Foreign multinationals in services sectors: A general equilibrium analysis of Brexit

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Abstract

We examine the role of foreign multinationals in services sectors in the context of Brexit, which we define as the combination of the increase in barriers to multinationals in services sectors as well as the increase in non-tariff barriers to trade and import tariff between the UK and the rest of EU. We use a state-of-the-art Melitz approach in manufactures with multinationals operating in imperfectly competitive services sectors in a multiregional general equilibrium framework. We find that the increased FDI barriers in services sectors explain about one third of the total welfare loss of Brexit. Furthermore, our decomposition analysis (by introducing each type of barriers separately) shows that the barriers against EU services multinationals in UK are harmful to British manufacturing sectors because they face a reduced (and more expensive) supply of intermediates of services.

Keywords: Foreign Direct Investment, Melitz, monopolistic competition, Servicification, trade in services.

JEL codes: C68, F14, F15, F17, F21

Introduction

A special characteristic of services, which differentiates them from goods, is that services can be traded via multiple modes of supply. The definition of supply modes is provided by the General Agreement on Trade in Services (GATS). It defines four classical ways of trading services: Mode 1: Cross-border supply via services exports; Mode 2: Consumption abroad, i.e. travel; Mode 3: Commercial presence through foreign affiliates' sales and Mode 4: Presence of natural persons.[1] An additional mode 5 has also been suggested by Cernat and Kutlina-Dimitrova (2014) which encompasses services traded as embodied inputs into a country's merchandise exports. As a variety within mode 5, some authors even suggest a potential "Mode 6" (e.g., Borchert, 2016; Latorre and Yonezawa, 2018). It would consist of the provision of services by foreign multinationals supplying intermediates embodied in the host economy's exports. The aim of this paper is to shed light on the impact of foreign affiliates in services through mode 3 *and* through their less known role as local providers of intermediates.

Nowadays services constitute the most important part of the global GDP. The World Bank (2018) reports the share of services in the global GDP of 65% in 2016. However, due to the complexity connected to the different ways of services provision, international statistics fall short of a proper coverage of their prominent role in countries' economies. Many initiatives have been launched to gather world data on all modes of services supply, but most of these projects are still in their infancy. The World Trade Organization (WTO) is developing a global dataset on trade in services by mode of supply, for which still very little public data are available (Steen et al., 2018). The WTO is also working with the World Bank to produce a New Services Trade Policy Database (STRI), focused on regulatory aspects, similar to the one produced by the OECD (Borchert et al., 2018). Other institutions such as the European Commission (Rueda et al., 2016), the BEA (Fetzer, 2018) and individual countries are also gathering data, but their efforts have covered only their respective regions so far.

Although services are becoming increasingly tradable and traded, it is still harder to export services than goods. That is why the presence of foreign multinational enterprises (MNEs) is an important mode of provision of services abroad. Francois and Hoekman (2010, p. 655) report that for the US MNEs constitute the main channel to sell services to foreigners and that the increase in foreign affiliates sales has been larger than trade in services since the mid-1990s. Using more recent data, Mann (2017) has confirmed the prominent role of MNEs as services providers in the US. They account for slightly more than 60% of the total provision of services within the US and by US MNEs abroad from 2012 till 2015. For the European Union (EU), Rueda et al. (2016) have found that European foreign affiliates account for 69% of the total services provision abroad. Some preliminary estimations for the world economy, proxied by 204 countries and 13 services sectors, suggest that mode 3 would be the most important way of provision for services supplied abroad or received in

[1] In Mode 2, the consumer travels to another country to consume services locally; Mode 4 implies the presence of natural persons,i.e., individuals who temporarily enter another country to provide services.

the host economies, with shares around 45% and 50% between 2005 and 2015[2] (Steen et al., 2018, p. 35).

With this background, in this paper we provide an in-depth analysis of the role of services MNEs in international trade and the impact on the economy. First, we deliver the latest data on the so-called "servicification" of economies, especially focusing on the trade (e.g., Borchert, 2016; Miroudot, 2017). According to Baldwin (2016, p. 160): "Nowadays, nations' manufactures base and merchandise trade competitiveness are quite dependent on the availability of local or imported services used as inputs in production". Servicification also reflects the fact that a substantial share of the value added behind traded merchandise goods, consists of services, so that services are exported not only by services firms but also by manufacturing firms. We also explore the literature focusing on the difference between the impact of services MNEs and the ones in manufacturing. Then, we illustrate the importance of services MNEs for the UK in a general equilibrium simulation analysis of Brexit.

It is well known that UK's specialization in services stands out in international context. The share of services in GDP in the UK amounts to 70% (in 2017), above the EU average which is 66% according to the World Bank (2018). UK is also among the top destinations and origins of foreign direct investment (FDI) flows in general. Foreign multinationals account for 35% of total sales in the UK in 2015 (Eurostat, 2018). This figure stands out in the European panorama, which is a region that is very active as origin and destination of foreign MNEs. Most of the previous analyses of Brexit have focused on the impact of trade, while neglecting FDI (e.g., Busch and Matthes, 2016; Fernandez-Pacheco et al., 2018; Latorre et al., 2018). We analyze the impact of Brexit incorporating services multinationals. In particular, we investigate how Brexit affects the performance of European and British MNEs and how this contributes to the overall losses of the UK economy.

We apply an innovative general equilibrium model, which combines the state-of-the-art trade theory with firm heterogeneity à la Melitz with foreign MNEs in services, thus, providing an appropriate modeling approach to Brexit. We split the world economy into 21 sectors and 11 regions: Rest of the European Union (henceforth REU, i.e., the EU28 excluding UK), UK, US, China, India, Japan, other advanced economies, South East Asia, Latin America, Middle East and Sub-Saharan Africa).

The rest of the paper is organized as follows. The next section elaborates on the concept and data behind servicification. Section 3 analyzes the differences between services and manufacturing MNEs. Section 4 describes the model and simulations, while section 5 offers the aggregate and sectoral results. Finally, some concluding remarks close the paper.

2. Servicification

[2] The shares of services supplied and received should be the same for the world as a whole, much in the same way as world imports and exports.. However, there are inconsintencies in national statistical methods. Fetzer (2018, pp. 9-11) offers some explanations of such inconsistencies for selected countries.

As economies develop, services share in GDP tends to grow.[3] This is a well-known evolution broadly investigated by economists (e.g., Richard Baldwin, 2016; Borchert, 2016; Cernat and Kutlina-Dimitrova,2014; Miradout, 2017). Indeed, some of them talk about the servicification of manufacturing, namely, the process by which today's manufacturing competitiveness relies on high-quality services inputs (e.g., Baldwin, 2016; Borchert, 2016; Miroudot, 2017).

The UK is one of the leaders in servicification. As described by Borchert (2016, p. 10): "The UK services sector has continuously deepened its integration into international production fragmentation, with the value added shares of domestic and foreign services inputs into UK total exports each having grown by 7 percent every year over the past two decades. Partly as a result of this process, more than half of the value added of UK total exports consists of domestic services (as of 2011), underpinning the crucial role of services for export performance". This latter evolution is illustrated in Figure 1. Using the data from the domestic services value added share in gross exports (OECD, 2018) we demonstrate the role of UK services contribution to value added in international context.

Figure 1. AROUND HERE

We see that the shares of services in UK's gross exports surpasses the ones of European countries since late 1990s (with the exception of Croatia as will be seen in Figure 2 below).[4] The UK share is well beyond countries like Sweden or Finland. The series for Finland, which is green, is hidden behind the one of Germany. Cernat and Kutlina-Dimitrova (2014) have estimated that in 2009 this share reached 35% for the EU-27 (i.e., EU-28 excluding Croatia) rising from a share of 28% in 1995. Figure 1 displays an overall increasing trend in these shares, although in some cases the crisis reduced the shares.

Figure 2 represents the world's leaders in terms of services value-added in gross exports. Hong Kong clearly stands out as the economy with the highest share, while Croatia comes as the second economy in the world and the first European country (always among the countries covered by the OECD, 2018). UK is at the third position worldwide, closely followed by the US and India.

Figure 2. AROUND HERE

In this paper, we take a step forward and argue that a part of the servicification process is related to the provision of services by foreign multinationals in the host economies. In

[3] The latest data available in the World Development Indicators (World Bank, 2018) show that the shares of services in GDP according to income levels are: low income (39.2%), lower middle income (49.6%), upper middle income (55.3%) and high income (69.6%).

[4] Data for 2011 are based on actual calculations while the ones for the next three years (2012-2014) are projections.

particular, multinationals tend to be more productive than domestic firms (e.g., Helpman et al., 2004; Latorre, 2009), and therefore provide high-quality services inputs which support manufactures competitiveness. Since a substantial share of the value of traded merchandise goods consists of services, any impediment to goods trade has potential indirect effects on embodied services, while impediments to services have an impact on manufactures.

The presence of foreign multinationals in the UK is surprisingly high. To be more precise, as suggested by Fernández-Pacheco et al. (2018a, 2018b), the share of total (EU-27 and non-EU-27) foreign affiliates in total sales in the UK stands out with 37.4%, compared to other large economies, such as Germany (22.7%), Spain (27.2%), France (20.4%) or Italy (18.1%) and also compared to the average of the EU-28 (28.6%) in 2014. In Table 1 we reproduce the weight of foreign multinationals among 21 sectors of the UK economy in 2015.[5] We can see that the overall share of foreign multinationals, which is at the bottom of the table, is 35%. We find a lot of heterogeneity across sectors. However, motor vehicles, finance and other primary goods exhibit the largest shares with percentages around 89%, 85%, 75%, respectively. What is more, in those sectors the presence of non-EU multinationals is particularly high.

In our simulation analysis we focus on the activities of multinationals operating in services sectors. Our model resembles the fact that firms can outsource the provision of activities, such as, business services (accounting, design, marketing, cleaning, security, etc), financial or insurance services, telecommunications and transport services. There is a choice for them to do all these tasks in-house or externally by other firms. The latter ones can be domestic firms or foreign MNEs operating in services sectors. Moreover, we also account for services provided through imports (cross-border supply).

Eurostat (2018) provides data on Foreign Affiliate Sales (FATs), which focus on European countries as host or home economies. It also offers some information for investment partners if they are big economies such as the US, China, Japan or Canada. Unfortunately, at the sectoral level the information is often missing. That is why for some sectors we use the data coming from Fukui and Lakatos (2012). They were the first to provide a worldwide three dimensional dataset set covering 128 countries and 31 sectors on the sales of foreign affiliates by home and host country.

Table 1. [AROUND HERE]

3. Services MNEs versus manufacturing MNEs

[5] These sectors represent the aggregation of the applied model. Appendix 1 provides a description of sectors and their mapping between different sectoral classifications.

For a long time the impact of MNEs has been analyzed relying only on data of manufacturing sectors. These were readily available, while the ones on services are more recent. Many econometric studies thus focus on manufactures (exceptions include Doytch and Uctum, 2011, and Bajo-Rubio and Díaz-Mora, 2015) and their economic effects have been summarized in Latorre (2009) and, more extensively in Latorre (2012a, chapter 2). However, starting with the stylized model of Markusen et al., (2005), the literature focusing on FDI in services in computable general equilibrium (CGE) models has analyzed the impact of services multinationals, as summarized by Tarr (2013).

There is a considerable empirical evidence suggesting that services MNEs play an important and growing role as providers of high quality intermediates that improve the economy-wide competitiveness and efficiency (Francois and Hoeckman, 2010). Some services, such as, finance, communications and business services provide inputs that are used across most sectors of the economy. An increased number of varieties provided by services MNEs may be beneficial for producers' productivity if the entry of MNEs results in a more competitive environment in which the intermediates become cheaper. This would help to save costs (and increase productivity) for downstream firms using those intermediates. Fernandez and Paunov (2012) and Arnold et al. (2008) find empirical support for this mechanism using panel data and controlling for the endogeneity of FDI. Applying a CGE model, Latorre (2016), Latorre and Yonezawa (2018), Latorre et al., (2018b) find that the entry of more services multinationals leads to lower services prices. These positive effects of an increased number of varieties have also been derived in the context of trade (Broda and Weinstein, 2016 and Goldberg et al., 2009). Increases in the number of varieties are also beneficial for consumers, whose welfare increases due to a broader spectrum for their choices.

Konan and Kim (2004), Konan and Maskus (2006) and Konan and Van Assche (2007) also obtain a beneficial impact from the entry of foreign services MNEs in Tunisia, using a CGE model. These latter studies show the high costs derived from the poor condition of domestic services in the country and the positive impact from FDI liberalization in services.

Latorre et al. (2018b) analyze the recent Chinese policies of liberalization in services. According to the OECD (2017), the 2015 edition of the "Catalogue for the Guidance of Foreign Investment Industries" points to an active FDI attraction policy in strategic services. FDI going to China has become in the latest years considerably more oriented to services than to manufacturing (UNCTAD, 2016, p. 45). As already noted, when countries develop, the share of services in GDP increases. Due to the relative small share of services in Chinese GDP of 51% in 2017 (World Bank, 2018), it seems there is a lot of scope for the growth in its services sectors. Latorre et al. (2018b) derive that the entry of more services MNEs in China reduces the prices of services and benefits Chinese manufactures, which use those as inputs. As a consequence, the export competitiveness of manufactures increases, resulting in an overall positive impact for the Chinese economy.

Generally, output of services is more domestically oriented and less export oriented than the one of goods.[6] Due to its export orientation, FDI in manufactures is more prone to crowd out more foreign competitors in the world market than FDI in services.[7] In reality, the mechanism, by which FDI in services can result in a crowding-out of foreign competitors in the world market, is through the increased export competitiveness in manufactures, but not so much through the export competitiveness of services themselves.

Latorre et al. (2018b) also find, however, that the entry of MNEs in Chinese services sectors crowds out national firms. This would bring about a reduction in production in the sectors to which MNEs accrue, generating a decrease in overall production in the sector. The only exception to these reductions in production would be the services sectors that were previously not protected with very high barriers to the entry of MNEs. However, crowding out of domestic firms may be absent or less pronounced in advanced economies. Francois and Hoekman (2010, p. 661) explain that barriers and protection tend to be larger in developing countries than in developed ones. This implies that when larger barriers are lowered through trade liberalization, the gain in competitiveness for the foreign firms that enter is greater than if barriers were not that high initially.

Latorre and Yonezawa (2018) analyze the potential impact of services MNEs due to lower FDI barriers under the Transatlantic Trade and Investment Partnership (TTIP). They do not find evidence for such crowding out effects for national firms, at least production does not contract, and obtain price reductions in services after the entry of MNEs. This again boosts manufactures competitiveness, but FDI in services does not crowd out foreign competitors in the world market, contrary to the case of China. Probably barriers to FDI are initially smaller for the TTIP partners compared China and the boost in manufactures competitiveness is smaller than in China.

To some extent, authorities in the host economy have the chance to implement more pro-competitive or protectionist regulation in order to shape the climate of competition after the entry of MNEs. This is particularly relevant in the case of services, because barriers to MNEs in services are very different from the ones of manufactures MNEs (or even from trade in goods). Due to the intangible and non-storable nature of services, customs and port procedures are generally less relevant for services than for manufactures. As illustrated by Konan and Van Assche (2007), services liberalization should deal with issues of market structure and needs to be addressed through domestic regulation. In particular, regulation should promote pro-competitive regulatory reforms, so that new entrants do not collude but compete with incumbents.[8] This would ensure cheap prices due to increased competition and stimulate technology transfer through foreign firms. This, however, has not always been the case. As de Luna Martinez (2007) describes, financial liberalization in Zambia failed to provide lending to the poor and to Small and Medium Enterprises. This was due to an

[6] This is a common trend across the world as shown by Latorre et al. (2018), who based their calculations on Aguiar et al. (2016).
[7] Zhou and Latorre (2014a, 2014b, 2015) derive that FDI accruing to Chines manuactures considerably crowds out competitors in the world market.
[8] Similar points have been illustrated theoretically for transport services by Francois and Wooton (2001).

inappropriate sequence of reform, to the crowding out of bank funds to finance the public sector, and to deficiencies in the basic infrastructure for financial sector development, among other reasons.

When the entry of services MNEs results in an increase of high-quality and cheap inputs, the spillovers expand throughout the entire economy. Again this may be quite different from the impact of manufacturing MNEs and from trade in goods. According to Konan and Maskus (2006) and Konan and Kim (2004), goods' liberalization through tariff reductions results in the specialization of an economy in a few sectors in which abundant factors benefit disproportionately. Latorre et al., (2009) and Latorre (2012; 2013) also find these specialization effects in the Czech Republic after the entry of MNEs in manufactures, while they are absent after the entry in services sectors, which they also simulate. Since the effects of MNEs are simulated in different sectors in isolation, they can compare the impact of each sector in turn. It is interesting that behind a rather similar increase in GDP of the Czech Republic following the increase in FDI in chemicals (0.68%) versus that of finance (0.82%), the sectoral effects are completely different. In particular, the increase of MNEs in chemicals expands production in that sector, but depresses many other sectors, while finance MNEs bring an overall expansionary effect (Latorre, 2013). These positive spillovers from FDI in finance on growth are also found by Doytch and Uctum (2011), who use a sample covering 60 countries during the period 1990-2004.

The analyses in Latorre et al. (2009) and Latorre (2012b) yield similar results to the ones of Latorre (2013). They suggest that if a policy maker is searching for a general increase in production across sectors, it may be preferable to offer incentives to attract MNEs to services sectors like finance and retail trade – that also boost production and employment in other domestic and multinational firms – than to chemicals and electronics. The latter may entail a similar GDP impact, but the positive effects will be highly concentrated in a few sectors, while depressing others.

Bajo-Rubio and Díaz-Mora (2015) is one of the few studies that analyzes the differential impact of FDI in manufactures compared to services. Their analysis focuses on outward FDI in Spain, which has overall a positive, but quantitatively small impact for domestic employment. The authors interpret this as a sign of increased competitiveness of those Spanish firms investing abroad, which enables them to increase their labor demand domestically. From a sectoral perspective, the positive effect of outward FDI on employment was lower for FDI outflows addressed to manufacturing and higher for those addressed to services, where the latter result could be explained by the unambiguous market-seeking nature of FDI in services. This is another important characteristic of FDI in services compared to manufactures. Services FDI tend to be horizontal (or market seeking), while in manufactures it is more heterogeneous and in many cases vertical FDI (fragmentation of the production process) prevails, so that the number of tasks performed in the host economy (and thus employment) would be less than in the case of services. These results are also in line with the analysis of Baldwin (2016) and Baldwin and Evenett (2015) on global value chains. They suggest that the future of manufacturing jobs, particularly in developed economies, which have experienced many job losses in manufacturing (OECD, 2017), lies

in being able to combine advanced services tasks with manufacturing tasks within the same firm. In other words, the future of manufactures relies heavily on high-quality servicification.

Barriers to the operations of foreign MNEs differ between services and manufactures. On the one hand, several indicators suggest that they are larger in services than in manufactures (Francois and Hoekman, 2010, pp. 662, 665).[9] Thus, liberalization of services within the WTO and in most regional agreements has not been very effective (Francois and Hoekman, 2010, pp.674). On the other hand, as already noted, services are different in nature with barriers being usually more related to domestic regulations, than in the case of goods.

Finally, the policies related to MNEs in services have to deal with a particular difficulty, namely, the four modes of services provision, while in goods the story is simpler. To a great extent, barriers to trade in manufactures apply directly to manufacturing MNEs, since they are very important agents behind trade in goods. For example, Fetzer et al. (2018) find that the imported content as a share of gross output is larger for MNEs than for non-MNEs in the US in the period 2005-2012. In other words, they provide evidence that the MNEs tend to be more dependent on trade than the non-MNEs. By contrast, as we have already argued, trade in services is still limited and a large share of the operations of foreign multinationals in services takes place by setting up commercial presence. So in a sense, for services multinationals barriers to FDI would tend to constrain more their activities than in the case of manufacturing. This is one of the reasons, together with others mentioned above, why a very important strand of the literature on FDI and multinationals has focused precisely on "multinationals in services" (see Tarr, 2013 for a review of these modes). It also explains why many CGE modelling exercises have introduced multinationals in services (and barriers to FDI only in services) and not in manufacturing (e.g., Balistreri et al., 2017, 2018; Rutherford and Tarr, 2018, Olekseyuk, 2016; Latorre, 2016).

All in all, the aforementioned studies seem to suggest that the entry of services MNEs tends to trigger positive spillovers that increase production across the board. This is because the new MNEs bring with them an increase in the number of services varieties, which is beneficial for producers' productivity, who use them as intermediates. Often new varieties are of high quality, given the more productive technologies of MNEs compared to other type of firms. The increase in varieties is also advantageous for consumers' welfare who have access to a broader range of choices. However, these potential positive outcomes are highly dependent on the resulting climate of competition arising after the entry of MNEs. In this sense, beyond-the-border (i.e., domestic) regulation should incentivize competition. Foreign MNEs may however, crowd out domestic firms, since the former tend to be much more productive than the latter. Due to the fact that services tend to be domestically (not so much export) oriented, they are less prone to crowd out competitors in foreign markets. This crowding out effects in the world market tend to happen more in case of manufacturing FDI.

[9] For manufactures we have indexes, but no estimations of the costs for firms that barriers imply. The latter are available, by contrast, for some services sectors (e.g., Fontagné et al., 2016; Jafari and Tarr, 2014).

In the last few decades, much of the research has focused on the reductions of barriers related to liberalization processes and globalization. Brexit is just the opposite, barriers between the REU and UK will rise. As a consequence, what we expect is that there will be more obstacles (differences in regulation, additional requirements) to the activities of MNEs of the Brexit partners. Domestic firms will face lower competition and lower quality varieties than the ones provided by MNEs. This in turn, may trigger negative spillovers to the rest of the economy.

Model and simulations

To analyze the impact of Brexit accounting for services MNEs, we use a general equilibrium model that follows the path breaking approach of Balistreri et al. (2015), who developed a multiregional CGE with FDI in services. In addition, according to Melitz (2003) we introduce a competitive selection of heterogeneous manufacturing firms following Balistreri et al. (2011), so the applied model is close to Latorre et al. (2018c).[10] The combination of the Melitz structure in manufacturing[11] with foreign multinationals in imperfectly competitive services sectors within a multiregional framework provides an appropriate approach to analyze Brexit for the service-oriented economy of the UK. Being more precise, in services we implement a Krugman (1980) model of large-group monopolistic competition among symmetric firms[12] and therefore account for trade-policy induced variety effects. Thus, increased protectionism due to Brexit induces foreign exit and leads to productivity losses because of reduced number of available varieties (according to the Dixit and Stiglitz (1977) variety effect).[13]

In general, CGE models including MNEs are rather scarce. So far, two different approaches have been used to model FDI. Some studies use series on the evolution of FDI flows and introduce them in the model as variations in productive capital across sectors. Since industries differ in their production structures as shown in the first two columns of Table 2 for the UK, the impact of productive capital will vary depending on the sector to which it accrues. This is the approach of recent studies such as Zhou and Latorre (2015, 2014a, 2015). Not all studies differentiate the impact of FDI across sectors. In fact there are many accomplished analyses that illuminate other aspects of multinationals lumping together data from all manufacturing sectors (e.g., Arkolakis et al., 2015; Arita et al. 2014; Burstein and

[10] Compared to Latorre et al. (2018c), the present model incorporates updated shares of MNEs in business services and communications using Eurostat (2018) data. See section 2 for details.
[11] We model the Melitz structure in manufacturing sectors with the share of intra-industry trade over 60% of total trade following Olekseyuk and Balistreri (2017). These sectors include food, textiles, chemicals, metals, motor vehicles, transport equipment, electronics, other machinery, other manufactures and construction. Agriculture, other primary goods, wood and paper industry as well as personal and other services run in a constant return to scale setting.
[12] The advanced services sectors with multinationals include water transport, air transport, communications, finance, insurance and business services.
[13] The algebraic description of the model is provided in an online appendix.

Monge-Naranjo, 2009; McGrattan and Prescott, 2009; Ramondo, 2013; Ramondo and Rogríguez-Clare, 2013).

Other CGE models differentiate production technologies not only across sectors but also within the sectors, by introducing different cost structures of multinational and domestic firms (Latorre, 2013; Latorre, 2014; Balistreri et al., 2015; Olekseyuk, 2016; Latorre and Hosoe, 2016; Latorre, 2016; Latorre and Yonezawa, 2018; Latorre et al., 2018b, 2018c). Among these studies some again rely on the evolution of FDI flows to grasp the activities of MNEs (e.g., Latorre, 2013; Latorre, 2014; Latorre and Hosoe, 2016), while others introduce diverging production and cost structure including non-tariff barriers (NTBs) to FDI, which are reduced or increased according to the shock analyzed (Balistreri et al., 2015; Ciuriak et al., 2015; Olekseyuk, 2016; Latorre, 2016; Latorre and Yonezawa, 2018; Latorre et al., 2018b; Latorre et al., 2018c). This latter approach is the one chosen for the analyses of Brexit in this paper.

Accounting for existing FDI in services, we allow for the presence of two different types of firms: (i) domestic firms producing for home and foreign markets and (ii) multinational firms supplying services directly in the host country. This means that business services can be supplied by foreign firms both operating in the host country (FDI case) and abroad (cross-border supply). As mentioned previously, the cost structure of the two firm types differs. While both domestic and FDI firms use local production factors and intermediates, MNEs additionally use imported specialized foreign inputs from the headquarter country. Moreover, on the production side we generally allow business services to substitute for the value-added since firms can use external services provided by, e.g., accounting firms instead of hiring professionals (i.e., skilled labor input). Such an extension of production structure is implemented in a number of empirical studies such as Jensen, Rutherford, and Tarr (2010), Balistreri et al., 2015; Olekseyuk (2016), Latorre and Yonezawa (2018) and Latorre et al. (2018b,c).

The initial database for the majority of micro and macroeconomic variables, as well as the input-output data comes from the GTAP 9 Database (Aguiar et al., 2016). Our model includes eleven regions, 21 sectors and four production factors, namely, land, capital, labor and sector-specific natural resources.[14] GTAP 9 resembles the world economy in 2011. To update the benchmark we conduct a forward calibration using the IMF (2015) GDP projections for 2020 (following the approach suggested by Böhringer et al., 2009). This year provides a reasonable benchmark for estimation of the initial Brexit impact. Therefore, it will be our reference year for the simulations.

To quantify the impact of Brexit we simulate two potential scenarios: *hard* and *soft* Brexit (following Latorre et al. (2018c), Ottaviano et al., 2014; and Dhingra et al., 2017). The soft Brexit is a post-Brexit arrangement similar to Norway, while the hard Brexit simulates a reversion to WTO rules. Thus, these simulations provide the most extreme possibilities, i.e., the closest possible relationship following the negotiated Withdrawal Agreement, i.e., the

[14] Recall that Appendix 1 presents description of sectors and their mapping between different sectoral classifications.

Norway case, and the absence of any trade agreement between the two (see Fernández-Pacheco et al., 2018 for more details). For a *hard Brexit* we increase import tariffs between the REU and UK to the trade weighted average MFN level calculated using the external tariff rates of the EU and UK's bilateral trade flows with the rest of the EU.[15] Moreover, the UK and REU will face an increase in their respective bilateral NTBs equivalent to 50% of NTBs that US faces on EU markets. We also assume an increase of existent FDI barriers between the UK and the rest of the EU by 50%. In case of *soft Brexit* we remain zero import tariffs, but increase the NTBs and FDI barriers by 25%.[16]

As noted above, the FDI impact has received less attention in the literature. Thus, it is not analyzed by, e.g., Ottaviano et al. (2014), Dhingra et al. (2017), Jafari and Writz (2017) or Aichele and Felfermayr (2015). Our assumptions for barriers to FDI between the UK and REU are based on the Product Market Regulation (PMR) indicator derived by the OECD (Koske et al., 2015) as well as on Jafari and Tarr (2015). The PMR deals with the EU internal market (Ecsip Consortium, 2014) and, therefore, should be a good indicator to capture the differences among national regulations within the EU.

The NTBs to trade stem from Ecorys (2009) who additionally estimated the share of rents and efficiency losses that were behind the NTBs between Europe and the US. On average, 60% of the costs of the NTBs were found to be efficiency losses, while 40% would create rents. They also calculated that 2/3 of the rents were earned by importers and 1/3 by exporters. We adopt these assumptions and model the 60% of efficiency losses as iceberg trade costs (see also Latorre and Yonezawa, 2018a, b). Ecorys (2009) does not offer barriers for agriculture, other manufacturing and other services. For these sectors we take the estimations used by the CEPII (Fontagne et al., 2013, p. 8), which are also the same estimations used by Francois and Machin (2014, p. 23). In turn, from Francois and Machin (2014, p. 23) we obtain the trade NTBs for "Other manufacturing" and "Other services".

We concentrate on the medium term impact of the emergence of these barriers. Not all of them will arise suddenly after Brexit. The UK is in compliance with EU regulations at the moment, but barriers will tend to grow as time passes and the UK and REU legislation drift apart under independent government decisions and rulings of their respective courts. However, other barriers, such as customs controls, will emerge immediately after Brexit.

All assumptions for trade and FDI barriers are illustrated in Table 3. Hereby, the first two columns show the potential MFN tariffs in case of hard Brexit. The next four columns present the NTBs related to trade and the final four columns the NTBs related to FDI in services. For both types of NTBs we have a soft and a hard version with the aforementioned 25% and 50% shares of the total values of the NTBs, respectively. As shown in Table 3, all the barriers are highly heterogeneous across sectors. Trade barriers are larger in agriculture, other primary goods (only in the case of NTBs), food, textiles, and motor vehicles. NTBs to

[15] For calculation of the potential tariff rates between the EU and UK, we use the external applied MFN tariffs of the EU from TRAINS for 2015 as well as trade flows for 2014.

[16] Since the UK faces much smaller barriers in the European markets than the US, we assume an increase of the proxy EU-US NTBs only by a fraction of the total barrier (consistently with Latorre et al., 2018c; Ottaviano et al., 2014; and Dhingra et al., 2017).

FDI are particularly high in business services and, to a lesser extent in air transport. These sectors with high barriers are likely to be the most affected by Brexit.

Results

Macroeconomic impact

Table 4 offers the impact for GDP, welfare, wages and capital remuneration for REU and UK. The results display the total effects of the soft and hard Brexit, together with their decomposed scenarios at the left and right of the table, respectively. The soft Brexit consists of increases in NTBs to trade and increases in NTBs to FDI (labelled as "FDI"), whereas the hard Brexit also includes the introduction of MFN tariffs (labelled as "Tariffs") on top of the two former decomposed scenarios.

In line with economic intuition, we obtain a much stronger reduction in UK's GDP and welfare than in the REU. This happens due to the relatively high dependence of the UK from the European market. In particular, the REU accounts for 46.9% and 48.4% of UK's aggregate exports and imports, while the UK explains only 6.3% and 5.3% of REU's exports and imports, respectively.[17] Thus, the UK loses its most important trade partner (i.e., REU) and suffers from Brexit much stronger than the REU. In detail, our results suggest a fall of UK's GDP by -1.24% and -2.55% after the soft and hard Brexit, respectively. By contrast, for the REU the decline in GDP would be only -0.17% and -0.38%. The rest of regions would remain nearly unaffected. This even holds for the hard Brexit, which could result in more intense trade diversion or creation effects. Since UK (as the most affected region) accounts for a small share of global GDP and trade, the potential spillovers of Brexit for outsiders seem to be quite dampened.[18]

Welfare reductions, measured as equivalent variation, are more pronounced than the ones of GDP due to lower household income, increased consumer prices and lower number of available product varieties.[19] In particular, UK losses would be 31.155 $billions of 2020 (-1.57% of the benchmark value of private consumption) and 63.143 $billions (-3.19%) in soft and hard Brexit scenarios, respectively. For the REU, the welfare cost would be -28.296 $billions of 2020 (-0.29%) and -62.153 $billions of 2020 (-0.63%).

The results of returns to factors of production also run in parallel to the ones described for GDP and welfare. Both capital remuneration and wages decline in the UK much stronger than in the REU. The strongest reduction occurs in the hard Brexit case with -2.80% for wages and -3.47% for capital remuneration in the UK. For the REU the values are much smaller with -0.41% and -0.45% for labor and capital returns, respectively.

[17] Calculations based on the GTAP data (Aguiar et al., 2016), see also Table 1.
[18] The trade regime against third countries remains unchanged in our simulations, which limits the impact.
[19] Percentage change in GDP is smaller compared to welfare also due to standard assumptions of static CGE models, namely, fixed investment, government spending, and trade balance.

Observing the decomposition of Brexit impact by the type of imposed barriers, we see that NTBs to trade account for the largest share of the total negative impact (around 60% in the case of soft Brexit and approximately 50% in the case of hard Brexit), since they are relatively high and affect all sectors of the model (see Table 3). However, the evolution of FDI barriers in services plays a significant role, since they explain about one third of the contraction in GDP and welfare. This confirms the findings in the literature that barriers against FDI in services significantly harm the economic performance of countries. The sectoral analysis in the next section illustrates that this impact is related to the production outcomes, and more precisely, to the strong contraction in services, which account for the large share in output and GDP (e.g., services constitute almost 76% of domestic value added in UK in our projections for 2020, see Table 2).

Sectoral results for the British economy

Since the UK constitutes the most affected economy, we focus in our sectoral analysis on this country in order to analyze in more detail the contribution of the different components (i.e., barriers) of the overall shock, as well as the evolution of trade. Table 5 and 6 offer the evolution of exports and imports by sector for the UK after the soft and hard Brexit (on the left and right, respectively). We show the impact for all the components of the soft and hard Brexit and their joint effects in different columns.

The effects for exports are pervasive in each sector. Focusing on the "Total" scenario in the soft and hard Brexit, we see that the fall in exports is more sizeable in sectors like other primary goods, agriculture, food, motor vehicles and textiles. In all these sectors contractions go well beyond 10% in the case of the soft Brexit and much more in the case of the hard one with the maximum of -57% in agriculture.[20] This occurs mainly due to the emergence of barriers to trade (NTBs to trade and, in the case of hard Brexit also MFN tariffs), which tend to be quite high in those particular sectors (Table 3). By contrast, FDI barriers have a rather limited impact on export flows, since they are applied exclusively against services MNEs.[21]

The fall in aggregate exports in the soft and hard Brexit in the "Total" scenario is of -7.4% and -16.7%, respectively. This is broadly explained by contractions in manufacturing exports of -9.5% and -21.6%, respectively, which contrasts with the small reduction in services exports of -2.5% and -5.8%. Since tariffs are not applied to services and NTBs to trade are smaller in services than in manufactures, exports flows in services tend to be considerably less affected by Brexit than in the case of manufactures. Moreover, the overall reductions in exports are entirely explained by the fall of the bilateral exports from UK to REU, and it is mitigated to some extent by the increase in exports to the rest of the world

[20] Other machinery is the only sector that experiences an increase in exports in the "Total" scenario of the soft Brexit. Barriers to trade are among the lowest in this sector with even a zero NTB to trade, which allows for slightly increased exports. In addition, other machinery is less integrated with REU than the other sectors since the share of its exports that goes to REU is smaller than in the rest of sectors (Table 1).

[21] FDI barriers affect trade flows due to the switch in the supply mode of multinationals as explained later on.

(the percentage decrease of exports to REU is larger than that of total exports, which indicates that the exports to the rest of the world is increased).

Sectoral imports decline also strongly with more sizeable reductions in the hard Brexit case due to higher barriers. This leads to a fall in total imports by -14.5% in hard Brexit case compared to -6.5% for the soft Brexit scenario. Only in the case of the FDI scenario, we see an increase of imports in air transport, business services and insurance. This occurs due to the switch of the European multinationals from local supply in the UK (mode 3 supply) to cross-border supply, given the highest barriers against FDI in these sectors (Table 3). Therefore, we observe an increase of imports from the REU in the aforementioned sectors, which illustrates the increased cross-border supply of the REU MNEs.

As in the case with exports, the fall in aggregate manufacturing imports is more sizeable than the one in services with -17.1% compared to -4.5% in the hard Brexit simulation. However, most of the services imports are related to the provision of intermediates both in manufactures and in services. According to Aguiar et al. (2016), 55.90% of manufacturing and 57.55% of services imports constitute intermediates. Therefore, apart from the effect of emerging barriers, we find that imports of services fall because of lower production and therefore lower demand for services as intermediates.

Table 7 illustrates changes in the supply of domestic and multinational firms for the UK market.[22] We observe that Brexit leads to an increase of domestic provision in manufacturing sectors (i.e., supply of UK manufacturing firms for domestic market) with an overall rise by 2.84% and 6.92% for all manufactures in the soft and hard Brexit scenario, respectively. Higher NTBs to trade and tariffs protect British market from foreign competition, so that domestic provision increases to compensate for the lost imports. Moreover, as also shown by Latorre et al. (2018c), less productive British firms enter the UK market due to increased protectionism, which leads to a fall of industry-wide average productivity in manufacturing sectors.

In services, we observe an opposite picture. In particular, domestic provision as well as provision of MNEs in UK decrease due to the emergence of barriers. Domestic firms (i.e., UK national firms) reduce their supply with an overall decline for all services by -0.33% in the case of hard Brexit ("Total" scenario). This goes in line with the fall in the number of domestic firms illustrated in Table 8. Regarding the MNEs' provision, the highest reduction occurs in air transport and business services with -8.35% and -2.65% for hard Brexit, respectively (see the bottom part of Table 7).[23] These two sectors are exposed to the highest increase in NTBs to FDI (see Table 3) which induces the highest reduction in the number of European multinationals supplying in the UK. According to our results in Table 8, 95.36% of European MNEs in air transport exit the UK market. In business services and insurance this decline amounts to -42.84% and -66.70%, respectively. Thus, to compensate for such a

[22] Total supply on the UK market consists of provision of domestic firms, MNEs operating in the UK as well as imports. Therefore, Table 7 includes the first two components, while imports are illustrated in Table 6.

[23] Only in water trasport we observe a small increase of MNEs' provision. This happens due to zero NTB to FDI in combination with a higher NTB to trade in the UK in this sector. Thus, we observe entry of European multinationals to the UK market in this sector, since exports to UK are more expensive than local provision.

big loss, there is an increase in the number of domestic firms and consequently in the domestic provision of air transport and business services.[24]

Our decomposition by types of barriers suggests that NTBs to trade are the main driver for reductions in domestic provision of services. For the supply of MNEs, FDI barriers are crucial since they directly hit European firms on the UK market. Moreover, FDI barriers lead not only to a reduction in the domestic provision of services but also to a small reduction of domestic provision of manufactures in the UK by -0.16% and -0.37% for the soft and hard Brexit case.[25] Thus, manufacturing firms suffer from reduced supply of services and higher prices for their important inputs. This finding reflects the suggestions from the literature that FDI barriers in services indirectly affect manufacturing sectors through the intermediate-input channel.

Our simulations suggest that FDI barriers force European MNEs to switch from direct supply in the UK (i.e., mode 3) to cross-border supply (i.e., foreign trade, mode 1), especially if no trade barriers are applied just like in the FDI only scenario. This implies the aforementioned strong decrease in the number of REU MNEs operating in the UK (Table 7) as well as a small increase of services imports by 0.2% or 0.9% for this scenario in case of soft and hard Brexit, respectively (Table 6). Moreover, since FDI barriers are also applied in REU, British MNEs in REU would also switch in their supply mode, so that we observe an increase in total British services exports by 0.3% or 0.6% for the soft and hard Brexit, which is mainly based on the higher exports to the REU (0.4% and 0.8%, respectively, see Table 5). This is also confirmed by the strong decrease in the number of British MNEs operating in REU, which reaches -99.75% in the case of air transport for hard Brexit (Table 8).

As already noted, empirical evidence from the literature suggests that an increase in the number of foreign MNEs results in more varieties at a lower price (e.g., Fernández and Paunov, 2012; Arnold et al., 2008; Latorre, 2016; Latorre and Yonezawa, 2018; Latorre et al., 2018b). This is beneficial from the point of view of consumers and producers, who can acquire either cheap final consumption goods or intermediates. Since Brexit leads to a rise of barriers to trade and FDI, there is a reduction in the number of foreign varieties, and this effect works now in the opposite direction. In particular, Table 8 provides changes of the weighted average number of varieties in services, which includes both domestic and FDI firms weighted with their market shares. We observe a strong decrease across all sectors both for soft and hard Brexit with the strongest effect in air transport of -15.22% for the hard Brexit case. The decomposition by different types of barriers indicates that NTBs against multinationals play the main role in the total reduction of available varieties in the UK. Thus, exit of European multinationals from the British market because of higher FDI barriers is strongly harmful. UK producers experience productivity losses due to the reduced number of available varieties of their intermediates and higher prices.

[24] Note that in insurance the output share of foreign MNEs is smaller (even smaller if applied to EU MNEs only) than in air transport and business services (Table 1). Therefore, the sector is less affected by the emergence of FDI barriers.
[25] See the simulations with increased FDI NTBs in Table 6.

Given the described sectoral results as well as output[26] by industry, we can see that the overall GDP effect in UK is mainly driven by the contraction of services sectors. This is intuitive given the trend of servicification and much higher share of services in total value added of Great Britain (75.9% compared to 23% in manufactures, Table 2). Since our analysis covers a very important form of services provision in the UK, namely, mode 3 and mode 6, we can identify an extra effect that has been neglected in quantitative analyses of Brexit. In total, NTBs against foreign affiliates explain around one third of the overall macroeconomic impact. Moreover, the reduction in UK's GDP after the soft Brexit of -1.24% coincides with the reduction in total services production by -1.36%, while the decline in manufacturing output amounts to only -0.59%. After the hard Brexit, the reduction in UK's GDP reaches -2.55%, which is close to the evolution of services output of -3.04%. Therefore, British economy is strongly affected by Brexit with services representing the main contributor to the overall losses.

Sensitivity Analysis

We assess the impact of the key model parameter values in our 'piecemeal sensitivity analysis' where we change each parameter one by one while we keep all other parameters unchanged. Table 9 shows how the welfare impacts of the hard Brexit on the UK and REU are affected by each parameter.

We see that our central results are quite robust to all the parameters here, and thus we focus on the parameters that have (relatively) larger impacts on the welfare results. The parameter that has the strongest impact on the welfare results is the elasticity of substitution between value-added and business services, σ(va, bs), and the welfare impact of UK (REU) ranges from 89% (77%) to 115% (131%) of the central results. When this elasticity is higher, we can substitute the business services for value-added input more easily, leading to the larger decrease of the business services from multinational firms and cross-border firms due to Brexit. When production of services and the number of available varieties is reduced, business services will be more costly and will cause a larger welfare loss for the economy in the love-of-variety setting.

The elasticities of substitution between firm varieties have modest impact on the welfare results. Especially, when the substitution elasticity between firm varieties of service sectors is lower, the welfare impact of UK (REU) is 114% (119%). When this elasticity (for both service and good sectors) is lower, the welfare loss becomes larger because lower values of this elasticity imply that varieties are less close to each other, and thus fewer varieties are more damaging.

[26] Sectoral resuls for total output are not separately included in a table due to space limitations. Only aggregate numbers for services and manufactures are highlighted in the text.

Also, the supply elasticity with respect to the price of output (for non-CRTS sectors) has a modest effect. When this supply elasticity is lower, the welfare loss of UK (REU) is 95% (92%). This might be surprising since in general lower elasticity means less flexibility and welfare loss from the welfare-decreasing policy tends to be larger (Le Chatelier principle). However, we lower this elasticity of all the regions. In this case, we have the less elastic supply of other regions as well, and expanding production of other regions (to fill the gap created by Brexit) is more costly, and other regions would take less advantage via trade diversion. Thus the welfare loss of UK becomes smaller.[27]

Other than the elasticities, the parameter that has a (relatively) strong impact on the welfare results is the share of capital remuneration of multinational firms. We assume that some portion of the capital remuneration is sent back to the source countries. When this share is low, more multinational firms leave because they have smaller incentive to stay in the host countries, and thus the welfare loss becomes larger (112% for UK and 138% for REU). The same mechanism (but the direction is opposite) is shown in Latorre and Yonezawa (2018) who demonstrate that when this share is high, the removal of FDI barriers leads to more multinationals (they have more incentive to come to the host countries) and thus larger welfare gain.

Conclusions

Contribution of services to GDP tends to grow with countries' degree of economic development. Thus, services are the largest sector of economy in many developed countries. Some authors talk about the process of "servicification" (e.g., Baldwin 2016; Borchert, 2016), which is related to this idea but goes beyond it. Less explicit version of servicification occurs via intermediate service inputs for non-service sectors in the economy. The TIVA statistics of the OECD show that a substantial share of the value added of traded merchandise goods consists of services (Miroudot, 2017; Cernat and Kutlina-Dimitrova, 2014). Hence, the importance of services in foreign trade is larger than illustrated by traditional trade statistics, because services are embodied as inputs in merchandise trade. Ultimately, some authors claim that the competitiveness of nation's manufactures is quite dependent on the availability of local or imported services used as inputs in merchandise production (Baldwin 2016; Baldwin and Evenett, 2015). In this paper we investigate the impact of losing foreign MNEs as local services providers (mode 3), paying a particular attention to their role as providers of high-quality inputs (a possible mode 6) in the UK in the context of Brexit.

Our literature review suggests that the entry of services MNEs tends to be beneficial to a broader range of sectors compared to the entry of MNEs in manufactures. Services MNEs produce high quality intermediates, such as finance, communications, business services etc., that are used across the board and, therefore, beneficial for many sectors in the economy. A

[27] We run the extra sensitivity analysis where we lower the supply elasticity of production only in UK, and we confirm that the welfare loss of UK becomes larger.

higher involvement of MNEs in host economies brings an increase in the number of services varieties, which improves the efficiency and productivity of producers who use them as intermediates. The increase in varieties also improves consumers' welfare, who have access to a broader range of choices. However, due to the intangible and non-storable nature of services, customs and port procedures are generally less relevant for services than for manufactures. Nevertheless, due to the substantial share of services as intermediate input in the value of traded merchandise goods, any impediment to goods trade has potential indirect effects on embodied services. Similarly, impediments to services have an impact on manufactures.

Our simulation results are consistent with the findings from the previous literature. We confirm that the overall negative GDP effect of Brexit in the UK is mainly driven by the contraction of services sectors. In particular, the reduction in UK's GDP after the soft Brexit of -1.24% coincides with the reduction in total services production by -1.36%, while the decline in manufacturing output amounts to only -0.59%. After the hard Brexit, the reduction in UK's GDP reaches -2.55%, which is close to the evolution of services output of -3.04%. Our decomposition by different types of barriers (tariffs, NTBs to trade as well as NTBs to FDI) suggests that NTBs against MNEs explain around one third of the overall macroeconomic impact. Hereby, barriers to FDI hit the European firms operating in the UK and, consequently, lead to a strong reduction of MNEs local provision for the British market. Moreover, these barriers induce a decline not only in the domestic provision of services, but also of manufactures since British domestic firms face a reduced supply of intermediates.

In addition, we provide important results for the interaction between foreign trade in services and MNEs' operations, which has received less attention in the literature. Particularly, we illustrate that European MNEs switch from local supply via foreign affiliates (mode 3) to supply via foreign trade (mode 1) if NTBs to FDI increase without any changes in barriers to trade. We observe a strong reduction in the number of European multinationals supplying directly in the UK with the highest decline in air transport and business services. These two sectors are exposed to the highest increase in NTBs to FDI, which induces exit of European MNEs from the British market and, consequently, the highest reduction in MNEs local supply. According to our results for hard Brexit, 95.36% and 42.84% of European MNEs in air transport and business services exit the UK market. Thus, to compensate for such a big loss, there is an increase in both imports and domestic provision of air transport and business services. Since FDI barriers also apply to the rest of the EU in the case of Brexit, British MNEs operating in other EU-27 countries also switch their supply mode, so that we observe an increase in total UK's services exports and a reduced number of British multinationals supplying the EU-27.

Overall, we find that barriers to FDI play a more important role than barriers to trade in the total reduction of services varieties available in the UK after Brexit. Since the present analysis covers mode 3 provision of services in the UK, we identify the effect that has been neglected in the most of the quantitative analyses of Brexit.

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Table 1. Shares of MNEs in UK sales (in percent).

	Share in total UK sales		Share in the total MNEs sales in UK	
	UK firms	Foreign MNEss	REU MNEs	Non-REU MNEs
1.Agriculture				
2.Other primary	25%	75%	23%	77%
3.Food	51%	44%	46%	58%
4.Textiles	82%	18%	26%	74%
5.Wood and paper	72%	28%	61%	39%
6.Chemicals	41%	59%	32%	68%
7.Metals	64%	36%	39%	61%
8.Motor vehicles	11%	89%	13%	87%
9.Transport equipment	63%	37%	63%	37%
10.Electronics	47%	53%	38%	62%
11.Other machinery	42%	58%	35%	65%
12.Other manufactures	59%	41%	57%	43%
13.Construction	89%	11%	65%	35%
14.Water Transport	53%	47%	17%	83%
15.Air Transport	38%	62%	71%	29%
16.Communications	68%	32%	48%	52%
17.Finance	15%	85%	1%	99%
18.Insurance	69%	31%	49%	51%
19.Business services	72%	28%	28%	72%
20.Personal services	67%	33%	49%	51%
21.Other services	66%	34%	38%	62%
Total	**65%**	**35%**	**37%**	**63%**

Source: Eurostat (2018), except for 14.Water Transport, 15.Air Transport, 17.Finance and 18.Insurance which are from Fukui and Lakatos (2012).

Note: Most of the data refer to 2015, in a small number of subsectors 2014 data were used since no data for 2015 were available. The totals are calculated without finance, since for this case the data are for 2011.

Table 2. Trade and GDP structure of the UK in 2020 (in percentage)

	% Share in total costs of remuneration of		% Shares in total			% Share going to (coming from) REU	
	Labor	Capital	Value Added	Exports	Imports	in Exports	in Imports
1.Agriculture	30.4	11.7	1.1	0.8	2.1	71.3	48.7
2.Other primary	7.0	68.1	2.1	3.8	7.0	68.0	11.4
3.Food	23.3	13.0	2.7	4.1	6.1	57.9	74.7
4.Textiles	36.2	4.6	0.9	1.8	5.4	62.3	30.3
5.Wood and paper	31.2	12.4	2.0	2.1	3.5	48.7	62.0
6.Chemicals	17.3	3.4	2.5	18.2	14.8	55.1	57.9
7.Metals	27.0	5.6	1.5	6.5	9.9	40.1	35.2
8.Motor vehicles	21.8	2.3	1.0	7.7	8.4	47.8	84.3
9.Other transport	27.3	8.6	0.9	4.1	2.9	32.7	36.6
10.Electronics	22.2	5.9	0.5	3.1	5.2	58.5	41.5
11.Other machinery	29.8	10.0	2.6	12.3	10.7	35.6	54.7
12.Other manufactures	26.6	6.0	1.2	2.3	3.3	38.0	36.9
13.Construction	22.1	18.2	5.2	0.4	0.3	34.0	37.6
14.Water Transport	23.8	3.2	0.5	0.5	0.6	42.0	56.7
15.Air Transport	12.7	4.7	0.4	3.0	2.7	34.4	51.2
16.Communications	38.1	14.0	3.5	0.7	1.0	72.9	50.0
17.Finance	21.2	6.6	4.3	5.8	2.2	44.2	37.0
18.Insurance	20.5	4.6	1.6	1.5	0.3	16.9	52.6
19.Business services	39.3	12.7	15.6	14.0	5.7	50.7	35.3
20.Personal services	32.4	21.0	3.3	1.7	1.5	44.4	46.6
21.Other services	39.3	21.7	46.6	5.5	6.3	33.4	43.9
All manufactures	23.4	12.0	23.0	66.4	77.5	48.2	49.9
All services	36.7	17.8	75.9	32.8	20.4	43.7	42.7
Total	32.1	15.8	100.0	100.0	100.0	46.9	48.4

Source: Authors' estimations based on Aguiar et al. (2016) and on IMF (2016) for the projections.

Note: Appendix 1 presents sectors'description and their mapping between different sectoral classifications.

Table 3. Assumed cost increases due to Brexit

	MFN Tariffs		NTBs to trade		NTBs to FDI			
	Hard Brexit		Soft Brexit	Hard Brexit	Soft Brexit		Hard Brexit	
	In REU	In UK	In REU and UK	In EU and UK	In REU	In UK	In REU	In UK
1.Agriculture	**10.2**	**10.8**	**14.2**	**28.4**				
2.Other primary	**0.0**	**0.1**	**14.2**	**28.4**				
3.Food	**19.8**	**22.0**	**14.2**	**28.4**				
4.Textiles	**10.0**	**9.5**	**4.8**	**9.6**				
5.Wood and paper	**0.5**	**1.0**	**2.8**	**5.7**				
6.Chemicals	**2.8**	**2.7**	**3.4**	**6.8**				
7.Metals	**1.9**	**2.0**	**3.0**	**6.0**				
8.Motor vehicles	**8.0**	**8.8**	**6.4**	**12.8**				
9.Transport equipment	**1.7**	**1.6**	**4.7**	**9.4**				
10.Electronics	**0.9**	**1.5**	**3.2**	**6.4**				
11.Other machinery	**1.7**	**1.8**	**0.0**	**0.0**				
12.Other manufactures	**2.6**	**2.2**	**2.8**	**5.7**				
13.Construction	**0.0**	**0.0**	**1.2**	**2.3**				
14.Water Transport	**0.0**	**0.0**	**2.0**	**4.0**	**2.8**	**0.0**	**5.6**	**0.0**
15.Air Transport	**0.0**	**0.0**	**0.5**	**1.0**	**4.6**	**4.7**	**9.1**	**9.3**
16.Communications	**0.0**	**0.0**	**2.9**	**5.9**	**0.2**	**0.2**	**0.5**	**0.4**
17.Finance	**0.0**	**0.0**	**2.8**	**5.7**	**0.5**	**0.6**	**0.9**	**1.1**
18.Insurance	**0.0**	**0.0**	**2.7**	**5.4**	**2.7**	**2.8**	**5.5**	**5.6**
19.Business services	**0.0**	**0.0**	**3.7**	**7.5**	**7.9**	**4.8**	**15.8**	**9.7**
20.Personal services	**0.0**	**0.0**	**1.1**	**2.2**				
21.Other services	**0.0**	**0.0**	**1.1**	**2.2**				

Source: for the NTBs Ecorys (2009), Latorre and Yonezawa (2018) and Latorre et al. (2018); TRAINS and WITS for tariffs and Jafari and Tarr (2017) and Koske et al., (2015) for barriers to FDI.Note: see note in Table 2.

Note: see note in Table 2.

Table 4. Impact on GDP, welfare, wages and capital remuneration (% changes with respect to the initial data)

	Soft Brexit			Hard Brexit	
	REU	UK		REU	UK
	GDP				
NTBs	-0.10	-0.82	NTBs	-0.18	-1.47
FDI	-0.07	-0.43	FDI	-0.14	-0.85
Total	-0.17	-1.24	Tariffs	-0.06	-0.39
			Total	-0.38	-2.55
Welfare					
NTBs	-0.16	-0.96	NTBs	-0.30	-1.76
FDI	-0.13	-0.62	FDI	-0.25	-1.21
Total	-0.29	-1.57	Tariffs	-0.10	-0.33
			Total	-0.63	-3.19
Welfare (in $billions of 2020)					
Bmk	9855.9	1980.3	Bmk	9855.9	1980.3
NTBs	-15.648	-18.962	NTBs	-29.099	-34.764
FDI	-12.667	-12.245	FDI	-24.502	-23.912
Total	-28.296	-31.155	Tariffs	-9.791	-6.528
			Total	-62.153	-63.143
Wages					
NTBs	-0.12	-0.97	NTBs	-0.22	-1.74
FDI	-0.06	-0.28	FDI	-0.12	-0.60
Total	-0.18	-1.25	Tariffs	-0.10	-0.88
			Total	-0.41	-2.80
Capital remuneration					
NTBs	-0.14	-0.98	NTBs	-0.24	-1.76
FDI	-0.08	-0.68	FDI	-0.15	-1.24
Total	-0.22	-1.66	Tariffs	-0.11	-0.93
			Total	-0.45	-3.47

Source: Authors' estimations.

Note: LAC stands for Latin America, OAC for other advanced countries, SEA for Southeast Asia, SSA for Sub-Saharan Africa and MEN for Middle-East and north of Africa.

Table 5. Impact on UK's total export and UK's export from REU (% changes with respect to the initial data)

	Soft Brexit						Hard Brexit							
	Total exports			Exports to REU			Total exports				Exports to REU			
	NTBs	FDI	Total	NTBs	FDI	Total	NTBs	FDI	Tariffs	Total	NTBs	FDI	Tariffs	Total
1.Agriculture	-31.2	0.2	-31.0	-43.7	0.2	-43.6	-48.3	0.4	-28.9	-57.0	-67.5	0.4	-39.5	-79.4
2.Other primary	-31.8	0.2	-31.6	-66.3	0.2	-66.2	-42.0	0.4	-0.1	-41.5	-90.2	0.3	-0.2	-90.2
3.Food	-33.4	0.5	-33.0	-53.9	0.4	-53.7	-48.9	0.9	-45.0	-59.0	-77.7	0.8	-70.4	-92.5
4.Textiles	-13.0	0.4	-12.7	-21.4	0.3	-21.1	-23.2	0.7	-28.0	-39.8	-38.2	0.6	-44.5	-64.9
5.Wood and paper	-6.2	0.6	-5.6	-13.9	0.6	-13.3	-11.9	1.1	-3.4	-13.0	-26.0	1.1	-5.2	-28.4
6.Chemicals	-7.7	0.2	-7.5	-14.9	0.2	-14.7	-14.8	0.4	-9.7	-20.9	-28.0	0.3	-16.4	-39.0
7.Metals	-5.6	0.1	-5.5	-14.3	0.1	-14.1	-10.6	0.2	-5.4	-14.3	-26.6	0.2	-12.0	-34.9
8.Motor vehicles	-14.7	0.2	-14.6	-28.9	0.2	-28.7	-24.0	0.3	-21.0	-34.0	-48.2	0.3	-39.8	-67.7
9.Transport equipment	-6.3	0.1	-6.2	-20.7	0.1	-20.6	-11.4	0.2	-4.0	-13.6	-37.0	0.2	-10.4	-43.1
10.Electronics	-8.6	0.2	-8.4	-15.0	0.2	-14.8	-15.9	0.3	-5.1	-18.8	-27.6	0.3	-7.3	-31.9
11.Other machinery	0.0	0.2	0.2	-0.2	0.2	0.0	-0.2	0.3	-4.8	-4.1	-0.4	0.3	-11.2	-10.8
12.Other manufactures	-4.7	0.4	-4.3	-13.4	0.4	-13.0	-9.0	0.7	-7.5	-13.5	-25.1	0.7	-16.5	-36.3
13.Construction	-0.8	0.3	-0.4	-5.2	0.4	-4.8	-2.1	0.7	-2.0	-2.6	-10.4	0.8	-2.5	-11.2
14.Water Transport	-2.2	0.1	-2.1	-5.0	0.1	-4.9	-4.4	0.1	-1.6	-5.3	-9.8	0.1	-1.8	-10.8
15.Air Transport	-1.3	0.2	-1.0	-2.2	0.4	-1.8	-2.7	0.8	-2.2	-3.1	-4.5	1.1	-2.4	-4.8
16.Communications	-4.7	0.2	-4.5	-6.7	0.2	-6.5	-9.2	0.2	-1.5	-9.9	-13.1	0.2	-1.7	-13.8
17.Finance	-3.2	-0.2	-3.4	-7.0	-0.2	-7.1	-6.3	-0.5	-1.4	-7.7	-13.6	-0.4	-1.7	-15.0
18.Insurance	-0.9	-0.4	-1.3	-6.4	0.0	-6.4	-1.9	-0.7	-1.2	-3.2	-12.5	0.3	-1.6	-13.0
19.Business services	-4.2	0.6	-3.6	-8.6	0.8	-7.9	-8.2	1.1	-1.5	-8.0	-16.4	1.4	-1.7	-16.1
20.Personal services	-0.8	0.2	-0.6	-2.9	0.1	-2.7	-1.8	0.3	-1.6	-2.4	-5.9	0.2	-1.8	-6.7
21.Other services	-0.4	0.4	0.0	-3.1	0.3	-2.7	-1.1	0.7	-1.6	-1.3	-6.3	0.7	-1.9	-6.7
All manufactures	-9.8	0.2	-9.5	-21.8	0.2	-21.7	-16.1	0.4	-10.9	-21.6	-35.6	0.4	-20.5	-46.4
All services	-2.8	0.3	-2.5	-6.7	0.4	-6.2	-5.5	0.6	-1.5	-5.8	-12.9	0.8	-1.8	-13.1
Total	-7.6	0.2	-7.4	-17.5	0.3	-17.2	-12.9	0.5	-8.0	-16.7	-29.1	0.5	-15.1	-36.7

Source: Authors' estimations.

Table 6. Impact on UK's total import and UK's import from REU (% changes with respect to the initial data)

	Soft Brexit						Hard Brexit							
	Total imports			Imports from REU			Total imports				Imports from REU			
	NTBs	FDI	Total	NTBs	FDI	Total	NTBs	FDI	Tariffs	Total	NTBs	FDI	Tariffs	Total
1.Agriculture	-7.0	-0.4	-7.3	-32.7	-0.4	-33.0	-11.1	-0.8	-6.8	-14.2	-55.8	-0.8	-28.9	-70.2
2.Other primary	-8.8	-0.1	-8.9	-74.1	-0.1	-74.1	-12.2	-0.3	-2.2	-13.8	-93.0	-0.2	-2.0	-93.2
3.Food	-29.0	-0.9	-29.8	-43.3	-0.9	-43.9	-45.2	-1.7	-40.9	-58.5	-68.2	-1.7	-62.3	-89.0
4.Textiles	-4.9	-0.7	-5.5	-19.7	-0.7	-20.3	-8.7	-1.4	-8.1	-14.9	-35.5	-1.4	-38.3	-61.2
5.Wood and paper	-4.1	-0.5	-4.6	-9.3	-0.6	-9.9	-7.6	-1.1	-1.8	-10.0	-17.8	-1.2	-2.8	-21.6
6.Chemicals	-6.9	-0.4	-7.3	-13.5	-0.5	-13.9	-12.6	-1.0	-6.2	-17.7	-25.0	-1.1	-11.7	-34.7
7.Metals	-2.9	-0.1	-2.9	-11.7	-0.1	-11.8	-5.1	-0.2	-3.3	-7.0	-21.9	-0.2	-9.6	-29.4
8.Motor vehicles	-10.3	-0.4	-10.7	-15.1	-0.5	-15.6	-18.9	-0.9	-16.3	-31.8	-28.4	-1.0	-23.6	-48.4
9.Transport equipment	-5.6	-0.2	-5.8	-19.1	-0.3	-19.4	-10.0	-0.5	-3.0	-12.3	-34.6	-0.6	-8.0	-40.4
10.Electronics	-2.7	-0.2	-2.9	-11.4	-0.3	-11.7	-4.8	-0.4	-1.9	-6.3	-21.6	-0.6	-6.1	-27.1
11.Other machinery	-0.7	-0.2	-0.9	-0.2	-0.3	-0.4	-1.1	-0.4	-3.6	-4.7	-0.2	-0.5	-7.2	-7.9
12.Other manufactures	-4.8	-0.7	-5.4	-12.7	-0.7	-13.4	-8.6	-1.3	-3.1	-12.1	-23.6	-1.4	-9.7	-32.4
13.Construction	-4.3	-0.4	-4.7	-7.1	-0.5	-7.6	-7.6	-1.0	0.4	-8.1	-13.2	-1.1	1.8	-13.0
14.Water Transport	-2.7	-0.3	-2.9	-4.3	-0.3	-4.6	-5.0	-0.6	-0.6	-5.8	-8.2	-0.7	0.5	-8.5
15.Air Transport	-1.2	1.0	-0.1	-1.4	1.0	-0.3	-2.1	6.6	0.0	4.4	-2.5	6.6	1.1	4.6
16.Communications	-4.2	-0.3	-4.5	-7.5	-0.4	-7.9	-7.7	-0.6	-0.4	-8.5	-14.1	-0.8	0.8	-14.3
17.Finance	-3.5	-0.1	-3.6	-7.1	-0.2	-7.3	-6.5	-0.2	-0.5	-6.9	-13.3	-0.3	0.7	-13.2
18.Insurance	-4.5	0.2	-4.3	-7.0	0.2	-6.8	-8.3	0.8	-0.2	-7.6	-13.1	0.7	1.0	-11.9
19.Business services	-4.4	1.0	-3.5	-9.2	0.9	-8.3	-8.1	1.7	-0.5	-6.8	-17.1	1.7	0.8	-15.3
20.Personal services	-1.8	-0.6	-2.4	-3.0	-0.6	-3.7	-3.4	-1.2	-0.3	-4.7	-5.9	-1.2	1.0	-6.5
21.Other services	-1.9	-0.5	-2.4	-3.3	-0.6	-3.9	-3.5	-1.1	-0.3	-4.7	-6.3	-1.1	1.0	-6.8
All manufactures	-7.1	-0.4	-7.5	-16.4	-0.5	-16.8	-11.9	-0.8	-8.3	-17.1	-28.1	-0.9	-18.9	-40.3
All services	-2.9	0.2	-2.7	-5.0	0.1	-4.9	-5.2	0.9	-0.3	-4.5	-9.5	0.9	0.9	-8.1
Total	-6.2	-0.3	-6.5	-14.7	-0.4	-15.0	-10.6	-0.4	-6.6	-14.5	-25.3	-0.6	-15.5	-35.1

Table 7. Impact on supply of domestic and multinational firms for the UK market (% changes with respect to the initial data)

	Soft Brexit			Hard Brexit			
	NTBs	**FDI**	**Total**	**NTBs**	**FDI**	**Tariffs**	**Total**
	Domestic provision						
1.Agriculture	4.14	-0.28	3.84	7.01	-0.56	3.47	8.04
2.Other primary	9.57	0.00	9.59	12.30	-0.06	-1.79	11.05
3.Food	8.22	-0.41	7.77	12.92	-0.80	11.74	15.95
4.Textiles	2.95	-0.30	2.66	5.26	-0.59	5.62	8.30
5.Wood and paper	0.55	-0.29	0.26	1.04	-0.59	-0.44	0.29
6.Chemicals	4.05	-0.18	3.87	7.38	-0.51	2.13	8.69
7.Metals	2.64	0.09	2.74	5.09	0.14	0.51	6.30
8.Motor vehicles	13.58	-0.20	13.37	25.90	-0.43	18.38	42.05
9.Transport equipment	3.46	-0.10	3.37	6.23	-0.23	0.44	6.34
10.Electronics	4.38	0.00	4.40	7.99	-0.01	0.66	8.48
11.Other machinery	-0.40	-0.01	-0.40	-0.73	-0.05	1.59	1.42
12.Other manufactures	1.07	-0.26	0.82	1.96	-0.51	0.35	1.88
13.Construction	-0.65	-0.11	-0.76	-1.13	-0.26	-0.73	-1.77
14.Water Transport	0.09	-0.18	-0.09	0.22	-0.45	-1.31	-1.01
15.Air Transport	-1.16	1.15	0.15	-2.20	7.27	-1.31	4.26
16.Communications	-0.74	-0.21	-0.95	-1.34	-0.49	-0.81	-2.31
17.Finance	-1.09	-0.30	-1.39	-2.12	-0.65	-0.95	-3.34
18.Insurance	-0.88	-0.21	-1.07	-1.58	-0.07	-0.56	-1.90
19.Business services	-0.86	1.31	0.44	-1.54	2.36	-0.92	0.27
20.Personal services	-0.84	-0.51	-1.35	-1.54	-1.03	-0.51	-2.88
21.Other services	-0.82	-0.38	-1.21	-1.48	-0.79	-0.57	-2.59
All manufactures	3.01	-0.16	2.84	5.25	-0.37	3.33	6.92
All services	-0.86	0.86	0.00	-1.55	1.73	-0.87	-0.33
Total	1.56	0.22	1.77	2.69	0.42	1.75	4.19
	Provision of MNEs in services						
14.Water Transport	0.11	-0.03	0.07	0.20	-0.07	-0.09	0.07
15.Air Transport	-0.06	-1.69	-1.89	-0.11	-8.20	-0.03	-8.35
16.Communications	-0.15	-0.26	-0.42	-0.31	-0.54	0.01	-0.85
17.Finance	-0.12	-0.26	-0.38	-0.25	-0.53	-0.04	-0.80
18.Insurance	-0.03	-0.34	-0.38	-0.05	-1.01	0.01	-1.14
19.Business services	-0.05	-1.36	-1.40	-0.09	-2.57	-0.01	-2.65

Source: Authors' estimations.

Table 8. Impact on number of firms and variety effects in services sectors (% changes with respect to the initial data)

	Soft Brexit			Hard Brexit			
	NTBs	FDI	Total	NTBs	FDI	Tariffs	Total
	Number of domestic firms						
14.Water Transport	-0.54	-0.02	-0.55	-1.19	-0.06	-0.60	-1.67
15.Air Transport	-0.81	0.47	-0.25	-1.72	2.83	-1.00	0.54
16.Communications	-0.19	-0.12	-0.31	-0.41	-0.28	-0.06	-0.78
17.Finance	-1.39	-0.25	-1.64	-2.95	-0.55	-0.35	-3.78
18.Insurance	-0.20	-0.33	-0.52	-0.43	-0.40	0.11	-0.75
19.Business services	-0.58	0.89	0.31	-1.18	1.64	-0.20	0.35
	Number of REU MNEs supplying in UK						
14.Water Transport	0.28	-0.16	0.11	0.50	-0.37	-0.45	-0.17
15.Air Transport	-0.57	-19.32	-21.51	-1.10	-93.78	-0.29	-95.36
16.Communications	-0.79	-1.25	-2.04	-1.60	-2.54	0.07	-4.13
17.Finance	-1.33	-4.61	-5.97	-2.71	-9.32	-0.08	-12.13
18.Insurance	-1.17	-19.88	-21.73	-2.34	-60.04	0.39	-66.70
19.Business services	-0.86	-22.02	-22.79	-1.72	-41.46	-0.02	-42.84
	Number of British MNEs supplying in REU						
14.Water Transport	-0.36	-7.81	-8.17	-0.71	-15.75	-0.10	-16.60
15.Air Transport	-0.38	-53.60	-55.09	-0.73	-99.75	-0.29	-99.62
16.Communications	-0.61	-0.97	-1.58	-1.25	-1.95	-0.09	-3.25
17.Finance	-0.24	-0.87	-1.12	-0.50	-1.77	-0.02	-2.31
18.Insurance	-0.32	-6.94	-7.38	-0.66	-17.01	-0.05	-18.58
19.Business services	-0.54	-23.65	-24.20	-1.11	-47.20	-0.07	-48.42
	Variety impact: weighted number of firms in UK						
14.Water Transport	-0.10	-0.06	-0.16	-0.26	-0.15	-0.45	-0.73
15.Air Transport	-0.77	-2.79	-3.75	-1.61	-13.07	-0.87	-15.22
16.Communications	-0.29	-0.35	-0.64	-0.60	-0.75	-0.03	-1.41
17.Finance	-0.37	-0.37	-0.74	-0.76	-0.77	-0.11	-1.61
18.Insurance	-0.22	-0.69	-0.92	-0.47	-1.51	0.11	-1.98
19.Business services	-0.48	-0.94	-1.41	-0.96	-1.80	-0.15	-2.82

Source: Authors' estimations.

Table 9. Piecemeal Sensitivity Analysis: Impact of the hard brexit on UK and REU

Parameter	Parameter Value			Equivalent Variation as a % of Consumption						Equivalent Variation as a % of Consumption					
				UK			REU			UK			REU		
	Lower	Central	Upper	Lower	Central	Upper	Lower	Central	Upper	Lower	Central	Upper	Lower	Central	Upper
$\sigma(q_i, q_j)$ – services sectors	2.5	3	3.5	-3.62	-3.19	-2.98	-0.75	-0.63	-0.58	113.66	-3.19	93.44	118.56	-0.63	91.32
$\sigma(q_i, q_j)$ – goods sectors	2.85	3.8	4.75	-3.19	-3.19	-3.19	-0.63	-0.63	-0.63	100.00	-3.19	100.00	100.00	-0.63	100.00
σ(va, bs)	0.625	1.25	1.875	-2.83	-3.19	-3.66	-0.49	-0.63	-0.83	88.65	-3.19	114.70	76.98	-0.63	131.37
σ(D, M)	x 0.5	x 1	x 1.5	-3.14	-3.19	-3.24	-0.63	-0.63	-0.63	98.38	-3.19	101.52	99.67	-0.63	100.32
σ(M, M)	x 0.5	x 1	x 1.5	-3.29	-3.19	-3.13	-0.65	-0.63	-0.62	103.05	-3.19	98.32	102.88	-0.63	98.43
σ(L, K)	0.5	1	1.5	-3.19	-3.19	-3.19	-0.63	-0.63	-0.63	100.10	-3.19	99.97	100.51	-0.63	99.80
$\sigma(A_1,\ldots A_n)$	0	0	0.25	NA	-3.19	-3.24	NA	-0.63	-0.64	NA	-3.19	101.62	NA	-0.63	102.24
ε(fi)	x 0.5	x 1	x 1.5	-3.03	-3.19	-3.25	-0.58	-0.63	-0.72	95.15	-3.19	101.79	92.49	-0.63	113.64
θ_m	0.025	0.05	0.075	-3.15	-3.19	-3.23	-0.58	-0.63	-0.65	98.84	-3.19	101.18	92.49	-0.63	102.34
π	0.25	0.5	0.75	-3.58	-3.19	-3.10	-0.87	-0.63	-0.62	112.43	-3.19	97.28	138.23	-0.63	98.48
α	3.924	4.582	5.171	-3.21	-3.19	-3.16	-0.64	-0.63	-0.63	100.68	-3.19	99.20	100.78	-0.63	99.32

Key:

$\sigma(q_i, q_j)$: Elasticity of substitution between firm varieties in imperfectly competitive sectors

σ(va, bs): Elasticity of substitution between value-added and business services

σ(D, M): Elasticity of substitution between domestic goods and imports in CRTS sectors

σ(M, M): Elasticity of substitution between imports from different regions in CRTS sectors

σ(L, K): Elasticity of substitution between primary factors of production in value added

$\sigma(A_1,\ldots A_n)$: Elasticity of substitution in intermediate production between composite Armington aggregate goods

ε(fi): Elasticities of imperfectly competitive firms' supply with respect to the price of their outputs

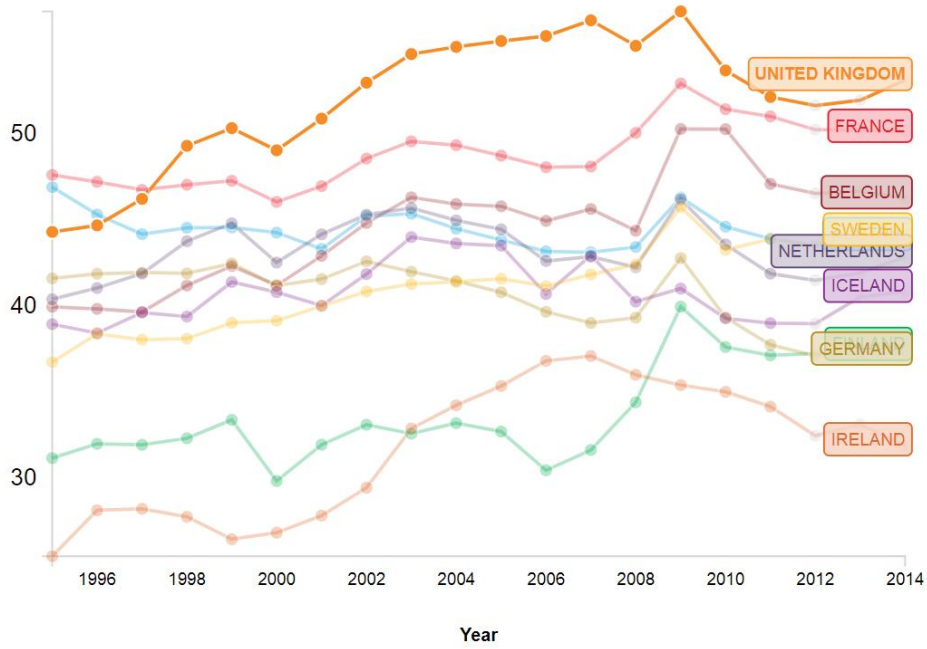
θ_m: Shares of value added in multinational firms due to specialized primary factor imports

π: Share of capital renumeration of multinatinal firms

α: Shape parameter for the Pareto distribution (Melitz). Note that the assumed values here are estimated by Balistreri et al. (2011).

Source: Authors' estimations.

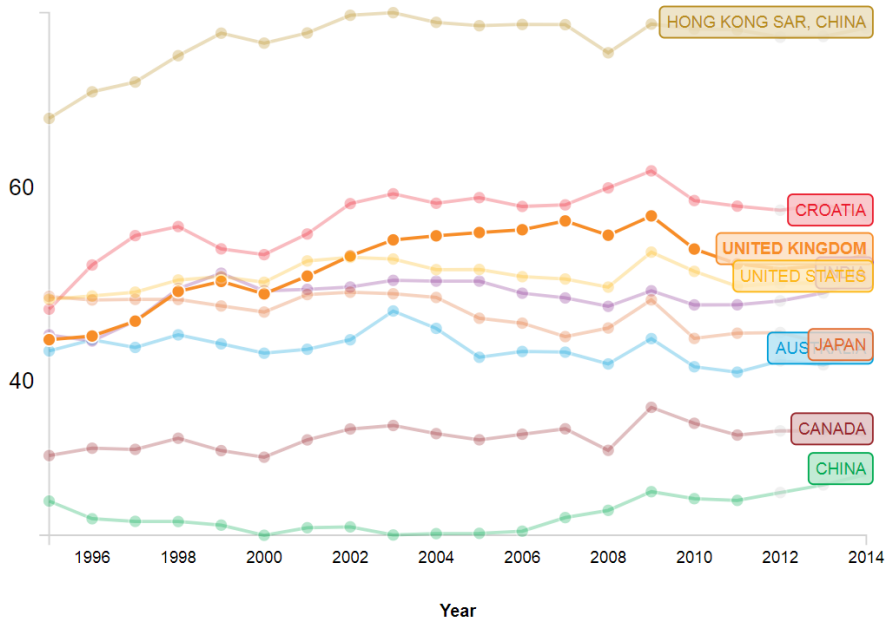
Figure 1. Domestic services value added share in gross exports (in percent for selected European countries)



Source: OECD (2018).

Figure 2.

Domestic services value added share in gross exports (in percent for the countries with the highest values worldwide)



Source: OECD (2018).

Appendix 1A. Mapping of model sectors to Nace Rev 2, Isic Rev 3.1 and GTAP classifications

Sectors	Nace Rev 2	Isic Rev 3.1	GTAP
1.Agriculture	A Agriculture, forestry and fishery products	ISIC 01-05	1-14
2.Other primary	B Mining and quarrying	ISIC 10-14	15-18
3.Food	C10 Manufacture of food products	ISIC 15-16	19-26
	C11 Manufacture of beverages		
	C12 Manufacture of tobacco products		
4.Textiles	C13 Manufacture of textiles		27-29
	C14 Manufacture of wearing apparel		
	C15 Manufacture of leather and related products		
5.Wood and paper	C16 Manufacture of wood and of products of wood, cork, straw and plaiting materials	ISIC 20-22	31-31
	C17 Manufacture of paper and paper products		
	C18 Printing and reproduction of recorded media		
6.Chemicals	C19 Manufacture of coke and refined petroleum products	ISIC 24-25	32,33
	C20 Manufacture of chemicals and chemical products		
	C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations		
	C22 Manufacture of rubber and plastic products		
12.Other manufactures	C23 Manufacture of other non-metallic mineral products	ISIC 23, 26	34,39,42
7.Metals	C24 Manufacture of basic metals	ISIC 27-28	35,36,37
	C25 Manufacture of fabricated metal products, except machinery and equipment		
10.Electronics	C26 Manufacture of computer, electronic and optical products	ISIC 30, 32	40
	C27 Manufacture of electrical equipment		
11.Other machinery	C28 Manufacture of machinery and equipment n.e.c.	ISIC 29, 31, 33	41
8. Motor vehicles	C29 Manufacture of motor vehicles, trailers and semi-trailers	ISIC 34	38
9.Other transport	C30 Manufacture of other transport equipment	ISIC 35	39
12.Other manufactures	C31 Manufacture of furniture	ISIC 23, 26	34,39,42
	C32 Other manufacturing		
11.Other machinery	C33 Repair and installation of machinery and equipment	ISIC 29, 31, 33	41
21.Other services	D Electricity, gas, steam and air conditioning supply	ISIC 40,41,50,51,52,63,75,80,85,90	43,44,45,47 48,56,57
	D35 Electricity, gas, steam and air conditioning supply		
	E Water supply; sewerage, waste management and remediation activities		
	E36 Water collection, treatment and supply		
	E37 Sewerage		
	E38 Waste collection, treatment and disposal activities; materials recovery		
	E39 Remediation activities and other waste management services		
13.Construction	F Construction	ISIC 45	46
	F41 Construction of buildings		
	F42 Civil engineering		
	F43 Specialised construction activities		
21.Other services	G Wholesale and retail trade; repair of motor vehicles and motorcycles	ISIC 40,41,50,51,52,63,75,80,85,90	43,44,45,47 48,56,57
	G45 Wholesale and retail trade and repair of motor vehicles and motorcycles		
	G454 Sale, maintenance and repair of motorcycles and related parts and accessories		
	G47 Retail trade, except of motor vehicles and motorcycles		
	H49 Land transport and transport via pipelines		
14.Water Transport	H50 Water transport	ISIC 61	49
15.Air Transport	H51 Air transport	ISIC 62	50
21.Other services	H52 Warehousing and support activities for transportation	ISIC 40,41,50,51,52,63,75,80,85,90	43,44,45,47 48,56,57
16.Communications	H53 Postal and courier activities	ISIC 70-74	51
21.Other services	I55 Accommodation	ISIC 40,41,50,51,52,63,75,80,85,90	43,44,45,47
	I56 Food and beverage service activities	ISIC 40,41,50,51,52,63,75,80,85,90	48,56,57
19.Business services	J582 Software publishing	ISIC 91-93	54
20.Personal services	J59 Motion picture, video and television programme production, sound recording	ISIC 91-93	55
	J60 Programming and broadcasting activities		
16.Communications	J61 Telecommunications	ISIC 70-74	51
19.Business services	J62 Computer programming, consultancy and related activities	ISIC 91-93	54
	J63 Information service activities		
17.Finance	K64 Financial service activities, except insurance and pension funding	ISIC 65,67	52
18.Insurance	K65 Insurance, reinsurance and pension funding, except compulsory social security	ISIC 66	53
17.Finance	K66 Activities auxiliary to financial services and insurance activities	ISIC 65,67	52
19.Business services	L68 Real estate activities	ISIC 91-93	54
	M69 Legal and accounting activities		
	M70 Activities of head offices; management consultancy activities		
	M71 Architectural and engineering activities; technical testing and analysis		
	M72 Scientific research and development		
	M73 Advertising and market research		
	M74 Other professional, scientific and technical activities		
	M75 Veterinary activities		
	N77 Rental and leasing activities		
	N78 Employment activities		
21.Other services	N79 Travel agency, tour operator reservation service and related activities	ISIC 40,41,50,51,52,63,75,80,85,90	43,44,45,47 48,56,57
19.Business services	N80 Security and investigation activities	ISIC 91-93	54
	N81 Services to buildings and landscape activities		
	N82 Office administrative, office support and other business support activities		
21.Other services	O - Public administration and defence; compulsory social security	ISIC 40,41,50,51,52,63,75,80,85,90	43,44,45,47 48,56,57
	P - Education		
	Q - Human health and social work activities		
20.Personal services	R - Arts, entertainment and recreation	ISIC 91-93	55
	S - Other services activities		
	S95 Repair of computers and personal and household goods		
	T - Activities of households as employers; undifferentiated goods and services		

Appendix 2A. Mapping of model regions.

Latin America and the Caribbean	Middle East, North Africa, Afghanistan and Pakistan	Sub-Saharan Africa	Emerging and Developing Asia	Other advanced countries
(Latin America, LAC)	**(Middle-East, MEN)**	**(Sub-Saharan A., SSA)**	**(Southeast Asia, SEA)**	**OAC**
Antigua and Barbuda	Afghanistan	Angola	Bangladesh	Hong Kong SAR
Argentina	Algeria	Benin	Bhutan	Iceland
The Bahamas	Armenia	Botswana	Brunei Darussalam	Israel
Barbados	Azerbaijan	Burkina Faso	Cambodia	Korea
Belize	Bahrain	Burundi	Fiji	New Zealand
Bolivia	Belarus	Cameroon	Indonesia	Norway
Brazil	Djibouti	Cabo Verde	Kiribati	Singapore
Chile	Egypt	Central African Republic	Lao P.D.R.	San Marino
Colombia	Georgia	Chad	Malaysia	Switzerland
Costa Rica	Iran	Comoros	Maldives	Taiwan Province of China
Dominica	Iraq	Dem. Rep. of the Congo	Marshall Islands	
Dominican Republic	Jordan	Republic of Congo	Micronesia	
Ecuador	Kazakhstan	Côte d'Ivoire	Mongolia	
El Salvador	Kyrgyzstan	Equatorial Guinea	Myanmar	
Grenada	Kuwait	Eritrea	Nepal	
Guatemala	Lebanon	Ethiopia	Palau	
Guyana	Libya	Gabon	Papua New Guinea	
Haiti	Mauritania	The Gambia	Philippines	
Honduras	Morocco	Ghana	Samoa	
Jamaica	Oman	Guinea	Solomon Islands	
Mexico	Pakistan	Guinea-Bissau	Sri Lanka	
Nicaragua	Qatar	Kenya	Thailand	
Panama	Russia	Lesotho	Timor-Leste	
Paraguay	Rest of Eastern Europe	Liberia	Tonga	
Peru	Rest of Former Soviet Union	Madagascar	Tuvalu	
St. Kitts and Nevis	Saudi Arabia	Malawi	Vanuatu	
St. Lucia	Sudan[1]	Mali	Vietnam	
St.Vincent & the Grenadines	Syria[2]	Mauritius		
Suriname	Tunisia	Mozambique		
Trinidad and Tobago	Turkey	Namibia		
Uruguay	Ukraine	Niger		
Venezuela	United Arab Emirates	Nigeria		
	Yemen	Rwanda		
		São Tomé and Príncipe		
		Senegal		
		Seychelles		
		Sierra Leone		
		South Africa		
		South Sudan		
		Swaziland		
		Tanzania		
		Togo		
		Uganda		
		Zambia		
		Zimbabwe		

Note: the classification follows the one of the IMF *World Economic Outlook*.

Online Appendix: The Algebraic Description of the Model

This document presents the algebraic formulation of a computable general equilibrium (CGE) model of the global economy, which is a numerical simulation model. This model has the similar structure to the models in Balistreri et al. (2014) and Balistreri and Tarr (2011). The model is what is called a mixed complementarity system in mathematics (for an explanation see the technical Appendices in Markusen (2002)). This model description is based on the Appendix F in Balistreri and Tarr (2011); however, the important distinctions include:

(i) this model is a multi-region model, whereas the model in Balistreri and Tarr (2011) is a single country model;

(ii) it incorporates both Krugman (1980) and Melitz (2003) model structures for Increasing Returns To Scale (IRTS) production following Balistreri and Rutherford (2013) and Olekseyuk and Balistreri (2017).

The model includes n commodities (goods and services), which are purchased by households, firms, and the government. Let the commodities be indexed by $g \in G$. Divide these commodities into the following three categories that define their treatment in the model formulation:

(a.) Business Services including foreign direct investment (FDI), characterized by monopolistic competition under Krugman structure, indexed by $i \in I \subset G$;

(b.) IRTS manufacturing sectors, characterized by monopolistic competition under Melitz structure, indexed by $j \in J \subset G$;

(c.) Constant Returns To Scale (CRTS) goods indexed by $k \in K \subset G$.

Commodities are also classified by their associated region, indexed by $r \in R$ where O indicates own region. The accounts track the incomes of the representative household in each region decomposed by the primary mobile factors of production as well as sector-specific inputs for the monopolistic competition sectors and business service sectors with FDI.

Table 1 summarizes the equilibrium conditions and associated variables, and Tables 2 and 3 summarizes the parameters. To reduce the notation burden, we consider the perspective from one country so that we can suppress the index of own region r in Table 1 and the following equations, although the model is a multi-region model. The non-linear system is formulated in GAMS/MPSGE and solved using the PATH algorithm. We proceed with a description and algebraic representation of each of the conditions itemized in Table 1.

Table 1: General equilibrium conditions

Equilibrium Conditions	**(Equation)**		**Associated Variables**
Dual representation of preferences and technologies:			
Armington-like unit-cost functions	(1)	$\forall i \in I$	A^g : Armington-like activity
	(2)	$\forall j \in J$	
	(3)	$\forall k \in K$	
Dixit-Stiglitz price indexes (Krugman)	(4)	$\forall i \in I$	Q_r^i : D-S Activity by region
Zero profits for Dixit-Stiglitz firms (Krugman)	(5)	$\forall i \in I$	N_r^i : Number of firms
Dixit-Stiglitz price indexes for FDI firms	(6)	$\forall i \in I$	Q_r^{FDI} : D-S FDI Activity by region
Zero Profits for Dixit-Stiglitz FDI firms	(7)	$\forall i \in I$	N_r^{FDI} : Number of FDI firms
Dixit-Stiglitz price indexes (Melitz)	(8)	$\forall j \in J$	Q_r^j : D-S Activity by region
Zero cutoff profits for Melitz firms	(9)	$\forall j \in J$	N_{rm}^j : Number of operating firms
Expected zero profits for Dixit-Stiglitz firms (Melitz)	(10)	$\forall j \in J$	M_r^j : Number of entered firms
Firm-level productivity for average firm (Melitz)	(11)	$\forall j \in J$	$\tilde{\varphi}_{rm}^j$: Productivity
Price including sector-specific capital	(12)	$\forall g \in (I \cup J)$ and $r = O$	$Z_r^j(Q_r^i)$: Sector-specific capital use
	(13)	$\forall g \in (I \cup J)$ and $r \neq O$	
	(14)	$\forall i \in I$ and $r \neq O$	Q_r^{FDI} : Sector-specific capital use for FDI
Input-output technologies for non primary energy	(18)	$\forall g \in G$ but $g = ene$	Y^g: Production level
Input-output technologies for primary energy	(20)		Y^{ene}: Production level
Unit expenditure function	(21)		U: Household utility index
Unit cost of public purchase	(22)		PUB: Government activity
Unit cost of investment	(23)		INV: Investment activity
Market clearance conditions:			
Composite goods and services	(24)	$\forall g \in G$	PA^g : Composite price indexes
D-S composites	(26)	$\forall j \in J$ and $r \neq O$	P_r^g: Prices of D-S composites
	(27)	$\forall j \in J$ and $r = O$	
Markets for IRTS composite input (Krugman)	(28)	$\forall j \in J$	PMC^j: Composite input prices
Markets for IRTS composite input (Melitz)	(29)	$\forall j \in J$	PMC^j: Composite input prices
Markets for output	(30)	$\forall k \in K$	PY^g: Output prices
	(31)	$\forall i \in I$	
	(34)	$\forall j \in J$	
Markets for imports	(35)	$\forall i \in I$ and $r \neq O$	PM_r^g: Import prices
	(36)	$\forall j \in J$ and $r \neq O$	
	(37)	$\forall k \in K$ and $r \neq O$	
Factor markets	(38)	$\forall f \in F$	PF_f: Factor prices
Specific factors	(39)	$\forall g \in (I \cup J)$	PZ_r^g: Sector-specific capital price
Fixed real investment	(40)		$PINV$: Unit cost of investment
Fixed real public spending	(41)		PG: Unit cost of public good
Nominal utility equals Income	(42)		PC: Unit expenditure index
Balance of payments	(43)		PFX: Price of foreign exchange
Income balance:			
Domestic agent income	(44)		RA_h: Household Income
Government budget	(45)		$GOVT$: Government spending
Foreign Entrepreneur	(46)		FE: External agent income
Auxiliary Conditions:			
Fixed real public spending	(47)		T: Index on direct taxes

Table 2: Model parameters

Symbol	Description
Elasticity of substitution parameters	
σ_{va}	Value added composite
σ_{vas}	Value added vs. business services composite
σ_{srv}	Business services composite
ϵ_r^g	Elasticity of substitution between sector specific capital and others
σ_F^i	Dixit-Stiglitz elasticity of substitution on business services
σ_F^j	Dixit-Stiglitz elasticity of substitution on IRTS goods
σ_{DM}^k	Armington elasticity of substitution on CRTS goods (Domestic vs. foreign)
σ_{MM}^k	Armington elasticity of substitution on CRTS goods (among foreign)
Other parameters	
$\overline{sav}$	Reference saving
$\overline{pub}$	Reference level of government spending
$\overline{dtax}$	Reference level of direct tax from household to government
$\overline{ftrn}$	Reference capital account surplus
ϕ_r^i	Share of Dixit-Stiglitz component in Armington-like activity of business services i
ϕ_r^{FDI}	Share of FDI component in Armington-like activity of business services i
ϕ_r^j	Share of Dixit-Stiglitz component in Armington-like activity of manufacturing sectors j
ϕ_r^k	Share of domestic or import component in Armington activity of CRTS goods k
θ_{Zr}^g	Share of specific capital component in marginal cost
θ_{rr}^g	Share of all other components in marginal cost
θ_{VAS}	Share of value-added/business service cost in marginal cost without sector specific capital
θ_g	Share of non-business service commodity in marginal cost without sector specific capital
θ^{VAB}	Share of value-added cost in value-added/business-services cost bundle
θ_f	Share of each factor cost in value added cost bundle
θ_i	Share of each intermediate business service cost in aggregate business service cost bundle
μ_C^g	Expenditure share commodity g in private consumption
μ_G^g	Expenditure share commodity g in public consumption
μ_{INV}^g	Expenditure share commodity g in investment consumption
a	Shape parameter of the Pareto distribution for Melitz structure
b	Minimum productivity determined by the Pareto distribution

Table 3: Parameter values for elasticities

Parameter	Description	Value
σ_{va}	Value-added bundle	1
σ_{vas}	Value-added vs. business services	1.25
σ_{srv}	Business services bundle	1.25
ϵ_r^g	Sector specific capital vs. others	See notes.
σ_F^i	Dixit-Stiglitz elasticity on business services	3
σ_F^j	Dixit-Stiglitz elasticity on IRTS goods	3.8
σ_{DM}^k	Armington elasticity (Domestic vs. foreign)	GTAP values
σ_{MM}^k	Armington elasticity (among foreign)	GTAP values
s_{ene}	Price elasticity of primary energy production	1

Notes: This elasticity is calibrated, instead of being chosen explicitly, to the supply elasticities based on the estimates of Schiff (2006). Also, the Dixit-Sitiglitz elasticity for IRTS goods is based on the plant-level empirical analysis by Bernard et al. (2003). For Armington elasticities see Hummels (2001) and Hertel et al. (2007).

1 Dual representation of technologies and preferences

Technologies and preferences are represented through value functions that embed the optimizing behavior of agents. Any linearly-homogeneous transformation of inputs into outputs is fully characterized by a unit-cost (or expenditure) function. Generally, setting the output price equal to optimized unit cost yields the equilibrium condition for the activity level of the transformation. That is, a competitive constant-returns activity will increase up to the point that marginal benefit (unit revenue) equals marginal cost. In the case of this model not all transformations are constant returns, so there are exceptions. In general, however, we will use the convention of setting unit revenues (left-hand side) equal to unit cost (right-hand side) and associating this equilibrium condition with a transformation activity level.

Agents in each region wishing to purchase a particular good or service g face an aggregate price PA^g. In constructing the aggregate prices, we will rely on the following notation for the component prices:

PY^k Price of output for CRTS sectors,

PM^k Price of import composite of CRTS goods,

P_r^g Dixit-Stiglitz price index on region-r varieties for IRTS sectors ($\forall g \in (I \cup J)$),

P_r^{FDI} Dixit-Stiglitz price index on region-r varieties for FDI firms ($r \neq O$).

Assuming a Constant Elasticity of Substitution (CES) aggregation of the components we equate the prices to the CES unit-cost functions:

$$PA^i = \left(\sum_r \phi_r^i (P_r^i)^{1-\sigma_F^i} + \sum_{r \neq O} \phi_r^{FDI} (P_r^{FDI})^{1-\sigma_F^i} \right)^{1/(1-\sigma_F^i)} \quad (1)$$

$$PA^j = \left(\sum_r \phi_r^j (P_r^j)^{1-\sigma_F^j} \right)^{1/(1-\sigma_F^j)} \quad (2)$$

$$PA^k = \left(\phi_D^k (PY^k)^{1-\sigma_{DM}^k} + \phi_M^k (PM^k)^{1-\sigma_{DM}^k} \right)^{1/(1-\sigma_{DM}^k)}, \quad (3)$$

where σ_F^i and σ_F^j are the Dixit-Stiglitz elasticity of substitution, σ_{DM}^k is the Armington elasticity of substitution on CRTS goods, and PM^k is the composite of imports from all other countries by using the Armington elasticities σ_{MM}^k. Thus, Armington trade is considered for CRTS goods, whereas trade with monopolistic competition (proposed by Krugman (1980)) and with endogenous entry (as extension to Krugman (1980)) is considered for business service sectors. The arguments of these functions are the component prices. The ϕ parameters are CES distribution parameters that indicate scale and weighting of the arguments. These are calibrated to the social accounts such that the accounts are replicated in the benchmark equilibrium.

For the business service sectors, we have the Dixit-Stiglitz price indexes following the Krugman structure. These are functions of the number of varieties, firm-level costs, and the optimal markup. Assuming each firm is small relative to the size of the market the demand elasticity for a firm's variety is σ_F^i and the optimal markup over marginal cost is given by $1/(1-\frac{1}{\sigma_F^i})$. Let marginal cost equal PMC_r^i, which is the price of a composite input to the Dixit-Stiglitz firms associated with region-r, and let the number of varieties by region equal N_r^i. The price indexes for the Dixit-Stiglitz goods are thus given by

$$P_r^i = \left[N_r^i \left(\frac{PMC_r^i}{1-\frac{1}{\sigma_F^i}} \right)^{1-\sigma_F^i} \right]^{1/(1-\sigma_F^i)}. \tag{4}$$

In equilibrium, the number of varieties by region adjusts such that we have zero profits. Denote the Dixit-Stiglitz composite activity level associated with equation (4) by Q_r^i. Given the Dixit-Stiglitz aggregation of varieties each firm produces a quantity $Q_r^i (N_r^i)^{\sigma_F^i/(1-\sigma_F^i)}$. Following the literature (e.g., Krugman (1980) and Helpman and Krugman (1985)), we assume a firm-level fixed cost of f_r^i (in composite input units) and also assume that fixed and variable costs are satisfied using the same input technology. Then, we have the zero profit condition

$$f_r^i - \frac{Q_r^i (N_r^i)^{\sigma_F^i/(1-\sigma_F^i)}}{\sigma_F^i - 1} = 0. \tag{5}$$

This same structure is assumed for FDI firms. The price indexes for the Dixit-Stiglitz FDI goods are given by

$$P_r^{FDI} = \left[N_r^{FDI} \left(\frac{PFDI_r}{1-\frac{1}{\sigma_F^i}} \right)^{1-\sigma_F^i} \right]^{1/(1-\sigma_F^i)}. \tag{6}$$

The zero profit condition is following:

$$f_r^{FDI} - \frac{Q_r^{FDI} (N_r^{FDI})^{\sigma_F^i/(1-\sigma_F^i)}}{\sigma_F^i - 1} = 0. \tag{7}$$

Regarding the IRTS manufacturing sectors, we adopt the competitive selection model of heterogeneous firms consistent with Melitz (2003) for the IRTS goods j. We modify the Krugman equations (4) and (5) with the equations (8) and (9) and include further equations (10) and (11) which determine firm's selection to different bilateral markets. To account for firm operation on

a particular bilateral link, we now have to add another country index $m \in R$ which identifies the destination (or importing) country. As firms are heterogeneous in this setup and have market power over their unique varieties, there is a continuum of firm-level prices, quantities and productivities. Following the initial Melitz representation, we simplify this by using a representative (or average) firm with the CES weighted average productivity $\tilde{\varphi}^j_{rm}$. Considering this we get a Dixit-Stiglitz price index for a composite commodity j in region m similar to the Krugman specification:

$$P^j_m = \left[\sum_r N^j_{rm} \left(\frac{PMC^j_r}{\tilde{\varphi}^j_{rm}(1 - \frac{1}{\sigma^j_F})} \right)^{1-\sigma^j_F} \right]^{1/(1-\sigma^j_F)}, \tag{8}$$

where N^j_{rm} is the number of firms operating on the r to m link.

Let M^j_r denote the number of entered firms in region r. Each of the entered firms pays the fixed entry cost f^s_{jr} and receives a firm-specific productivity draw φ from a Pareto distribution. Taking the fixed cost of operation on the r to m link (f^j_{rm}) into account, there will be a marginal firm with a level of productivity such that operating profits are zero. Linking this marginal firm in a given bilateral market to a representative firm earning positive profits, we can specify a zero-cutoff-profit condition in terms of average firm revenues:

$$f^j_{rm} - \frac{Q^j_r (N^j_{rm})^{\sigma^j_F/(1-\sigma^j_F)}}{\tilde{\varphi}^j_{rm}(1 - 1/\sigma^j_F)} \cdot \frac{(a + 1 - \sigma^j_F)}{a\sigma^j_F} = 0, \tag{9}$$

where a is the shape parameter of the Pareto distribution.[1] This condition is associated with the number of operating firms (N^j_{rm}) meaning that the average-firm revenues fall with more firms shipping from r to m.

The free entry condition or expected zero profits are given by the difference of the firm-level annualized flow of entry payments δf^s_{jr} and the expected profits from each potential market:

$$\delta f^s_{jr} - \sum_s \frac{Q^j_r (N^j_{rm})^{\sigma^j_F/(1-\sigma^j_F)}}{a\tilde{\varphi}^j_{rm}} \cdot \frac{N^j_{rm}}{M^j_r} = 0, \tag{10}$$

where δ denotes a probability of a negative shock that forces exit in each future period and N^j_{rm}/M^j_r indicates the probability that a firm from M^j_r will operate in the market m. Given the last one and applying the Pareto distribution we get the productivity of the average firm:

$$\tilde{\varphi}^j_{rm} = b \left(\frac{a}{a + 1 - \sigma^j_F} \right)^{\frac{1}{\sigma^j_F - 1}} \left(\frac{N^j_{rm}}{M^j_r} \right)^{-\frac{1}{a}}, \tag{11}$$

where b is the minimum productivity determined by the Pareto distribution.

The technologies for producing the composite inputs for use in the Dixit-Stiglitz sectors

[1] We assume a value for the Pareto shape parameter of 4.582, which is the central value estimated by Balistreri et al. (2011).

depend on the type of sector. For the IRTS manufacturing sectors and business service sectors (including FDI) there is a sector-specific capital input from the respective source region. Let $PZ_r^g \ \forall g \in (I \cup J)$ be the price of this sector-specific capital input. Domestic firms (producing goods or services) use domestic inputs, so the unit cost function is given by

$$PMC_r^g = \left[\theta_{Zr}^g (PZ_r^g)^{1-\epsilon_r^g} + \theta_{Dr}^g (PY^g)^{1-\epsilon_r^g}\right]^{1/(1-\epsilon_r^g)}, \quad \text{for} \quad r = O \ and \ \forall g \in (I \cup J) \quad (12)$$

where ϵ_r^g is the elasticity of substitution between the sector-specific capital input and other inputs, and the θ's are the CES distribution parameters. Imports of these sectors embody the gross of tariff imported inputs:

$$PMC_r^g = \left[\theta_{Zr}^g (PZ_r^g)^{1-\epsilon_r^g} + \theta_{Mr}^g (PM_r^g)^{1-\epsilon_r^g}\right]^{1/(1-\epsilon_r^g)}, \quad \text{for} \quad r \neq O \ and \ \forall g \in (I \cup J). \quad (13)$$

FDI firms, on the other hand, use domestic inputs as well as a specialized imported service from the sources region. The price of the specialized imports equals the price of foreign exchange (denoted PFX). The unit cost for FDI firms ($PFDI$) is thus given by the following:

$$PFDI_r = \left[\theta_{Zr}^i (PZ_r^i)^{1-\epsilon_r^i} + (\theta_{Dr}^i PY^i + \theta_{Mr}^i PFX)^{1-\epsilon_r^i}\right]^{1/(1-\epsilon_r^i)}, \quad \text{for} \quad r \neq O. \quad (14)$$

Note that the price of domestic inputs used for FDI firms (PY) is inclusive of the iceberg trade cost. In the counterfactual simulations, we reduce the iceberg trade cost component. Also, import tariff (t_{gr}^{imp}) and export tax (t_g^{exp}) create the wedge between the import price and foreign output price or between the domestic output price and import price of foreign countries.

For the CRTS sectors and upstream of the other technologies, we have domestic production in accordance with the input output data. Denote the price of this output PY^s, for $s \in G$. The technology includes an upstream CES value-added nest which then combines business services and ultimately then this composite combines with other intermediates in fixed proportions. Let PF_f indicate the price of primary factor of production $f \in F$ and let P_s^{vas} be the value-added business-services composite price for sector s. The composite of business services and value added, P_s^{vas}, is the CES aggregate of two CES aggregates (P_s^{srv} and P_s^{va}) as follows:

$$P_s^{vas} = \left[(1-\theta^{VAB})(P_s^{srv})^{1-\sigma_{vas}} + \theta^{VAB}(P_s^{va})^{1-\sigma_{vas}}\right]^{1/(1-\sigma_{vas})}, \quad (15)$$

$$P_s^{srv} = \left(\sum_i \theta_i^s [(1+t_{is}^{int})PA_i]^{1-\sigma_{srv}}\right)^{1/(1-\sigma_{srv})}, \quad (16)$$

$$P_s^{va} = \left(\sum_f \theta_f^s [(1+t_{fs})PF_f]^{1-\sigma_{va}}\right)^{1/(1-\sigma_{va})}, \quad (17)$$

where t_{gs}^{int} is the tax in sector s on purchases of good g and t_{fs} is the factor tax. The substitution elasticity between value added and the business services composite is given by σ_{vas}, whereas the substitution between business services and between factors are given by σ_{srv} and σ_{va}. With

P_s^{vas} established, the top-level Leontief unit cost function for sector s is given by

$$PY^s = \theta_{vas}^s P_s^{vas} + \sum_{g \neq I} \theta_g^s (1 + t_{gs}^{int}) PA^g, \tag{18}$$

where the θ is share parameters determined in the calibration to the input-output accounts.

Regarding the primary energy production sector, it includes the resource factor that is sector-specific, and thus this sector is subject to decreasing returns to scale. We calibrate the elasticity of substitution betweeen the resource factor and the rest of inputs to match the given price elasticities of supply, denoted s_{ene}. As Rutherford (2002) shows, the calibrated substution elasticitiy σ_{ene} is given by

$$\sigma_{ene} = s_{ene} \frac{\theta_{res}}{1 - \theta_{res}}, \tag{19}$$

where θ_{res} is the value share of resource factor input. Then, instead of equation (18), the top-level unit cost function of the primary energy production sector becomes

$$PY^{ene} = \left[\theta^{res} (PF_{res})^{1-\sigma_{ene}} + (1 - \theta^{res}) (\theta_{vas}^s P_s^{vas} + \sum_{g \neq I} \theta_g^s (1 + t_{gs}^{int}) PA^g)^{1-\sigma_{ene}} \right]^{1/(1-\sigma_{ene})}. \tag{20}$$

Final demand includes three categories: household demand, government demand, and investment. The representative agents for each household h are assumed to have identical Cobb-Douglas preferences over the aggregated goods and services. The preferences are specified via a unit expenditure function associated with an economy-wide utility index (U). Let PC be the true-cost-of-living index indicated by the following unit expenditure function:

$$PC = \prod_g [(1 + t_g^{cons}) PA^g]^{\mu_C^g}, \tag{21}$$

where the μ are value shares. The government faces a Leontief price index, PG, for government purchases:

$$PG = \sum_g \mu_G^g (1 + t_g^{gov}) PA^g. \tag{22}$$

Similarly the price of investment, $PINV$ is a Leontief aggregation of commodity purchases:

$$PINV = \sum_g \mu_{INV}^g (1 + t_g^{inv}) PA^g. \tag{23}$$

Equations (1) through (23) define all of the transformation technologies for the model. Next we turn to a specification of the market clearance conditions for each price.

2 Market clearance conditions

For each good or service there is a market, and, for any non-zero equilibrium price, supply will equal demand. We will use the convention of equating supply, on the left-hand side, to demand, on the right-hand side. The unit-value functions presented above are quite useful in deriving the appropriate compensated demand functions, by the envelope theorem (Shephard's Lemma).

Supply of the composite goods and services, trading at PA^g, is given by the activity level, A^g, and demand is derived from each production or final demand activity that uses the good or service. The market clearance condition is given by

$$A^g = \sum_s h_{gs}(Y^s, \boldsymbol{p}) + \mu_C^g U \frac{PC}{(1+t_g^{cons})PA^g} + \mu_G^g PUB + \mu_{INV}^g INV, \tag{24}$$

where $h_{gs}(Y^s, \boldsymbol{p})$ are the conditional input demands (as a function of output and the price vector). These are found by taking the partial derivative of the unit cost function for sector s with respect to the gross of tax price of input g. For inputs that are not business services input demands are proportional to output: $h_{gs}(Y^s, \boldsymbol{p}) = \theta_g^s Y^s \ \ \forall g \in (J \cup K)$. The input demands for business services are, however, more complex:

$$h_{is}(Y^s, \boldsymbol{p}) = \theta_i^s \theta_{vas}^s Y^s \left(\frac{P_s^{srv}}{(1+t_{is}^{int})PA_i} \right) \left(\frac{P_s^{vas}}{P_s^{srv}} \right)^{\sigma_{vas}} \tag{25}$$

where P_s^{srv} is the composite price of business services inputs as defined in equation (16).

For the IRTS sectors we have market clearance for the Dixit-Stiglitz regional composites:

$$Q_r^j = A^j \left(\frac{PA^j}{P_r^j} \right)^{\sigma_F^j} \quad r \neq O; \tag{26}$$

and for domestic firms we include demand for the Dixit-Stiglitz exports (or import demand of other countries)

$$Q_D^j = A^j \left(\frac{PA^j}{P_D^j} \right)^{\sigma_F^j} + \sum_r FORIM_r^j. \tag{27}$$

Since we consider the perspective from one country for reducing the notation burden in this document of model equations, here we simply call the foreign import demand as $FORIM_r^j$. The IRTS composite input (trading at PMC_r^j) is supplied by an activity, denoted Z_r^j, and is demanded by the firms:

$$Z_r^j = f_r^j N_r^j + Q_r^j (N_r^j)^{1/(1-\sigma_F^j)}. \tag{28}$$

To derive (28) recall that firm-level output is $Q_r^j (N_r^j)^{\sigma_F^j/(1-\sigma_F^j)}$ so the use of the input across all firms is $Q_r^j (N_r^j)^{1/(1-\sigma_F^j)}$ plus the total input use on fixed costs, $f_r^j N_r^j$.

Under the Melitz structure, demand includes three components: the use of inputs for fixed entry costs, $\delta f_{jr}^s M_r^j$; for operating fixed costs, $\sum_m f_{rm}^j N_{rm}^j$; as well as operating inputs, $\sum_m [Q_r^j (N_{rm}^j)^{1/(1-\sigma_F^j)}]/\tilde{\varphi}_{rm}^j$.

$$Z_r^j = \delta f_{jr}^s M_r^j + \sum_m f_{rm}^j N_{rm}^j + \sum_m \frac{Q_r^j (N_{rm}^j)^{1/(1-\sigma_F^j)}}{\tilde{\varphi}_{rm}^j}. \tag{29}$$

Market clearance for the output of CRTS sectors depends on supply (simply given as an

activity of production) and domestic and foreign demand from the Armington activity:

$$Y^k = \phi_D^k A^k \left(\frac{PA^k}{PY^k}\right)^{\sigma_{DM}^k} + \sum_r FORIM_r^k. \tag{30}$$

While the supply of business service sectors is simply the activity of production, the demand is either from the domestic or FDI firms (on top of the demand from foreign countries):

$$\begin{aligned} Y^i &= \theta_{DD}^i Q_O^i \left(\frac{PMC_O^i}{PY^i}\right)^{\epsilon_O^i} + \sum_{r \neq O} \theta_{Dr}^i Q_r^{FDI} \left(\frac{PFDI_r}{\theta_{Dr}^i PY^i + \theta_{Mr}^i PFX}\right)^{\epsilon_r^i} \\ &+ \sum_r FORIM_r^i, \end{aligned} \tag{31}$$

$$Q_r^i = A^i \left(\frac{PA^i}{PMC_r^i}\right)^{\sigma_F^i}, \tag{32}$$

$$Q_r^{FDI} = A^i \left(\frac{PA^i}{PFDI_O^i}\right)^{\sigma_F^j} \quad r \neq O. \tag{33}$$

For IRTS sectors, supply is simply given by the production activity. Output is then demanded by the domestic and foreign firms. The market clearance conditions are given by

$$Y^j = \theta_{DD}^j Z_D^j \left(\frac{PMC_D^j}{PY^j}\right)^{\epsilon_D^j} + \sum_r FORIM_r^j. \tag{34}$$

Import demand is derived from the Armington activities or embodied in the foreign Dixit-Stiglitz firm's inputs. For $r \neq O$, we have the following:

$$IM_r^i = \phi_r^i Q_r^i \left(\frac{PMC^i}{PM_r^i}\right)^{\sigma_F^i} \tag{35}$$

$$IM_r^j = \theta_{Mr}^j Z_r^j \left(\frac{PMC_r^j}{PM_r^j}\right)^{\epsilon_r^j} \tag{36}$$

$$IM_r^k = \phi_r^k A^k \left(\frac{PA^k}{PM_r^k}\right)^{\sigma_{DM}^k}. \tag{37}$$

Factor markets clear, where factor supply is given by the exogenous endowments to households, denoted $\overline{S}_f$, and input demands are derived from the cost functions:

$$\overline{S}_f = \sum_s \theta_f^s \theta_{vas}^s Y^s \left(\frac{P_s^{va}}{(1+t_{fs})PF_f}\right) \left(\frac{P_s^{vas}}{P_s^{va}}\right)^{\sigma_{vas}}, \tag{38}$$

where P_s^{va} is the composite value-added price as defined in equaiton (17). In addition, we have the market for the specific factor used in the IRTS sectors. Denoting the regional endowments of the specific factors $\overline{SF}_r^g \ \forall g \in (I \cup J)$, we have:

$$\overline{SF}_r^g = \theta_{Zr}^g (Z_r^j + Q_r^i) \left(\frac{PMC_r^g}{PZ_r^g} \right)^{\epsilon_r^g} \quad \forall g \in (I \cup J). \tag{39}$$

Real investment equals real savings by households:

$$INV = \overline{sav}. \tag{40}$$

Real government purchases equal the nominal government budget scaled by the government price index:

$$PUB = \frac{GOVT}{PG}. \tag{41}$$

Household utility (U) equals nominal income across households scaled by the true-cost-of-living index. That is, in each region we have an aggregate activity U, which supplies utility to the representative household of that region, and its nominal income is RA. The corresponding market clearance condition is thus

$$U = \frac{RA}{PC}. \tag{42}$$

The final market clearance condition reconciles the balance of payments. The supply of foreign exchange includes its generation in the export activities and net borrowing from the rest of the world (net capital account surpluses). The real capital account surplus is held fixed at the exogenous benchmark observation, denoted $\overline{ftrn}$. Foreign exchange is demanded for direct import purchases as well as the payments to foreign agents for their contribution to production.

$$\begin{aligned} \sum_{r \neq O} \sum_g FORIM_r^g + \overline{ftrn} &= \sum_{r \neq O} \sum_g IM_r^g \\ &+ \sum_{r \neq O} \sum_i \theta_{Mr}^i Z_r^i \left(\frac{PMC_r^i}{\theta_{Dr}^i PY^i + \theta_{Mr}^i PFX} \right)^{\epsilon_r^i} \\ &+ \frac{FE}{PFX}, \end{aligned} \tag{43}$$

where FE equals the nominal claims that the foreign entrepreneurs have on specific factor rents in the Dixit-Stiglitz service sectors.

3 Income Balance Conditions

The representative agent (household) earns income from factor endowments, but disposable income nets out savings and a direct tax transfer to the government. Real savings is held fixed (by the coefficient $\overline{sav}_h$). We also hold fixed the real level of government spending, but this requires an adjustment in direct taxes on households. Removal of tariffs, for example, impact the government budget and the shortfall is made up for by an endogenous increase in the direct

taxes on households. We use the auxiliary variable T to scale the direct taxes appropriately. In addition, the household is assumed to hold any benchmark net international capital flows. The household's budget is given by

$$\begin{aligned} RA &= \sum_f PF_f \overline{S}_f \\ &+ \sum_g PZ^g \overline{SF}^g \\ &- \overline{sav} PINV \\ &- \overline{dtax} PG \times T \\ &+ \overline{ftrn} PFX \end{aligned} \tag{44}$$

The government budget is given by net direct and indirect taxes on domestic and international transactions. The full nominal government budget is

$$\begin{aligned} GOVT &= \overline{dtax}_h PG \times T \\ &+ \sum_g t_g^{cons} PA^g \mu_C^g U \frac{PC}{(1+t_g^{cons})PA^g} \\ &+ \sum_g t_g^{inv} PA^g \mu_{INV}^g INV \\ &+ \sum_g t_g^{gov} PA^g \mu_G^g PUB \\ &+ \sum_s \sum_i t_{is}^{int} PA_i \theta_i^s \theta_{vas}^s Y^s \left(\frac{P_s^{srv}}{(1+t_{is}^{int})PA_i} \right) \left(\frac{P_s^{vas}}{P_s^{srv}} \right)^{\sigma_{vas}} \\ &+ \sum_s \sum_j t_{js}^{int} PA_j \theta_j^s Y^s \\ &+ \sum_s \sum_k t_{ks}^{int} PA_k \theta_k^s Y^s \\ &+ \sum_s \sum_f t_{fs} PF_f \theta_f^s \theta_{vas}^s Y^s \left(\frac{P_s^{va}}{(1+t_{fs})PF_f} \right) \left(\frac{P_s^{vas}}{P_s^{va}} \right)^{\sigma_{vas}} \\ &+ \sum_{r \neq O} \sum_g t_{gr}^{imp} (PFX) IM_r^g \\ &+ \sum_{r \neq O} \sum_i t_i^{exp} \frac{PMC^i}{1 - \frac{1}{\sigma_F^i}} FORIM_r^i \\ &+ \sum_{r \neq O} \sum_j t_j^{exp} \frac{PMC^j}{1 - \frac{1}{\sigma_F^j}} FORIM_r^j \\ &+ \sum_{r \neq O} \sum_k t_k^{exp} PX_r^k FORIM_r^k \end{aligned} \tag{45}$$

Again, the index T is adjusted endogenously to hold the real level of public spending fixed. In addition to the household and government agents we need an agent representing the foreign entrepreneurs who own the specific factors associated with Dixit-Stiglitz service goods. The

foreign entrepreneur's nominal income is FE, which is spent on foreign exchange:

$$FE = \sum_{r \neq O} \sum_{g} PZ_r^g \overline{SF}_r^g \quad \forall g \in I. \tag{46}$$

4 Auxiliary Conditions

In addition to the three sets of standard conditions presented above, we use an auxiliary condition to fix the real size of the government. Specifically, we need to determine the index which scales direct taxes on households. Associated with the variable T is the following condition:

$$PUB = \overline{pub}. \tag{47}$$

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