indices, but we can also recover sectoral trade shares for each country in terms of world prices, technologies and trade costs, that is, we can find expressions for the share of total expenditure on goods produced in

[19] In particular, $\Gamma^j = (\Gamma(1 + \frac{(1-\eta)}{\theta^j}))^{\frac{1}{1-\eta}}$, where $\Gamma(\cdot)$ denotes the Gamma function evaluated for $z > 0$. Notice this implies that parameters have to be such that $\eta - 1 < \theta$.

sector j that is spent in each country. Let $E^j_{i,t}$ denote total expenditure by country i on sector j goods, and $E^j_{ih,t}$ total expenditure by country i on sector j goods produced in country h, so that $E^j_{i,t} = \sum_{h=1}^{I} E^j_{ih,t}$. Then, the share of total expenditure in sector j by country i in goods produced by country h, $\pi^j_{ih,t} \equiv \frac{E^j_{ih,t}}{E^j_{i,t}}$, is given by

$$\pi^j_{ih,t} = \frac{T^j_{h,t}\left(c^j_{h,t}\tau^j_{ih,t}\right)^{-\theta^j}}{\Phi^j_{i,t}}, \tag{17}$$

and are such that $\sum_{h=1}^{I} \pi^j_{ih,t} = 1$ for all $i = 1, \ldots, I$ and $j = 1, \ldots, J$. Note that by the expression that we obtained before for equilibrium prices, equation (15), we can rewrite this share in terms of the sectoral price in country i as

$$\pi^j_{ih,t} = \left(\Gamma^j\right)^{-\theta^j} T^j_{h,t} \left(\frac{c^j_{h,t}\tau^j_{ih,t}}{P^j_{i,t}}\right)^{-\theta^j}. \tag{18}$$

These prices and trade shares fully summarize the optimal decisions by the firms given technologies and factor prices, as well as bilateral trade flows given sectoral expenditure levels in all countries. This can be appreciated in (15), which implicitly defines sectoral prices as a function of factor prices, and (18), which defines all bilateral trade shares given these sectoral prices.

3.2.3 Households: Investment and Savings

Solving the problem for the household can be simplified by dividing it into two subproblems, a static subproblem and a dynamic one. Let us first consider the static subproblem that the household faces in period t given choices for $B_{i,t+1}$ and $K_{i,t+1}$. Conditional on $C_{i,t}$, which is implied by the choices of $B_{i,t+1}$ and $K_{i,t+1}$, the household optimally chooses sectoral consumption expenditure across sectors according to $P^j_{i,t}C^j_{i,t} = \mu^j_{i,t}P^C_{i,t}C_{i,t}$ where $P^C_{i,t}$ denotes the ideal consumption price index given by $P^C_{i,t} = \varkappa^C_i \prod_{j=1}^{J}\left(P^j_{i,t}\right)^{\mu^j_{i,t}}$ such that total consumption expenditure is given by $E^C_{i,t} \equiv \sum_{j=1}^{J} P^j_{i,t}C^j_{i,t} = P^C_{i,t}C_{i,t}$ and where $\varkappa^C_i$ is a constant that depends on μ^j_i.

Turning to investment, conditional on the choice of $X_{i,t}$, which is also pinned down by the choices of $B_{i,t+1}$ and $K_{i,t+1}$, the household optimally chooses sectoral investment levels across sectors according to $P^j_{i,t}X^j_{i,t} = \chi^j_{i,t}\frac{P^X_{i,t}}{\xi_{i,t}}X_{i,t}$, where $P^X_{i,t}$ denotes the ideal investment price index before adjusting by efficiency, which is given by $P^X_{i,t} = \varkappa^X_i \prod_{j=1}^{J}\left(P^j_{i,t}\right)^{\chi^j_{i,t}}$ such that total investment expenditure is given by $E_{i,t}^{X} \equiv \sum_{j=1}^{J} P_{i,t}^{j} X_{i,t}^{j} = \frac{P_{i,t}^{X}}{\xi_{i,t}} X_{i,t}$ and where $\varkappa_{i}^{X}$ is a constant that depends on χ_{i}^{j}.

Let us now turn to the dynamic subproblem, that is, the optimal determination of $C_{i,t}$ and $X_{i,t}$ implied by the optimal choices of $B_{i,t+1}$ and $K_{i,t+1}$ by the household in country i. The household in country i takes its wealth at $t = 0$ as given, composed of $W_{i,0} \equiv R_0 B_{i,0}$ and $K_{i,0}$, and chooses $\{C_{i,t}, X_{i,t}, K_{i,t+1}, B_{i,t+1}\}_{t=0}^{\infty}$ to maximize

$$\sum_{t=0}^{\infty} \beta^{t} \ln \left(C_{i,t}\right) \tag{19}$$

subject to the sequence of budget constraints and the law of motion for capital given by

$$P_{i,t}^{C} C_{i,t} + \frac{P_{i,t}^{X}}{\xi_{i,t}} X_{i,t} + B_{i,t+1} + \frac{\psi}{2} \left(B_{i,t+1} - \bar{B}_{i}\right)^{2} = w_{i,t}^{U} U_{i,t} + w_{i,t}^{S} S_{i,t} + r_{i,t} K_{i,t} + R_{t} B_{i,t} + \mathcal{T}_{i,t} \tag{20}$$

and

$$K_{i,t+1} = X_{i,t} + (1 - \delta) K_{i,t}, \tag{21}$$

respectively, for every $t = 0, \ldots$.

The solution to the household's dynamic problem is characterized by a pair of Euler equations. First, the Euler equation corresponding to the optimal choice of bonds,

$$\frac{P_{i,t+1}^{C} C_{i,t+1}}{P_{i,t}^{C} C_{i,t}} = \frac{\beta R_{t+1}}{1 + \psi \left(B_{i,t+1} - \bar{B}_{i}\right)}. \tag{22}$$

The second Euler equation corresponds to optimal capital accumulation decisions and is given by

$$\frac{R_{t+1}}{P_{i,t+1}^{X} / P_{i,t}^{X}} \frac{\xi_{i,t+1}}{\xi_{i,t}} = \frac{r_{i,t+1}}{P_{i,t+1}^{X} / \xi_{i,t+1}} + (1 - \delta). \tag{23}$$

In addition, the budget constraint and the law of motion for capital complete the set of equations that characterize the household's problem.

3.3 Market Clearing Conditions

Let $Y_{i,t}^{j}$ denote the value of gross production in sector j, and $E_{i,t}^{j}$ total expenditure by country i on sector j goods. Then, the value of total gross production and total expenditure net of tariffs in country i and sector j define sectoral net exports,

$$NX_{i,t}^{j} = Y_{i,t}^{j} - \left(E_{i,t}^{j} - \sum_{h=1}^{I} \kappa_{ih,t} \frac{\pi_{ih,t}^{j} E_{i,t}^{j}}{1+\kappa_{ih,t}} \right), \tag{24}$$

and aggregate net exports are then simply given by $NX_{i,t} = \sum_{j=1}^{J} NX_{i,t}^{j}$.

First, the markets for non-tradable sectoral goods and factors must clear in every country and period. These conditions are given by

$$C_{i,t}^{j} + X_{i,t}^{j} + \sum_{k=1}^{J} D_{i,t}^{k,j} = Q_{i,t}^{j} \tag{25}$$

for all i and j, and $\sum_{j=1}^{J} U_{i,t}^{j} = U_{i,t}$, $\sum_{j=1}^{J} S_{i,t}^{j} = S_{i,t}$ and $\sum_{j=1}^{J} K_{i,t}^{j} = K_{i,t}$ for all i. Condition (25) states that demand for non-tradable goods must equal supply in each country i. We can reformulate this condition in terms of expenditures, in which case we can appreciate that total expenditure in goods in sector j in equilibrium must be given by

$$E_{i,t}^{j} = P_{i,t}^{j} C_{i,t}^{j} + P_{i,t}^{j} X_{i,t}^{j} + \sum_{m=1}^{J} P_{i,t}^{j} D_{i,t}^{m,j}. \tag{26}$$

Thus, these equilibrium conditions can be rewritten simply as $E_{i,t}^{j} = P_{i,t}^{j} Q_{i,t}^{j}$.

We now turn to market clearing in tradable goods markets. In terms of expenditure, we refer to these conditions as the flow of goods across countries equilibrium conditions. These conditions are given by

$$Y_{i,t}^{j} = \sum_{h=1}^{I} \frac{\pi_{hi,t}^{j} E_{h,t}^{j}}{1+\kappa_{hi,t}^{j}}, \tag{27}$$

and must hold for every country i and sector j. This condition states that expenditure by all countries on sector j goods produced in country i must equal the value of total gross production in country i. In particular, country h spends $\pi_{hi,t}^{j} E_{h,t}^{j}$ on sector j goods produced in country i inclusive of the tariff $\kappa_{hi,t}^{j}$. Thus, the actual expenditure in sector j by country h on goods produced in country i that firms receive after tariffs is $\frac{\pi_{hi,t}^{j} E_{h,t}^{j}}{1+\kappa_{hi,t}^{j}}$.

Total tariff revenue in country i is given by the sum of tariff revenues across sectors, $\mathcal{T}_{i,t} =$

$\sum_{j=1}^{J} \mathcal{T}_{i,t}^{j}$, where the revenue for sector j of country i is given by

$$\mathcal{T}_{i,t}^{j} = \sum_{h=1}^{I} \kappa_{ih,t}^{j} \frac{\pi_{ih,t}^{j} E_{i,t}^{j}}{1+\kappa_{ih,t}^{j}}. \tag{28}$$

Lastly, there are country-specific resource constraints. This is one of the main differences between a model with endogenous trade imbalances and static trade models. Net exports in goods and services must be consistent with optimal saving decisions by the representative household in country i. This equilibrium resource constraint is given by

$$B_{i,t+1} - R_t B_{i,t} = \sum_{j=1}^{J} NX_{i,t}^{j}. \tag{29}$$

Another way to interpret this condition is through the balance of payments. This condition is equivalent to the balance of payments identity that is trivially satisfied in most international macroeconomic models and not present in static trade models. This identity can be appreciated by rewriting the previous condition as $NX_{i,t} + (R_t - 1) B_{i,t} + B_{i,t} - B_{i,t+1} = 0$, where $CA_{i,t} \equiv NX_{i,t} + (R_t - 1) B_{i,t}$ denotes the current account in country i, and $KA_{i,t} \equiv B_{i,t} - B_{i,t+1}$ denotes the broadly defined capital account.

3.4 Steady State Equilibrium

We will use the model to compare steady state outcomes for different configurations of trade barriers.[20] Hence, we now turn to the characterization of the steady state of the model. Notice that all equilibrium conditions of the model are static in nature except for the Euler equations. Therefore, we focus on these conditions.

For any variable $F_{i,t}^{j}$, let F_{i}^{j} denote its steady state value. In a steady state equilibrium of the model, equation 22 implies that the distribution of net foreign assets is given by $\left\{\bar{B}_i\right\}_{i=1,\ldots,I}$ and current accounts are zero for all countries as long as $\psi > 0$. In addition, capital stocks for all countries must be such that the two following conditions hold:

$$\frac{r_i}{P_i^X/\xi_i} = \frac{1}{\beta} - (1-\delta) \text{ and } \delta K_i = X_i. \tag{30}$$

The first equation in (30) is the Euler equation in steady state while the second one is derived from

[20] We focus on the case of trade barriers even though the model can be equally useful to examine the effects of changes in other types of parameters like productivities or efficiency shifters.

the law of motion for capital.

The first equation in (30) shows how lower trade costs leading to a lower price of investment goods will lead to an increase in the return to capital and, therefore, an increase in investment leading to a larger capital stock in a new steady state. However, notice also that such changes in trade costs can also have general equilibrium effects on the rental rate, r_i, through HO forces that could attenuate the direct effect of trade costs on investment prices.

4 Taking the Model to the Data

One of the appealing features of the model presented in Section 3 is that it can be mapped to data in a clear and clean manner. In this section we describe the data we use as well as the steps we follow to carry out this mapping. The main objective is to find the exogenous parameters of the model such that its endogenous outcomes match as closely as possible their data counterparts observed in a particular year.[21]

The exogenous parameters of the model can be grouped into two categories: (i) time-invariant parameters and exogenous observable endowments, and (ii) exogenous shifters. We assume that the world economy is in a steady state in 2016 and will proceed to choose values for the aforementioned objects of the model to match this steady state. The calibration of time-invariant parameters and exogenous observable endowments is described in Section 4.2. Exogenous shifters, which encompass *trade barriers, productivities and investment efficiencies* and are not directly observed in the data, are recovered by inverting the model given observed endogenous outcomes, as described in Section 4.3. We consider data for 31 countries, 30 core countries and a rest of the world block (ROW), and 40 sectors, 20 of which we treat as tradable and 20 as non-tradable.[22] The group of 30 core countries considered consists of 20 AEs and ten EMs, and account for more than 85 per cent of world GDP and exports. We will consider the ROW block as another EM, making a total of eleven in our sample.

4.1 Data

We either collect or estimate data on (i) bilateral trade flows; (ii) sectoral gross output and value added; (iii) input-output tables; (iv) capital stocks and labor endowments of low- and high-skilled

[21] The procedure follows that in Reyes-Heroles (2017) closely.

[22] Non-tradable sectors in the model are simply those in which trade barriers across countries are set to infinity. The sets of countries and sectors we consider are described in Appendix A.

workers; (v) aggregate and sectoral compensations to capital, low- and high-skilled workers; (vi) aggregate GDP, consumption and investment; (vii) sectoral consumption and investment shares; and (viii) sectoral prices.[23] Whenever possible, we collect this data for the year 2016 in order to consider this as the benchmark year. However, certain data are not available for 2016, in which case we use the most recent data available. All the details on the data and their sources are provided in Appendix A.

4.2 Time-invariant Parameters and Exogenous Observable Endowments

4.2.1 Time-invariant Parameters

We start by calibrating the time-invariant parameters of the model. Table 1 provides the parameter values considered, along with the sources used to choose their values.[24]

Table 1: Time-invariant Parameters

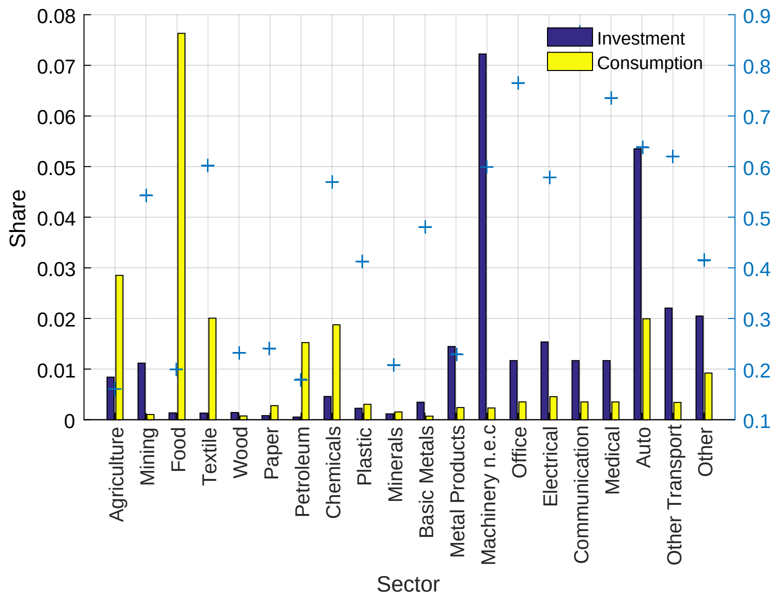
Parameter	Value	Variable	Source
ν_i^j	-	Value added to gross output ratio	Data: OECD Stan, WIOD (SEA), UNs' INDSTAT2 and the NAs
$\alpha_i^{j,k}$	-	Input-output coefficients	Data: WIOD 2016 release and OECD
γ_i^j, φ_i^j	-	Factor shares in value added	Data: WIOD 2016 release and model
θ^j	–	Trade elasticities	Caliendo and Parro (2015)
σ, ρ	-	Elasticities of substitution acros factors	Parro (2013)
η	2	Elasticity of substitution in tradable goods	Standard in literature
β	0.95	Discount factor	In line with annual data
δ	0.05	Depreciation rate	In line with annual data
μ_i^j	–	Sectoral consumption expenditure shares	Data: WIOD 2016 release
χ_i^j	–	Sectoral investment expenditure shares	Data: WIOD 2016 release

We compute value added to gross output ratios and input-output coefficients directly from the data. To back out factor shares in value added, we rely on data for sectoral factors of production, factor prices and the optimality conditions derived by the firms in the model. Factor prices are obtained as the ratio of total compensation to a particular factor divided by its total endowment. We consider the same values of elasticities of substitution across factors of production as Parro (2013), and the same values for trade elasticities as Caliendo and Parro (2015). The values we consider for parameters η, β and δ are standard in the literature. Sectoral consumption and investment shares are computed directly from data provided in the World Input-Output Database for the year 2014.

A key channel through which the negative output effects of higher trade barriers can be amplified over time is if final investment is tilted towards sectors that are traded more intensively.[25] If this is the case, increases in tariffs would disproportionately affect investment relative to consumption,

[23]Details on the data and estimation procedures are provided in Appendix B.
[24]The parameter ψ is not included in the table because this parameter is irrelevant in the steady state of the model.
[25]See for Bussière et al. (2013) other work related to this issue.

Figure 11: Investment and Consumption Sectoral Shares in Tradable Sectors



given that the relative price of final investment would increase. Figure 11 shows the average sectoral consumption and investment shares across countries for tradable sectors. It can be seen in the figure that sectors with high shares in final consumption tend to be the ones with low shares in final investment and vice-versa. The figure also plots, for each sector, the average share of total expenditure on foreign goods—the foreign trade share—across countries. The data seems to point in the direction of final investment being tilted towards sectors with higher foreign trade shares. Indeed, regressing the difference in sectoral shares, $\Delta y_i^j = \chi_i^j - \mu_i^j$ on the foreign trade share, $x_i^j = 1 - \pi_{ii}^j$, and controlling for country fixed effects, we obtain a statistically significant positive (0.03) coefficient on the foreign trade share. Therefore, the data points in the direction of investment being tilted towards more tradable sectors, which suggest that the investment channel might play a key role in amplifying shocks to treade barriers. We will see if this is the case when we conduct our counterfactual exercises in Section 5.

4.2.2 Exogenous Observable Endowments

Exogenous observable endowments are given by skilled and unskilled labor ($U_{i,t}$ and $S_{i,t}$), as well as capital ($K_{i,t}$). Labor endowments are directly observed in the data in a particular point in time. To recover the capital stock such that is consistent with the world economy being initially in a steady state, we use data on investment and recover the steady state level of capital consistent with such a level.

Notice that in this model, differences in factors of production lead to comparative advantage differences in the spirit of Heckscher-Ohlin models. That is, even in the absence of productivity differences, trade between countries would arise as a result of difference in factor endowments.

4.3 Exogenous Shifters

Given values for time-invariant parameters and exogenous observable endowments, we can now proceed to recover exogenous unobservable shifters. In particular we recover *trade barriers, productivities and investment efficiencies*, given by $\left\{\tau^j_{ih,t}, T^j_{i,t}, \xi_{i,t}\right\}$ for a given year $t = 2016$. We show in this section the procedure to calibrate these unobsorvable shifters relying on the model and using the available data.

4.3.1 Trade Barriers

We recover trade barriers by exploiting the multi-sector gravity structure of the model. In particular, to recover $\tau^j_{ih,t}$, we consider the ratio of $\pi^j_{hh,t}$ to $\pi^j_{ih,t}$, both given in (17). Given values for trade elasticities, this ratio identifies $\tau^j_{ih,t}$ as a function of data only—bilateral trade shares and relative sectoral prices—. Hence, we can recover the values of bilateral trade barriers.

The values recovered for trade barriers are shown in Figures 12 and 13. Figures 12a and 12b show the median and 25-75 percentile ranges of bilateral importing and exporting trade costs for each country. The average median bilateral importing (exporting) trade cost is 134 (135.13) percent of sales prices. EMEs (blue bars) face higher average exporting and importing costs than AEs (red bard). While this average for AEs' importing (exporting) costs is 125.58 (125.83) percent, it is 129.31 (152.06) percent for EMEs.

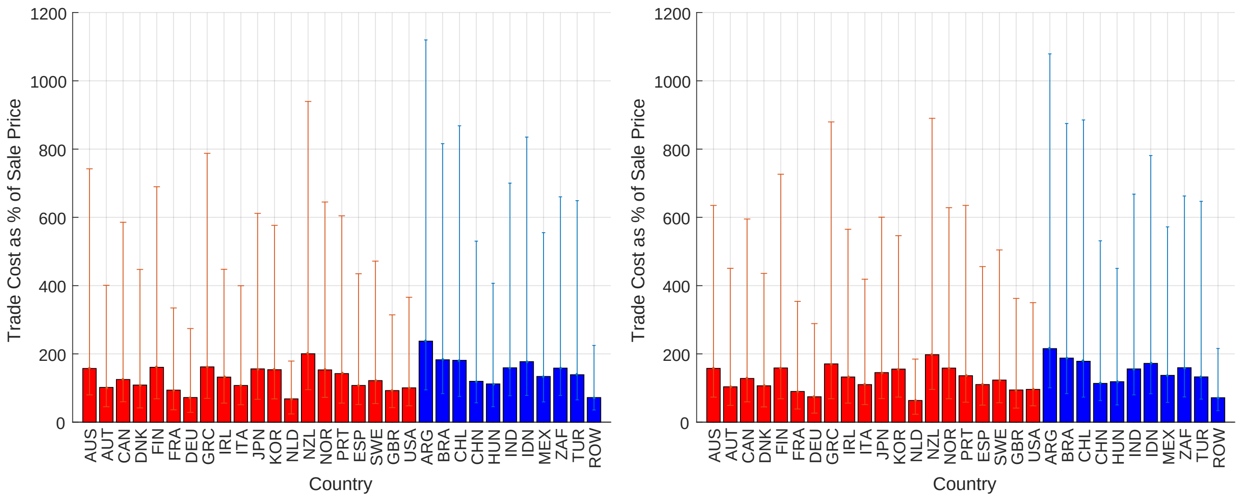
Taking average trade costs across sectors masks a great deal of heterogeneity across the latter. Figure 13 shows median and 25-75 percentile ranges for trade costs in each tradable sector. The figure clearly shows the large difference between trade costs in sectors like food, petroleum, plastic, minerals and machinery, and the remainder. Very high bilateral trade costs reflect sectors in which, given small differences in relative prices across country-pairs, bilateral trade flows are fairly small. Thus, this fact has to be explained by high trade barriers.

4.3.2 Sectoral Productivities

To recover sectoral productivities we rely on the expression for equilibrium trade shares given in (18). Notice that from this expression we obtain that for any given country i, productivity in sector

Figure 12: Trade Costs Across Countries: Median and 25th-75th percentile ranges

(a) Exporting Costs (b) Importing Costs



j is $T_i^j = \pi_{ii,t}^j \left(\Gamma^{-\theta}\right) \left(c_{i,t}^j / P_{i,t}^j\right)^{\theta^j}$, where all terms in the right-hand-side of the equality are data. Figure 14 shows the logarithm of adjusted sectoral productivities, $\left(T_i^j\right)^{\theta^j}$, relative to the U.S.

Notice that according to figure 14a, productivities in EMEs (blue bars) are on average singificantly lower than in the U.S. and other AEs (red bars). Our estimates imply that the U.S. represents the technological frontier—conditional on focusing on the median productivity across sectors—. However, notice that the 75th percentile productivity being above zero for multiple AEs implies that these countries represent the technological frontier in certain sectors.

Differences in sectoral producitivities across countries drive Ricaridan comparative advantage in the model. Notice that both paramters, T_i^j and θ^j, matter for differences in Ricardian comparative advantage across countries.

4.3.3 Investment Efficiencies

Investment efficiency shifters help us pin down the model to a steady state in a particular year. However, these shifters do not matter for the configuration of trade across countries. To recover investment efficiencies, we assume that the model is in a steady state in 2016 and use data on investment rates, that is, investment as a share of GDP. The law of motion for capital in a steady state implies that $X_i = \delta K_i$. Hence, given investment expenditures in 2016, we can recover the capital stock that is consistent with the former condition and solve the model. We pin down investment efficiencies such that the steady-state Euler equation for capital, condition (30), holds.

Figure 13: Sectoral Trade Costs: Median and 25th-75th percentile ranges

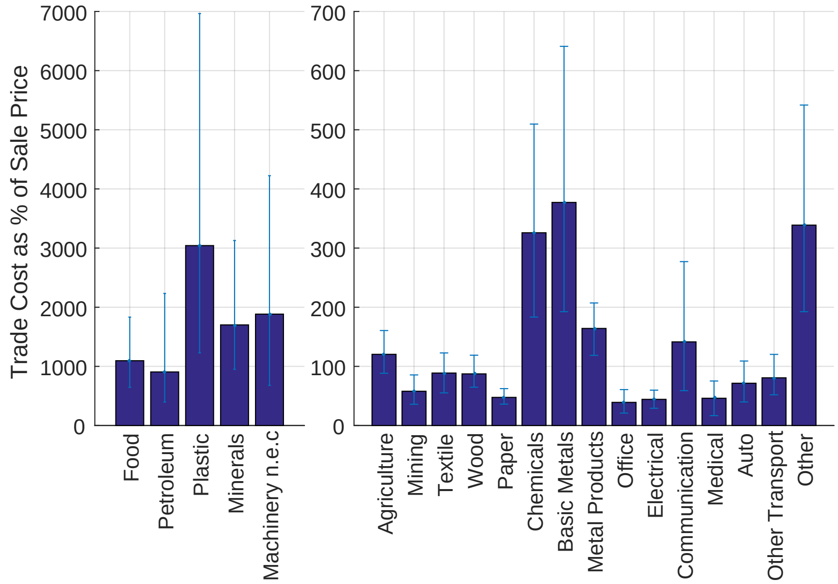
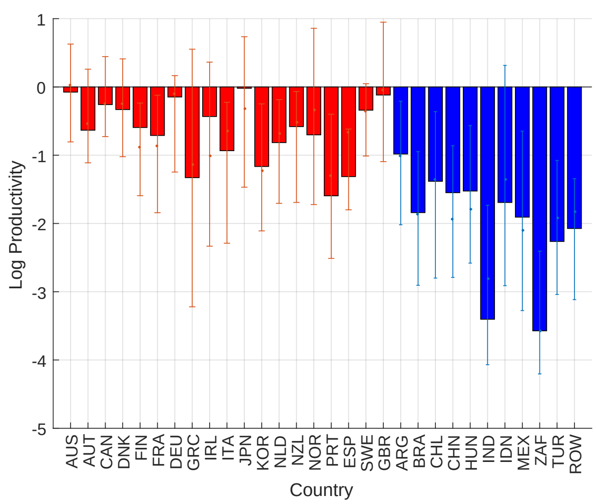
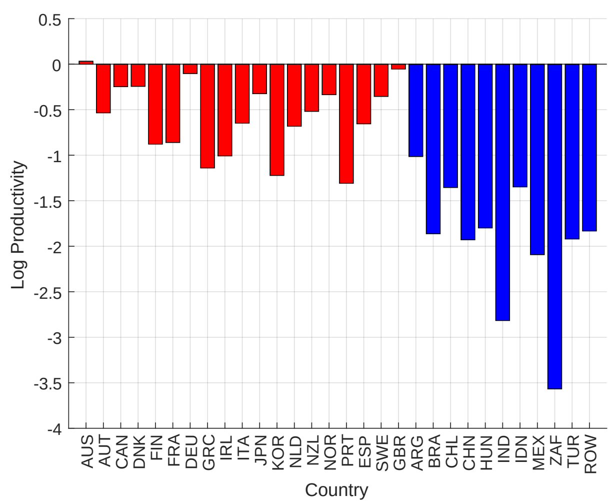


Figure 14: Sectoral Productivities: Median and 25th-75th percentile ranges, relative to the U.S.

(a) Productivities in Tradable Sectors



(b) Productivities in Non-tradable Sectors



5 The Effects of Rising Trade Barriers on Emerging Markets

We use the calibrated model to conduct two counterfactual experiments and analyze the effects of rising trade barriers on EMs. Our first experiment considers the effects of a global increase in bilateral trade barriers. The second experiment assumes that bilateral trade barriers increase between AEs and studies the effects of the spillovers generated for EMs.

Each counterfactual experiment considers exogenous changes in trade barriers in isolation. Thus, we leave baseline sectoral productivities, investment shifters and endowments of skilled and unskilled labor unchanged. However, the model can be used to study other types of counterfactuals in which the aforementioned exogenous forces change. For each counterfactual configuration of trade barriers, we solve the model to find the new steady state equilibrium wages and rental rates such that the labor market and capital markets clear. Then we compute several outcomes of interest. In particular, we will focus on macroeconomic outcomes that include changes in GDP, welfare, relative factor prices and aggregate trade flows.

5.1 Global Increase in Trade Barriers

The macroeconomic consequences of a global trade war are presented in Figure 15.

The global increase in trade barriers generates efficiency losses that lead to a sizable drop in output around the world. In the new steady state, world GDP is 5.5 percent below its initial steady state value. Moreover, even though higher trade barriers generate GDP losses in the absence of changes in capital, a sizable share of these losses arises because of adjustments in the new steady state level of capital. Of the overall drop in output, around half—2.7 percentage points—is driven by this endogenous adjustment, which is absent in static models.

Figure 15a shows the percent change in GDP by country, where we split the group of countries into AEs and EMEs. The first result to point out is that, even though the increase in trade barriers is homogeneous across countries, its effects on GDP are heterogeneous. Moreover, the heterogenity of these effects is greater within EMs, as can be seen from the yellow bars. For instance, the GDP of some small EMs like Chile and Hungary decreases by more than 15 percent, while the output of other larger economies like Brazil, India and China decreases by less than five percent. Overall, GDP drops by 4.8 and 6.7 percent in AEs and EMs respectively.

Figure 15b shows the effects on consumption–which reflects changes in welfare–across countries. Notice that welfare losses are similar in magnitude to GDP losses; however, the former are primarily driven by the increase in trade barriers absent an adjustment in investment. This difference reflects how the decline in investment triggered by the increase in trade costs generates larger drops in output than in consumption, as investment decreases.

The increase in tariffs leads to an increase in the price of investment relative to consumption goods as shown in figure 15c. This increase reflects the fact that tradable sectors play a disproportionate role in final investment relative to final consumption goods. The increase in the relative price amplifies the drop in investment that would obtain if the prices of final consumption and investment were the same. This is a key and sizable channel through which increases in trade barriers affect economic activity in the long-run. As in the case of GDP, the effects of higher trade costs on the relative price of investment is more heterogeneous across EMs than AEs.

The effects of trade shocks on different types of workers has become the subject of an extensive literature in recent years.[26] Our model can also speak to inequality across workers-types depending on their level of skill. In particular, higher trade barriers can affect the returns to different skills unevenly. Figure 15d shows how uneven these effects can be even when the trade shock is symmetric across countries. Most of the countries experience a decline in their wage premium consistent with technologies featuring capital-skill complementary and the decline in investment generated by higher trade barriers. However, there are a few exceptions like Greece, India and Indonesia, which are countries that do not exhibit large increases in the relative price of investment. This result points in the direction of final investment in certain EMs being less exposed to import intensive sectors.

Let us now turn to the effects on trade flows. The increase in trade barriers leads to a decline in exports as a share of world GDP of 4.8 percentage points (17.6 to 12.8 percent). The decline in world exports is unevenly distributed across sectors. Figure 15e shows that the effects on total exports are concentrated in sectors generally associated with low trade costs like agriculture, mining and communications, which reflects the non-linear nature of the effects of changes in trade costs on exports. Higher trade barriers also lead to a redistribution of world export across AEs and EMs. Figure 15f shows how EMs role in exports increases. In particular, EMs share in world exports increase by 6.2 percentage points. Moreover, this increase is explained entirely by an increase in inter-region trade—exports from EMs to AEs—of close to eight percentage points.

The results of our experiment shed light on how increasing trade barriers around the world would affect EMs. The increase in barriers would have sizable negative effects on global output and welfare, but EMs would be disproportionately affected. The effects on EMs are larger and more

[26] See, for example, Burstein and Vogel (2017), Burstein et al. (2019) and Cravino and Sotelo (2019)

heterogeneous, thus reflecting these economies' higher exposure to trade and the fact that they are not alike in terms of trade. Approximately half of the negative effects on output are driven by endogenous responses in investment to lower returns to capital, which reflects the exposure to trade-intensive sectors. Moreover, this channel seems to play a key role in the decline in welfare in EMs. Higher trade barriers lead to a redistribution of world exports toward EMs that ameliorate the welfare losses for these economies.

5.2 Spillovers to Emerging Economies: Increasing Trade Barriers between Advanced Economies

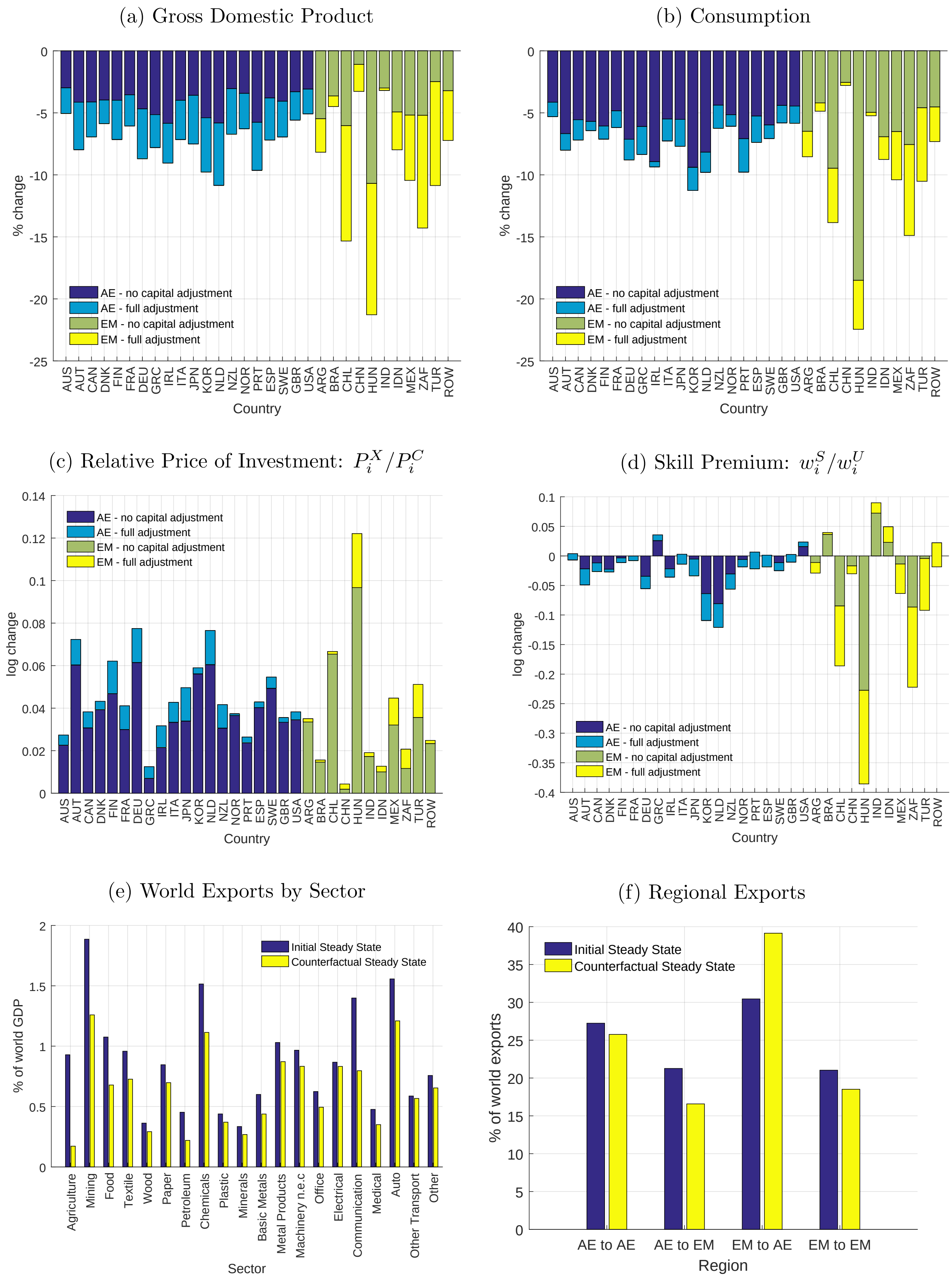
To study the effects of spillovers of increasing trade barriers between third-party countries on EMs, we consider a counterfactual in which trade barriers only increase bilateraly between AEs. We assume that all bilateral trade barriers between these countries increase by 25 percentage points.

The macroeconomic consequences of an increase in trade barriers between advanced economies are presented in Figure 16.

Figure 16a shows how the negative effects of increasing trade costs concentrate on AEs, as these are the countries that suffer large efficiency losses. AEs GDP decreases by 1 percent, even though some output in some AEs like Canada, Ireland and the Netherlands drops by more than 2.5 percent. However, the figure also shows how the effects of higher barriers spillover to EMs. In particular, the results imply that all EMs see an increase in GDP through spillover effects and delivering an increase in EMs GDP of 0.2 percent (world GDP decreases by 0.4 percent). However, a key result that emerges is that the across-the-board positive spillover effects for EMs arises from an increase in capital in these economies. Absent adjustments in capital, eight out of eleven EMs would suffer GDP losses. These losses are counteracted in the long-run by the fact that AEs switch expenditure to EMs, thus experiencing an increase in demand for their exports leading to an increase in investment. The effects of expenditure switching and their effect on investment can be seen in the fact that the relative price of investment increases considerably in basically all AEs, but it does not in EMs as shown in figure 16c.

Turning to consumption, shown in figure 16b, it can be appreciated that the decrease in consumption in AEs is less than the decline in GDP. Overall, consumption in AE decreases by 0.9 percent, 0.1 percentage point less than GDP. The smaller decline in consumption can be explained by the fact that AEs can switch expenditure towards EMEs and exploit their comparative advantages vis-à-vis those countries. Thus, trade with EMs provide AEs an option to dampen the negative

Figure 15: Global Trade War: Macroeconomic Effects



welfare consequences of higher trade barriers. Regarding EMs, it is interesting to point out that India and Indonesia end up experiencing negative welfare effects from spillovers. Overall, the spillover effects of increasing trade barriers between AEs are very heterogeneous across EMs—while some EMs benefit considerably, others suffer losses—.

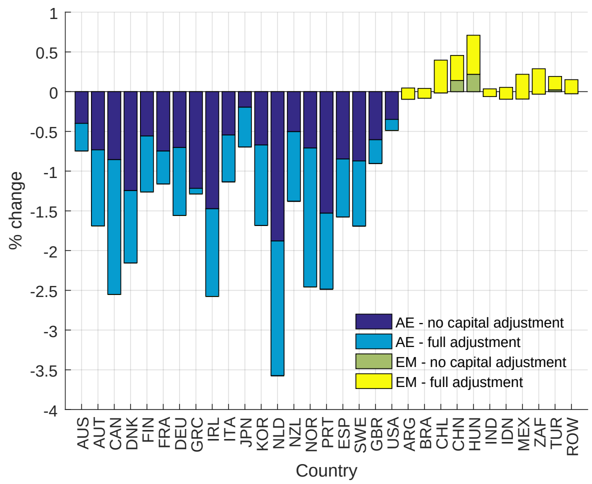
Higher trade barriers between AEs lead to an increase in the skill-premium for all EMEs. As shown in figure 16d, the increase in the skill premium is largely driven by the effects of trade costs absent any adjustments in capital. This implies that capital-skill complementarity is not the main driver of the increase in the skill-premium, but that the initial expenditure switching from AEs toward EMEs is concentrated on goods that are more intensive in the capital-skill bundle in production. The spillover effects on EMEs leaed to an increase in the skill-premium as predicted by the Stolper Samuleson theorem.

Lastly, let us turn to the effects on trade flows. World exports decline only by 0.5 percentage point as a share of world GDP. This contraction is considerably smaller than the one that arises given a global increase in trade barriers. The smaller reduction is driven by the fact that the reduction in exports by AEs of 0.8 percentage points as a share of world GDP is compensated by an increase in export by EMEs 0f 0.3 percentage points. As shown in figure 16e, the decline in exports seem to be concentrated on sectors that are usually considered as capital intensive. When we consider the effects on the contirbution of trade flows across regions, we see in figure 16f that export bacome more concentrated in EMEs. Trade among EAs declines, generating an increase in the share of exports from EMEs to AEs. Overall, the increase in inter-region trade is close to four percentage points.

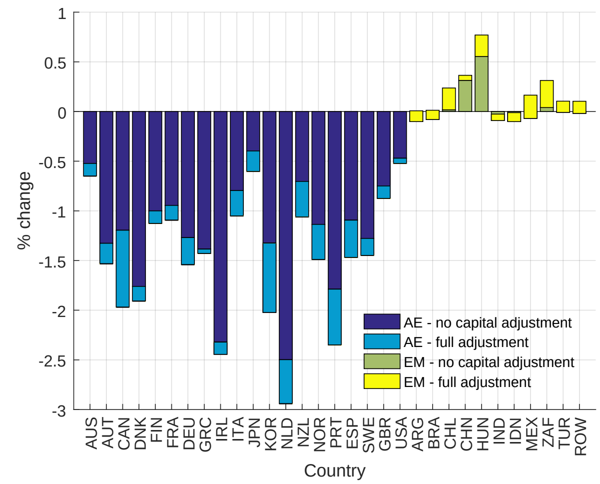
In summary, the results of the previous counterfactual scenario shed light on how increases in trade barriers between third-party countries spill-over to EMs. As AEs switch expenditure towards EMs, these economies witness an increase in output. However, the lion's share of the positive GDP spillovers arises due to the endogenous adjustment in investment that diverts towards EMs. Furthermore, the effects lead to an increase in inequality in EMs, as skilled-workers disproportionately rip the benefits of the spillovers. Regarding welfare, the effects are very heterogeneous across EMs.

Figure 16: Trade War between Advanced Economies: Macroeconomic Effects

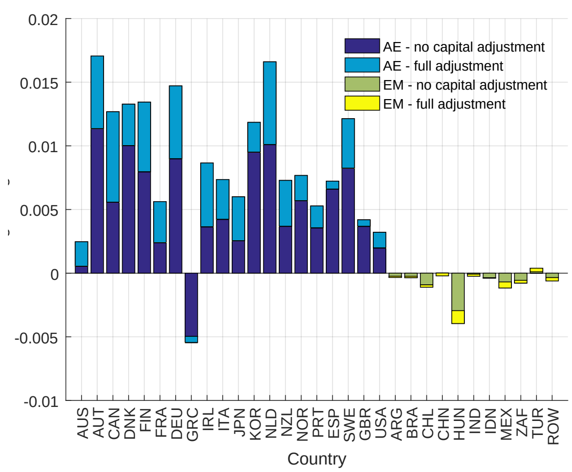
(a) Gross Domestic Product



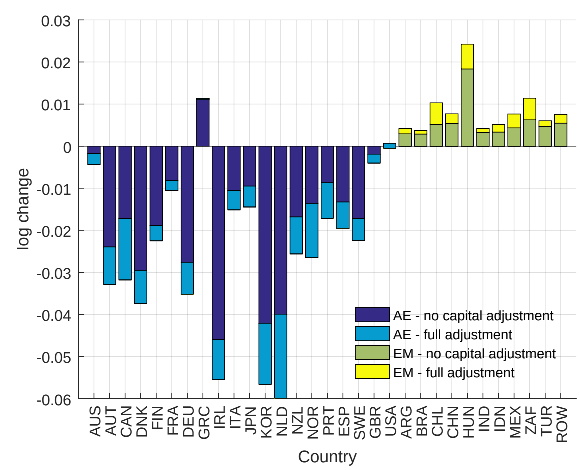
(b) Consumption



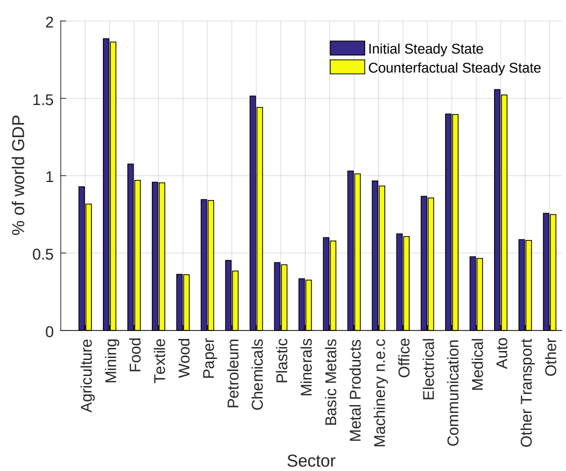
(c) Relative Price of Investment: P_i^X/P_i^C



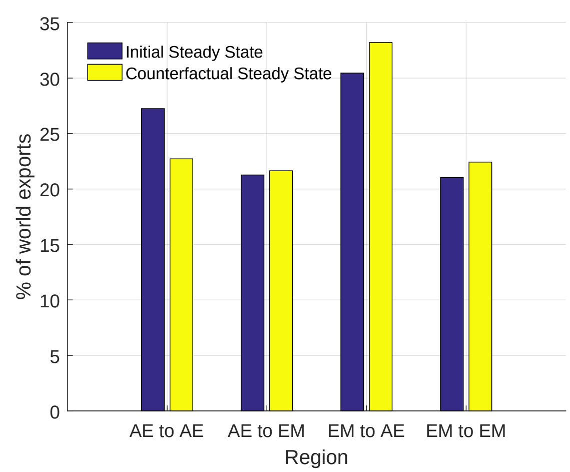
(d) Skill Premium: w_i^S/w_i^U



(e) World Exports by Sector



(f) Regional Exports



6 Conclusions

One of the key challenges faced by EMs given the current state of the world economy is the potential increase in trade barriers. This challenge is particularly relevant for these economies given the major role that they currently play in global trade. A new geography of trade has emerged in which EMs are key heterogeneous players: not all EMs are alike. These facts are key in understanding how higher trade barriers can affect not only these economies, but the world in general.

We propose a dynamic general equilibrium quantitative model of international trade to understand how harmful increasing trade barriers could be for EMs in the long-run. Our results show that EMs would be particularly exposed to the negative effects of increasing trade barriers around the world. However, if trade barriers were to increase only among AEs, EMs could potentially benefit from spillover effects.

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A Appendix: Countries, Sectors and Dara Sources

The countries we consider are:

- **AEs [20]** Australia (AUS), Austria (AUT), Germany (DEU), Canada (CAN), Denmark (DNK), Spain (ESP), Finland (FIN), France (FRA), Italy (ITA), Greece (GRC), Ireland (IRL), Japan (JPN), Korea (KOR), the Netherlands (NLD), New Zealand (NZL), Norway (NOR), Portugal (PRT), Sweden (SWE), the Unite Kingdom (GBR), and the United States (USA).

- **EMEs [11]** Argentina (ARG), Brazil (BRA), Chile (CHL), China (CHN), Hungary (HUN), Indonesia (IDN), India (IND), Mexico (MEX), Turkey (TUR), South Africa (ZAF), Rest of the World (ROW).

Table 2 shows the sectors we consider, which are the same as in as in Caliendo and Parro (2015).

Table 2: Sectors

Tradable				**Non-Tradable**			
1	Agriculture	11	Basic metals	21	Electricity	31	Real estate
2	Mining	12	Metal products	22	Construction	32	Renting machinery
3	Food	13	Machinery nec	23	Retail	33	Computer
4	Textile	14	Office	24	Hotels	34	R&D
5	Wood	15	Electrical	25	Land transport	35	Other business
6	Paper	16	Communication	26	Water transport	36	Public
7	Petroleum	17	Medical	27	Air transport	37	Education
8	Chemicals	18	Auto	28	Aux transport	38	Health
9	Plastic	19	Other transport	29	Post	39	Other services
10	Minerals	20	Other	30	Finance	40	Private

1. Trade We use bilateral trade from the United Nations Statistical Division Commodity Trade (UNCOMTRADE) database for 2016 at the Harmonized System 6-digit (HS-6) level. We include 30 separate countries, which together account for more than 85 per cent of world GDP, and a rest-of-the-world (ROW) modeled as one aggregate block.[27] We map these HS-6 product level codes to the 20 tradable sectors as in Caliendo and Parro (2015) using the HS-ISIC concordance tables.

2. Tariffs We collect tariff data for 2016 from the United Nations Statistical Division-Trade Analysis and Information System (UNCTAD-TRAINS) and Most-Favored Nation (MFN) databases for the same 30 countries and a rest-of-the-world average. The UNCTAD TRAINS data contain

[27] The 30 countries include Argentina, Australia, Austria, Brazil, Canada, Chile, China, Denmark, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Portugal, South Africa, South Korea, Spain, Sweden, Turkey, the United Kingdom, and the United States.

bilateral tariffs at the Harmonized System 6-digit (HS-6) product level. The MFN data provide importer-specific MFN tariff rates, which is also at the HS-6 product level.

We then aggregate the HS-6 product level tariff data to sectoral tariffs by using bilateral trade weights for all the HS-6 level trade flows within a sector. All told, we compute 31 by 31 bilateral tariffs for each of the 20 tradable sectors in 2016 and assume infinitely large trade barriers for the 20 non-tradable sectors to serve as our baseline. The implemented and proposed tariffs are taken from the lists released by the United States Trade Representative (USTR) and China's Ministry of Commerce (MOFCOM).[28]

3. Input-output tables We use the World Input-Output Database (WIOD)[29] for 2014 to compute the input-output coefficients as the total dollar value of an input sector's intermediate goods divided by the total dollar value of the output sector's inputs. We supplement these data with the OECD's input-output (I-O) tables for 2011 for those countries that are not included in WIOD.

4. Gross output and value added We use sectoral gross output and value added data from the OECD STAN database for 2016. We supplement these data with the sectoral gross output and value added data from the Socio Economic Accounts (SEA), the United Nations' INDSTAT2 and the National Accounts databases.

B Appendix: BEC Goods Classification

1. Intermediate goods
    - 121–Food and beverages, processed, mainly for industry
    - 21–Industrial supplies not elsewhere specified, primary
    - 22–Industrial supplies not elsewhere specified, processed
    - 322–Fuels and lubricants, processed (other than motor spirit)
    - 42–Parts and accessories of capital goods (except transport equipment)
    - 53–Parts and accessories of transport equipment
2. Commodities (excluding oil)

[28] The published lists typically disaggregate goods at the HS-10 product level. Therefore, when computing the imposed and prospective tariffs for our counterfactual analysis, we convert the HS-10 product level codes to HS-6 product level codes.

[29] http://www.wiod.org/release16

- 111–Food and beverages, primary, mainly for industry
- 112–Food and beverages, primary, mainly for household consumption

3. Capital goods

- 41–Capital goods (except transport equipment)
- 521–Transport equipment, industrial

4. Other

- 122–Food and beverages, processed, mainly for household consumption
- 31–Fuels and lubricants, primary
- 321–Fuels and lubricants, processed (motor spirit)
- 51–Passenger motor cars
- 521–Transport equipment, industrial
- 522–Transport equipment, non-industrial
- 61–Consumer goods not elsewhere specified, durable
- 62–Consumer goods not elsewhere specified, semi-durable
- 63–Consumer goods not elsewhere specified, non-durable
- 7–Goods not elsewhere specified