wiiw

JANUARY 2024

Working Paper 239

Can Multinationals Withstand Growing Trade Barriers?

Mahdi Ghodsi, Nina Vujanović and Michael Landesmann

The Vienna Institute for International Economic Studies
Wiener Institut für Internationale Wirtschaftsvergleiche

Can Multinationals Withstand Growing Trade Barriers?

MAHDI GHODSI
NINA VUJANOVIĆ
MICHAEL LANDESMANN

Mahdi Ghodsi and Nina Vujanović are Economists at The Vienna Institute for International Economic Studies (wiiw). Michael Landesmann is Senior Research Associate at wiiw and Professor of Economics at the Johannes Kepler University Linz.

This paper is part of the TWIN SEEDS project, funded by the European Union (Horizon-CL2-2021; Project no 101056793).

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

The authors would like to thank David Zenz for statistical support.

Abstract

Multinational enterprises (MNEs) are increasingly dealing with challenges shaped by the new geopolitical and trade environments. Besides traditional tariffs, exporting firms need to comply with regulatory non-tariff measures (NTMs) in the form of technical barriers to trade (TBTs) and sanitary and phytosanitary (SPS) measures. Although trade costs associated with these policy measures affect all firms, implications could be multifaceted for multinationals that base their international activities on exporting and importing and are important for the formation of global supply chains. Applying Poisson pseudo maximum likelihood to the unique Orbis dataset of firms on multinational subsidiaries, we show that NTMs pose a greater challenge to MNEs' subsidiaries' activity and performance than tariffs do. High-tech manufacturing subsidiaries of foreign MNEs are particularly vulnerable to these NTMs, as they suffer higher regulatory losses. However, multinational affiliates that have higher productivity, those with full foreign ownership representation, those that are embedded within a larger international network of subsidiaries, and those that are located in trading partners with deep preferential trade agreements can turn these trade challenges to their advantage. Our results have important implications for policy makers regulating trade in goods.

Keywords: trade, FDI, global supply chains, tariffs, non-tariff barriers, multinational firms

JEL classification: F23, F211, F12, F13, F15, C55

CONTENTS

TABLES AND FIGURES

1. Introduction

The importance of foreign direct investment (FDI) in facilitating international production activities by multinational enterprises (MNEs) cannot be understated. At present, a few large MNEs dominate most sectors and establish global networks of subsidiaries to distribute trade, investment and production activities. Existing literature on FDI drivers generally classifies them into two categories: (i) market-seeking FDI, which aims to gain better access to the host economy's final goods market or neighbouring markets; and (ii) efficiency-seeking FDI, driven by the desire to enhance production efficiency by leveraging location advantages such as skilled labour, lower labour costs, capital and infrastructure, natural resources, and other competitive factors. Additional modes of FDI, including 'export-platform' FDI, 'tariff-jumping' FDI, and 'resource-seeking' FDI, are also recognised. These modes involve supplying goods to third markets, accessing host markets by circumventing high import tariffs, and seeking locally sourced inputs at a lower cost, respectively. From a firm-level perspective, subsidiary-specific competitive advantages such as intangible assets, unique technologies, patents, branding, organisational capital, established marketing infrastructure, and promotional activities in the host economy are considered to be influential in driving FDI.

This study builds upon the trade-investment choice literature, specifically Helpman et al. (2004), which explores the interdependence of FDI and trade decisions made by heterogeneous firms. These decisions are influenced by factors such as industrial structure, productivity variations, and relative costs associated with FDI, export and import activities. In our analysis, we examine the impact of non-tariff measures (NTMs), which are country- and sector-specific regulations, on the investment decisions and production of global ultimate owners (GUOs) and their subsidiaries. The regulatory environment in both the home and host countries, along with sector-specific factors, plays a crucial role in determining the location choices and investment intensity of parent companies in their subsidiaries, which then translates into the performance of their subsidiaries. Regulatory NTMs such as technical barriers to trade (TBTs), and sanitary and phytosanitary (SPS) measures are the most commonly used NTMs. These regulatory NTMs have heterogenous effects on trade of goods at the Harmonised System (HS) 6-digit level. Sometimes they can even stimulate trade as they provide better information to the consumers, hence improving demand. Although NTMs impose additional costs on producers, as they incur variable compliance costs or fixed costs of investing in better production procedures, they may also enforce product quality and compliance with environmental standards, which can stimulate demand. Therefore, their effects on trade costs in any direction could substantially affect the patterns of global value chains (GVCs) and thus the performance of subsidiaries of MNEs. Consequently, the intensity of NTMs and their associated costs could influence the decisions of MNEs regarding country and sector allocation, as well as production, export and import choices. This paper analyses how the trade costs associated with the regulatory NTMs affect the output and performance of foreign subsidiaries of MNEs.

Measuring NTMs accurately has been a challenge in the literature. Previous studies relied on simplistic NTM counts, which provided only a rough indication of their intensity. However, recent research has developed techniques to compute import tariff equivalents, known as the ad valorem equivalents (AVEs) of NTMs, thus enabling a more precise measurement of NTMs' impact. Our contribution to the literature is multifaceted. First, we update estimates of bilateral time-varying AVEs of NTMs at a detailed product level (6-digit HS classification). This approach allows for heterogeneous effects of NTMs across trading partners and enhances the interpretation of NTM impact for each country, sector and type of measure. Second, we construct a firm-level panel dataset using the Orbis database, which captures foreign ownership relationships between GUOs and their foreign subsidiaries. We utilise a methodological approach that leverages detailed firm-level data across countries, focusing on the direct ownership links between parent multinational enterprises (MNEs) and their subsidiaries. This approach also mitigates the issue of aggregation bias, which is dominant in studies using country-level and industry-level FDI data. This aspect is particularly critical in the current global economic landscape, where a limited number of sizeable MNEs dominate each industry sector. Third, we focus on high-tech sectors, which rely heavily on FDI for global production efficiency, in addition to assessing manufacturing firms in general. Lastly, our analysis has a global scope, covering multiple countries and spanning the period from 1996 to 2020.

By analysing the time-varying bilateral AVEs of NTMs, we examine the impact of NTM stringency imposed by the home and host countries on the performance indicators (revenue, turnover and labour productivity) of foreign subsidiaries owned by MNEs. We also analyse how firm heterogeneity in terms of a subsidiary's productivity could affect the impact of regulatory NTMs on a subsidiary's output. It is expected that firms with higher productivity are better equipped to circumvent the trade obstacles raised by regulatory NTMs, as the literature suggests (Fontagné et al., 2015; Navaretti et al., 2018). Our findings confirm that NTMs have significant effects on subsidiary performance indicators. We observe diverse impacts resulting from measures imposed by the host and home countries, across sectors and across different types of NTMs (AVEs of TBTs and SPS measures). NTMs pose a greater challenge than tariffs to MNE affiliates' activity and performance. In particular, high-tech manufacturing subsidiaries of foreign MNEs face heightened regulatory losses as a consequence of these NTMs. However, subsidiaries with higher productivity, full foreign ownership and integration within a larger international network of subsidiaries can leverage these trade challenges to their advantage. Additionally, 'deep' preferential trade agreements (PTAs) that include provisions for recognising regulatory frameworks among trading partner countries can effectively mitigate the impact of stricter NTMs. This suggests that, although trade costs associated with NTMs would harm the production of foreign subsidiaries, as they impact the supply chains, such NTMs might not have strong negative impacts within deep PTAs. We also conduct an interesting analysis of the differentiated impact of NTMs on firm performance based on subsidiary productivity levels, which reveals that higher-productivity firms are more resilient to the negative effects of restrictive NTMs. Furthermore, we test for variations in the effects on MNEs based on the degree of ownership of their subsidiaries, specifically majority ownership or full (100%) ownership.

The rest of the paper is structured as follows. Section 2 briefly elaborates on the literature framework and defines the research questions. Section 3 covers the methodology applied in this paper: the econometric framework is introduced, which studies the impact of tariffs and NTMs on firm/subsidiary performance indicators, followed by a detailed discussion of how the estimates of AVEs of NTMs were arrived at. Section 4 presents some descriptive information on the development of tariffs and AVEs of NTMs over the period 1996-2020, and Section 5 reports the results of the econometric analysis, starting with a discussion of results for two base samples (one including firms with majority ownership, and the other including only firms with full ownership). It then looks at the impact of firm differentiation by productivity levels, followed by discussing the impact of 'MNE network size' (proxied by the number of subsidiaries), and concluding with the specific impacts of NTMs in the high-tech sector.

2. Literature background and research questions

It has long been established that MNEs are important drivers of growth at the global scale. Between 2000 and 2014, the global gross output of foreign affiliates grew from USD 7trn to USD 20trn (Cadestin et al., 2018). MNEs are the biggest contributors to innovation (Dunning and Lundan, 2008; Vujanovic et al., 2022), which is a pivotal economic component, especially for the successful green and digital transition taking place (Voegtlin and Scherer, 2017). Even though trade growth decreased after the global financial crisis, trade growth rates were relatively stable within the MNEs' networks (Anderer et al., 2020), suggesting that these networks play an important role in global trade.

It comes as no surprise that the fragmentation of production within GVCs also has been largely driven by MNEs (Baldwin, 2016). The relevance of MNEs in this regard lies in their ability to maintain the GVCs across dispersed geographical locations (Ryan et al., 2020). Digitalisation has had an enormous influence on the nature of business abroad, and hence on GVCs themselves (Baldwin, 2016). Digital trade and digital FDI have both begun to play an increasing role in international production (Baldwin, 2016; Casella and Formenti, 2018; Trentini et al., 2022).

The geographical extent of the GVCs, however, goes beyond the digitalisation-trade nexus. The way in which GVCs evolve is also a result of the interaction of firm-level decisions and the trade policy environment (Pananond et al., 2020). As MNE's networks of headquarters and foreign affiliates shape GVCs, their foreign affiliates' performances are likely to be affected by rising trade costs. MNEs' strategies can counter the negative effects of some trade policies on the configurations of GVCs by changing supply-chain partners (Gereffi et al., 2021).

MNEs tend to bypass regulatory tariffs and non-tariff trade barriers by shifting production to export markets that impose protective trade measures (Lee et al., 2020). However, the supporting empirical evidence is scarce and mostly covers tariffs. The literature on the effects of tariffs on FDI has been well explored, but has been largely based on aggregate data, excluding the more detailed analysis of the performance of MNEs' networks of foreign affiliates abroad. According to this literature, if a firm aims to find new international markets for its products, exporting and FDI are substitutive strategies. In such cases, rising tariffs can lead to increased FDI (Martínez-San Román et al., 2016). This is called 'tariff-jumping' (Bloningen et al., 2004) or non-conventional FDI (Lee et al., 2020), as its primary aim is to circumvent a regulatory obstacle.

A different situation arises when MNEs expand abroad to deepen their production alongside expanding GVCs in order to source cheaper inputs abroad. This FDI is known as vertical FDI, where trade and FDI are complementary; an increase in tariffs would reduce FDI (Reed et al., 2016). The research investigating the relationship between tariffs and FDI is extensive (Cole and Davies, 2011; Cardamone and Scoppola, 2012; Du et al., 2014; Reed et al., 2016). However, it mostly relies on country-level data, and this causes some aggregation bias as the more detailed performance of MNEs is not investigated. In addition, FDI inflows suffer from poor data quality at an aggregated level (UNCTAD, 2020; Vujanovic et al., 2021b).

Moreover, the literature so far gives little consideration to how non-tariff barriers affect FDI and MNEs' performances. According to UNCTAD (2012), NTMs are policy measures beyond tariffs that can also affect trade costs (prices and quantity) and have relevant economic implications. The evidence of the effect of non-tariff barriers on FDI and even trade is scarce and mainly focused on quantitative NTMs (e.g. quotas), with little focus on TBTs. Unlike tariffs, which are protectionist by definition, NTMs have a corrective role. The most prominent NTMs are TBTs, the role of which is to correct for asymmetric information between producer and consumer. Furthermore, SPS standards should contribute to the ecosystem and reduce health risks. TBTs, according to the latest data (UNCTAD, 2022), regulate two-thirds of global trade. Their widespread influence on trade thus calls for richer empirical investigation of MNEs too.

The effects of NTMs on trade at the product level and at the aggregate level have been well investigated (Bora et al., 2002; Blind and Jungmittag, 2005; Niu et al., 2018; Ghodsi and Stehrer, 2016). However, the evidence of NTMs' effect on FDI is scarce, with work in this area focusing only on quantitative NTMs (Belderbos et al., 2013). The reason for the rather limited investigation of TBTs and SPSs is that they are rather opaque measures that are more challenging to quantify, for reasons that will be clarified later. The effects of TBTs and SPS measures on FDI have only recently been investigated (Adarov and Ghodsi, 2023; Ghodsi, 2020a).

Ghodsi and Stehrer (2016) investigate how regulations embodied in TBTs and SPSs affect GVCs. Their findings are that these regulations can improve the quality of intermediate goods used in both non-service and service sectors, and thus the value added and the productivity further up the value chain. However, the authors do not disentangle whether these effects are driven by multinational firms or local firms. Ghodsi (2020a) investigates the effects of TBTs on FDI in Central, East and Southeast Europe (CESEE) and finds that this relationship is contingent on various factors. It also finds that the imposition by CESEE countries of tariffs and specific trade concerns (STCs) on TBTs imposed by other countries encourages FDI to the region. The opposite holds true for other types of TBTs. EU FDI is particularly encouraged when STCs are imposed by non-EU members of CESEE, indicating that the tariff-jumping motive is particularly strong when trade regulations are not aligned between host (non-EU) and home (EU) economy. Non-EU FDI to the CESEE region increases with rising TBTs, signalling that market efficiency attained through higher TBTs also encourages FDI from more distant locations. Adarov and Ghodsi (2023) go a step further empirically by analysing the effects of SPS measures on FDI too. The results reveal that SPS measures have no significant effect on FDI, while the effects of TBTs largely depend on whether they are levied by the home or the host economy. Despite offering the first thorough analysis on the bilateral trade costs on FDI at the firm level, this research shows little variation of the relationship across industry and firm characteristics.

The research presented in this paper fills some of the gaps by investigating the effects of rising tariff and non-tariff barriers on various performance measures of MNEs' foreign affiliates in the non-service sector, which is more likely to be exposed to international fragmentation abroad. This research will answer several questions. First, our main research question investigates the effect of tariffs and non-tariff barriers (SPS and TBTs) on two measures of performance of foreign affiliates: productivity and output. We use a relatively conservative definition of a foreign firm, whereby a firm is a foreign affiliate if it has at least 50.01% of foreign ownership stake, implying a major role in the decision-making process.[1] We also

[1] OECD and IMF define a foreign firm as any firm that has at least 10% of its equity owned by a foreign investor. This is a more widely used definition of a foreign firm (Vujanovic et al., 2021b; 2022; Kosová, 2010; Javorcik, 2004), but includes many firms whose voting power is dominated by local owners.

investigate whether the relationship between firm output and productivity and trade costs changes if a foreign firm is a 100% multinational subsidiary. Second, we examine the relationship with respect to the existence of PTAs between home and host economies. Third, we investigate how this relationship varies with respect to the productivity level of the foreign affiliate and the network size of the GUO to which it belongs. Fourth, considering the rising importance of high-tech and digital FDI, we also investigate how tariff and non-tariff barriers affect the high-tech sector in particular. Finally, the empirical investigation also takes into account that some destinations could attract unproductive FDI (e.g. offshore financial centres) and thus we provide an estimation that excludes these country groups.

3. Methodology and data

In the following, we analyse how the performance of non-service subsidiaries of MNEs respond to trade costs associated with different types of trade policy measures that affect the trade patterns between the home country ('home' or 'origin') of the MNE and the host country ('host' or 'destination') of its subsidiaries. We would like to understand how trade costs related to regulatory NTMs could affect the performance of MNEs and how PTAs could play a role in this.

Following the literature on gravity models (Head and Mayer, 2014; Yotov et al., 2016), one needs to control for multilateral resistance while studying the bilateral trade or investment relationships. This is usually achieved by including country-sector-time fixed effects for both trading partners in addition to bilateral sector fixed effects. Although tariffs can vary over time by each bilateral sector, regulatory NTMs such as TBTs and SPS measures are usually unilaterally imposed against all exporting countries. By including exporter-sector-time fixed effects, these unilateral trade policy measures would be excluded from the econometric analysis. Thus, one needs to find a way to include these unilateral measures in the gravity settings. Furthermore, what matters for MNEs that are heavily involved in GVCs are the trade costs associated with these regulatory measures, rather than their mere existence or proliferation. Therefore, it is necessary to include a measurement of their trade costs that could vary bilaterally over years in each sector. One main way to do this is to estimate the time-varying bilateral AVEs of NTMs, which could differ not only across sectors and importers, but also across exporters and over years. While the methodology for the estimation of AVEs of NTMs is elaborated in the sub-section below, the econometric methodology to analyse the performance of subsidiaries of foreign MNEs is explained here. The equation for the estimation of the performance of foreign subsidiaries is as follows:

$$Y_{fgdosrt} = EXP\ [\gamma + \gamma_n \sum_n PTA_{n,dot-1} \times (\gamma_{n,1} \operatorname{arc} AVE_{n,dost-1} + \gamma_{n,2} \operatorname{arc} AVE_{n,odst-1}) \tag{1}$$

$$+\gamma_3 \operatorname{arc} T_{odst-1} + \gamma_4 \operatorname{arc} T_{dost-1} + +\gamma_7 X_{ft-1} + \gamma_8 l_{ft-1} + \gamma_9 GDP^{sim}_{dot-1}$$

$$+\gamma_{10} HC^{dif}_{dot-1} + \gamma_{11} KL^{dif}_{dot-1} + \gamma_f + \gamma_g + \gamma_{ost} + \gamma_{dst} + \gamma_{dos} + \gamma_{rt}] + v_{fgdosrt}\ ,$$

$$\forall t \in \{1, \dots, T\}, \forall o, r \in \{1, \dots o, \dots r, \dots, I\}, n \in \{TBT, SPS\}$$

where $Y_{fgodsrt}$ is the performance indicator of the subsidiary f in NACE 2-digit sector s in destination country d that is owned by the global ultimate owner (GUO) g in sector r that is in the origin country o at time t; the performance indicator could take one of the following variables in each specification: operating revenue (alternatively, turnover)[2] O_{ft}, and labour productivity $prod_{ft}$ (number of employees relative to turnover) of the subsidiaries of foreign MNEs; $PTA_{n,dot}$ indicates the depth of the preferential trade agreement (PTA) between the two countries d and o with special provisions on NTM type n, which is either the TBT or SPS measure. The data on this PTA variable is borrowed from Hofmann et al. (2017), and could take higher values up to four (in the case of EU member states) when more than one

2 We shall at times refer to the two alternative variables as proxies for 'output' or 'sales'.

agreement is signed between the two countries.[3] $\mathrm{arc}\,AVE_{n,dost}$ is the arcsine transformation of the simple average of AVEs of NTMs of type n in NACE 2-digit sector s imposed by country d against the imports of goods at the HS 6-digit level from the country o. And, conversely, $\mathrm{arc}\,AVE_{n,odst}$ is the arcsine transformation of the simple average of AVEs of NTMs of type n in NACE 2-digit sector s imposed by country o against the imports of goods at the 6-digit level of HS from the country d. Because AVEs can take on zero and negative values, arcsine log transformation is used following the literature (Bellemare and Wichman; 2020; Mullahy and Norton, 2022).[4] These AVEs are interacted with PTA variables to infer conclusions on the heterogeneity of impacts of NTMs on the performance of subsidiaries with and without PTAs. $\mathrm{arc}\,T_{odst}$ is the arcsine transformation of the simple average tariffs imposed by country o against 6-digit products imported in sector s from country d in year t. And again, conversely, $\mathrm{arc}\,T_{dost}$ is the arcsine transformation of the simple average tariffs imposed by country d against 6-digit products imported in sector s from country o in year t. As tariffs could be zero for many products and countries, the arcsine transformation is used. X_{ft} is either labour productivity of the subsidiary f in year t when the dependent variable is either turnover or sales, or it is the capital (total assets) to labour ratio of the subsidiary KL_{ft} when the dependent variable is labour productivity of the subsidiary. l_{ft} is the number of employees of firm f in year t that measures the size of the subsidiary. Then, following the literature on the Knowledge-And-Physical-Capital (KAPC) model of Bergstrand and Egger (2007, 2013) extending the Knowledge-Capital (KC) model of Markusen (2002, 2013), bilateral country variables are included as control variables.

GDP_{dot}^{sim} is similarity in size of the two countries, calculated as follows:

$$GDP_{dot}^{sim} = log\left[\left(\frac{GDP_d}{GDP_d + GDP_o}\right) \times \left(\frac{GDP_o}{GDP_d + GDP_o}\right)\right] \quad (2)$$

When country d and o are identical in size, similarity is maximised ($GDP_d = GDP_o \leftrightarrow GDP_d = \frac{1}{2} \times (GDP_d + GDP_o) \leftrightarrow GDP_{dot}^{sim} = \frac{1}{4}$); HC_{dot}^{dif} is the logarithm of absolute value in the difference in human capital of both countries; and KL_{dot}^{dif} is the logarithm of absolute value in the difference in capital to labour ratio of both countries in year t. The data on these country-level variables are collected from the 2021 edition of Penn World Table 10.01[5] provided by Feenstra et al. (2015). Using these country-level variables, one can identify the dominance of horizontal versus vertical FDI in the data. For instance, a positive and significant coefficient of size similarity in GDP indicates the dominance of market-seeking and horizontal FDI – as countries of similar size might have stronger commonalities in terms of ‘taste formation’, as a reminder of the Linder hypothesis (Linder, 1961). A positive and significant coefficient of difference in the physical capital to labour ratio shows the dominance of vertical FDI, owing to efficiency-

3 When there is no PTA between two countries, the value of this variable should be equal to zero. That is the minimum value of this variable. Therefore, the interaction between the PTA and the NTM variable would suggest that if we want to consider the impact of NTMs for countries without PTAs, we should look at the single coefficient of the NTM, rather than the interaction term. However, the interaction term would hint at the effect of NTMs after the two countries deepen their PTAs.

4 Tariffs on many products traded between many countries are set to zero under many PTAs. In addition, some tariffs on some products in some countries are strictly larger than 100%. For instance, in 2008 Australia imposed a tariff equal to 5,000% on imports of ‘tobacco, not stemmed/stripped’ from several countries. And in 2019 South Africa imposed a tariff equal to 5,000% on the imports of ‘waters, including mineral waters and aerated waters, containing added sugar or other sweetening matter or flavoured from several countries’. Therefore, tariffs or AVEs or any other variable that is a continuous variable including zeros need to be transformed using the hyperbolic sine transformation as the literature recommends, which gives a better estimate than the logarithmic form of the variable plus one.

5 https://www.rug.nl/ggdc/productivity/pwt/?lang=en

seeking (comparative advantage based on factor endowment differences) motives. Similarly, a positive and significant coefficient of difference in human capital shows the dominance of vertical FDI between knowledge-intensive headquarters and subsidiaries (of course, there could also be ‘horizontal’ skill differentiation effects when MNCs try to complement their own host-situated human capital with human capital situated in other countries; this leaves scope to interpret the results obtained).

Furthermore, γ_f and γ_g respectively control for subsidiary and owner fixed effects; γ_{ost}, γ_{dst}, and γ_{dos} are origin-sector-time, destination-sector-time, and bilateral sector fixed effects that are controlling for multilateral resistance terms in trade policy measures following the gravity literature (Head and Mayer, 2014; Yotov et al., 2016); and γ_{rt} is the owner’s sector-time fixed effects that control for technological change in the sectors of the foreign owners. Furthermore, one could consider the endogeneity bias caused by the PTA or the trade policy variables. However, as Baier and Bergstrand (2007) analysed the endogeneity of PTAs in gravity models, and as Yotov et al. (2016) also note, one major solution to control for the endogeneity of PTAs or trade policy measures in the panel data is to use either first-differencing bilateral flows or bilateral fixed effects. Therefore, using the bilateral fixed effects in equation (1) will control for the endogeneity bias of the trade policy measures. Furthermore, the choice of the one-lag dependent variables would additionally eliminate the reverse causality. As the dependent variables include both positive and zero values, Poisson pseudo maximum likelihood (PPML) (Santos Silva and Tenreyro, 2006; Head and Mayer, 2014) will be used as this is also robust against heteroscedasticity in the error term.

The benchmark specification in equation (1) will be run on the whole sample of subsidiary-owner relationships for non-services subsidiaries that are owned directly or indirectly by the foreign owner. Majority ownership (i.e. more than 50.01%) is considered here. As a robustness check, the specifications are run on the sample of subsidiary-owner relations with 100% ownership (directly or indirectly). Further robustness checks are run excluding the subsidiaries in offshore financial centres (OFCs). However, because the estimations include the number of employees of subsidiaries, all offshore accounts or special purpose vehicles without employees are not included in the benchmark specification. Additional estimations are undertaken on the sample of high-tech manufacturing that includes NACE 2-digit sectors 21, 26 and 30.3, which are respectively ‘manufacture of basic pharmaceutical products and pharmaceutical preparations’, ‘manufacture of computer, electronic and optical products’ and ‘manufacture of air and spacecraft and related machinery’. A further additional analysis is undertaken to check the differentiated impacts of trade costs on firms located across a productivity level distribution: here, the main NTM variables will be interacted with the labour productivity of subsidiaries to allow for heterogeneity of firms (Melitz, 2003) and the implications for the impact of trade costs across the productivity distribution. Moreover, one can argue that the size of the MNE network may represent the scope and scale of capabilities to counter regulatory costs. An MNE that has subsidiaries in many countries may be better equipped with regulatory compliance as the amount of knowledge and intangible assets of firms facilitate awareness of diverse regulations and standards. Therefore, in a further analysis, a new variable NW_g is generated as the number of subsidiaries in the network of a GUO and it is interacted with the NTM variables.

3.1. ESTIMATION OF BILATERAL SECTORAL TIME-VARYING AD VALOREM EQUIVALENTS (AVES) OF NTMS

This paper estimates the annual bilateral AVEs of regulatory NTMs at the HS 6-digit level over the period 1996-2021 following the methodology proposed by Kee et al. (2008, 2009). However, they estimated the unilateral AVEs of NTMs using a cross-section of bilateral trade data at the 6-digit level. Using the bilateral trade data over the period, this paper estimates the time-varying AVEs of TBTs and SPS measures that vary over time and across importer-exporter-products.

Methodology

To achieve that goal, we *first* need the bilateral import demand elasticities that vary across importer-exporter-products for the whole period. Import demand elasticities are usually less sensitive to changes in time as they are anchored in consumers' behaviour, which tends to be more consistent than the trade impacts of NTMs, which may show significant variation over years. Import demand elasticities indicate how much (in percentage terms) the import volume changes when the import price changes by 1%. The bilateral import demand elasticities are taken from Adarov and Ghodsi (2023), which are estimated for the period 1996-2018. *Second*, we need to quantify the impact of regulatory NTMs on the volume of trade in goods at the 6-digit level. Because TBTs and SPS measures are heterogeneous regulatory measures that are imposed on various products with different characteristics and specifications, we will need to estimate the average impact of TBTs and SPS measures imposed by all countries in the world on the trade of each 6-digit product each year. Therefore, the second stage will estimate the impact of TBTs and SPS measures on the volumes of bilateral trade of 6-digit products in each year. The data for the estimation of the impact of NTMs on trade volumes are improved and updated to more recent years for the period 1996-2021. *Third,* we calculate the annual bilateral AVEs of TBTs and SPS measures using the time-invariant bilateral import demand elasticities and the time-variant estimated coefficients of TBT and SPS measures from estimated gravity equations (see Section 4 for details). Thus, the AVEs of NTMs would represent a tariff-equivalent indicator that could be positive (like a tariff) when it restricts trade, and negative (like a subsidy) when it promotes trade. In fact, this indicator could tell us how much a supply price of the bilateral goods sold in a particular (host) market would change when the NTM is removed from the bilateral trade flow of that good. The methodology to quantify the impact of NTMs on import volumes is elaborated below.

Using a gravity framework developed by Kee et al. (2009), we estimate the impact of a regulatory NTM of type $n \in \{TBT, SPS\}$, on the volume of product h imported to country i from country j in year t as follows:

$$q_{ijht} = exp^{[\beta_{oht} + \beta_{oht1} \ln(1+T_{ijht}) + \sum_n \beta_{n,oht2} NTM_{n,ijht} + \beta_{oht3} X_{it} + \beta_{oht4} X_{jt} + \beta_{oht5} G_{ij} + \beta_{oht6} W_{ijt}]} + \mu_{oijt}, \quad (3)$$
$$\forall h \in HS, \forall t \in \{1, \dots, T\}, \forall i, j \in \{1, \dots i, \dots j, \dots, I\}, n \in \{TBT, SPS\}$$

where q_{ijht} is the volume of product h imported from country i to country j in year t; $\ln(1 + T_{ijht})$ is the log of tariffs in percentages, and they are added to one because they can equal zero for some bilateral trade flows; $NTM_{n,ijht}$ is the stock number of an NTM of type n which refers to either a TBT or SPS measure imposed by the importing country j in force in year t on the import of product h from the exporting country i; X_{it} and X_{jt} include country-level variables for the exporter and the importer, respectively, which have the nominal GDP in US dollars as an indicator of the size of the economy and real GDP per capita as a proxy for the level of development; G_{ij} includes time-invariant gravity variables that comprise geographic distance between the two trading partners, colonial history, common language, contiguity and having been the same country historically; W_{ijt} is a binary variable equal to one when both trading partners are members of the World Trade Organisation (WTO) in that year; μ_{oijt} is the error term. Following the literature on the gravity frameworks (Santos Silva and Tenreyro, 2006; Head and Mayer, 2014), a PPML model is used to estimate this equation which allows us to keep the zero trade volumes and control for the heteroscedasticity of the error term. When a regulatory NTM restricts trade, one can expect zero trade volumes. Therefore, excluding such an important observation will lead to biased estimation of NTMs.

Furthermore, NTMs could be endogenous in the estimation of imports for three main reasons. Omitted variable bias, measurement error and reverse causality are the three sources of endogeneity of NTMs (Ghodsi, 2020b). Therefore, an instrumental variable (IV) approach will be applied following the literature (Kee et al., 2009; Bratt, 2017; Niu et al., 2018). Log of export volumes of product h from country j to country i in year t ($\ln q_{jiht}$) [6] and the growth of imported volumes in the previous year ($\Delta \ln q_{ijht-1}$) are the two exogenous variables that would control for the reverse causality bias. To control the bias rooted in the measurement errors, the price-weighted average of NTMs that are imposed across the globe excluding the ones imposed by the importing country is used as the third exogenous instrument. Kee et al. (2009) used the GDP-weighted average of NTMs imposed by several countries that are geographically closest to the importing country. However, this assumption is relaxed here as distant countries might also impose similar regulatory measures. Furthermore, as quality of traded goods is sometimes affected by regulatory NTMs, price weights are used to construct this measure. Therefore, this instrument $\overline{NTM}^p_{jwht}$ for each NTM of type n that is imposed by country j against the import of product h from country i is constructed as follows:

$$\overline{NTM}^p_{jwht} = \sum_i \sum_k \frac{p_{kiht}}{\sum_k p_{kiht}} NTM_{n,kiht}\,, \quad k \neq j \ \wedge \ i \neq j \ \wedge \ i \neq k, \qquad (4)$$
$$\forall h \in HS, \forall t \in \{1, \dots, T\}, \forall i, j, k \in \{1, \dots i, \dots j, \dots k, \dots, I\}, n \in \{TBT, SPS\}$$

where p_{kiht} is the unit value of product h in year t imported from country i to country k, which is different from country j that is the importing country in equation (3). Thus, the first-stage equation to estimate the NTM of type n using PPML is as follows:

$$NTM_{n,ijht} = exp^{\left[\beta_{1ht}+\beta_{1ht1}\ln(1+T_{ijht}) + \beta_{n',1ht2}NTM_{n',ijht}+\beta_{1ht3}X_{it}+\beta_{1ht4}X_{jt}+\beta_{1ht5}G_{ij}+\beta_{1ht6}W_{ijt}+\beta_{1ht7}\ln q_{jiht}+\beta_{1ht8}\Delta \ln q_{ijht-1}+\beta_{1ht9}\overline{NTM}^p_{jwht}\right]} + \mu_{1ijt}, \qquad (5)$$
$$\forall h \in HS, \forall t \in \{1, \dots, T\}, \forall i, j \in \{1, \dots i, \dots j, \dots, I\};\ n, n' \in \{TBT, SPS\}, n \neq n'$$

When we estimate each NTM type n in equation (5), the NTM of other types n' is also included as the control variable. After obtaining the fitted values $\widehat{NTM}_{n,ijht}$ from equation (5), they will be inserted in the gravity equation as follows:[7]

---

6 As there are zero trade values in export and import quantities, hyperbolic sine transformation of these traded values is used instead of the natural logarithm, which yields asymptotic marginal effects as in natural logarithm (Bellemare and Wichman, 2020).

7 According to the Sargan test statistics, $E\left(\widehat{NTM}_{n,ijht}\, \mu_{2ijt}\right) = 0$. The augmented Durbin-Wu-Hausman test proposed by Davidson and MacKinnon (1993) is used to test the inconsistency of estimating equation 3 without the IV PPML

$$q_{ijht} = exp^{[\beta_{2ht}+\beta_{2ht1}\ln(1+T_{ijht}) + \sum_n \beta_{n,2ht2}\widehat{NTM}_{n,ijht}+\beta_{2ht3}X_{it}+\beta_{2ht4}X_{jt}+\beta_{2ht5}G_{ij}+\beta_{2ht6}W_{ijt}]}\mu_{2ijt}, \quad (6)$$
$$\forall h \in HS, \forall t \in \{1, \dots, T\}, \forall i, j \in \{1, \dots i, \dots j, \dots, I\}, n \in \{TBT, SPS\}$$

where equation (5) and equation (6) are run for each product and each year separately on the global bilateral trade of goods during the period 1996-2021. Because the EU single market has mutual recognition and harmonisation of regulatory measures and standards, *intra-EU trade is not included in the sample of estimations*. However, individual EU members can still impose NTMs that are independent from the NTMs imposed by the EU or other members, which apply only to third-party countries. Therefore, the number of NTMs may vary across EU member states. After obtaining the coefficients $\beta_{n,2ht2}$ from equation (6) that are statistically significant at 10% level, and using the time-invariant bilateral import demand elasticities ε_{ijh}, one could calculate the annual bilateral AVE of NTM of type n as follows:

$$AVE_{n,ijht} = \frac{1}{\varepsilon_{ijh}} \frac{\partial \ln(q_{ijht})}{\partial NTM_{n,ijht}} = \frac{e^{\beta_{n,2ht2}} - 1}{\varepsilon_{ijh}} \times 100, n \in \{TBT, SPS\}, i \neq j, \quad (7)$$
$$\forall h \in HS, \forall t \in \{1, \dots, T\}, \forall i, j \in \{1, \dots i, \dots j, \dots, I\}, n \in \{TBT, SPS\}$$

We truncate the resulting AVEs at the extreme values of the distribution (values below -100 at the low end and above 10,000 at the top end of the distribution). This has only a marginal impact on the data as these amount to less than 1% of all estimated AVEs.[8] Furthermore, as equation (6) was estimated using zero trade flows, these AVEs could be used for both positive and zero trade flows. As the global bilateral data of traded goods at the HS 6-digit level including zero trade flows for the whole period of analysis is enormously large (with about 6.285bn observations), the simple averages of these AVEs are used to calculate the AVEs for more aggregated sectors such as NACE 2-digit industries, which will be used in the next part of the analysis.

Data

The data used to estimate AVEs of NTMs are compiled from several sources. Data on trade volumes and values are obtained from UN COMTRADE, provided by the World Integrated Trade Solution (WITS). The data on the stock numbers of TBT and SPS measures are obtained from the WTO Integrated Trade Intelligence Portal (I-TIP). The data on tariffs are obtained from WITS, where effectively applied tariff rates are used with priority; where these are missing, preferential rates are used; and where these are also missing, unilateral most-favoured nation (MFN) tariffs are applied. All tariffs are downloaded and used in ad valorem form. The data on gravity bilateral variables such as geographical distance, contiguity, common language and common colony are obtained from the CEPII database (Mayer and Zignago, 2011). Other country-level variables are obtained from the Penn World Table (10.01) provided by Feenstra et al. (2015).

---

approach. Furthermore, the exogeneity of instruments is additionally tested using the Anderson-Rubin test (Anderson and Rubin, 1949). These test results are available upon request.

8 This is a common practice in the literature. In our case, the threshold level is less restrictive. For instance, Bratt (2017) removes about 2% of the estimated AVEs: 1% from the top and 1% from the bottom of the distribution. In our case, the bottom threshold level of -100 is used, as a trade-promoting NTM can reduce the price of an imported good by maximally only 100%. The upper threshold of 10,000 is used in order to have a comparable number of observations truncated from each side of the distribution.

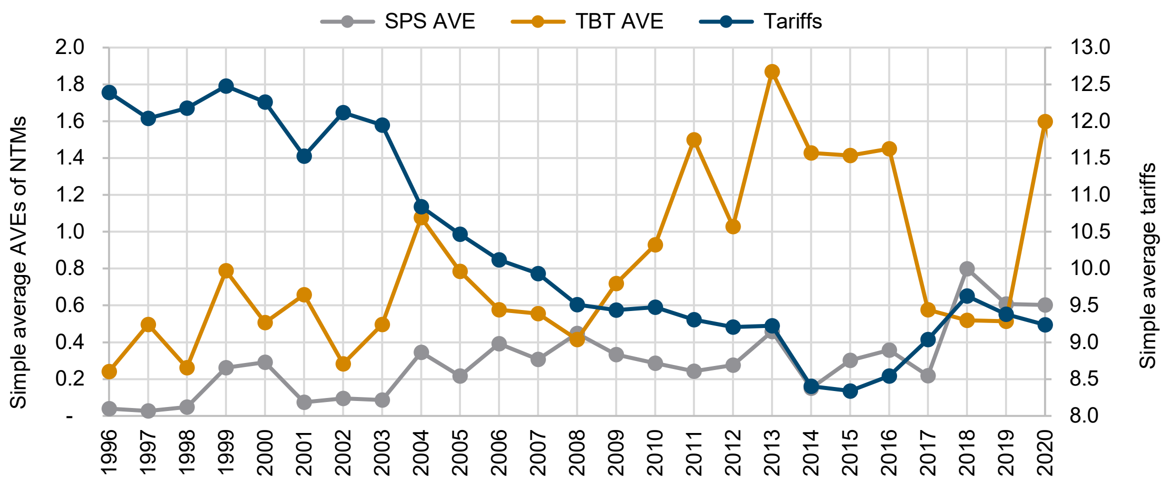
4. Descriptive statistics

This section presents some descriptive statistics on the estimated AVEs of TBTs and SPS measures aggregated over years and across industries. The data pertaining to estimated annual AVEs and bilateral import demand elasticities are available upon request.

4.1. TRADE COSTS ASSOCIATED WITH TARIFF AND NON-TARIFF BARRIERS

Figure 1 plots the trade costs associated with NTMs (as calculated by AVEs of NTMs) and tariffs over the period 1996-2020)[9] and across different non-service industries (Figure 2). These figures reveal that tariff measures had been decreasing until the onset of the US-China trade war. On the other hand, TBTs and SPS measures were gaining importance over time. This is also in strong alignment with the conclusions of the latest trade (policy) report by UNCTAD (2022).

Figure 1 / Simple average of tariffs and estimated AVEs of NTMs (across all trade flows including zero trade flows), 1996-2020



Sources: WTO I-TIP; UN COMTRADE; WITS; authors' estimations.

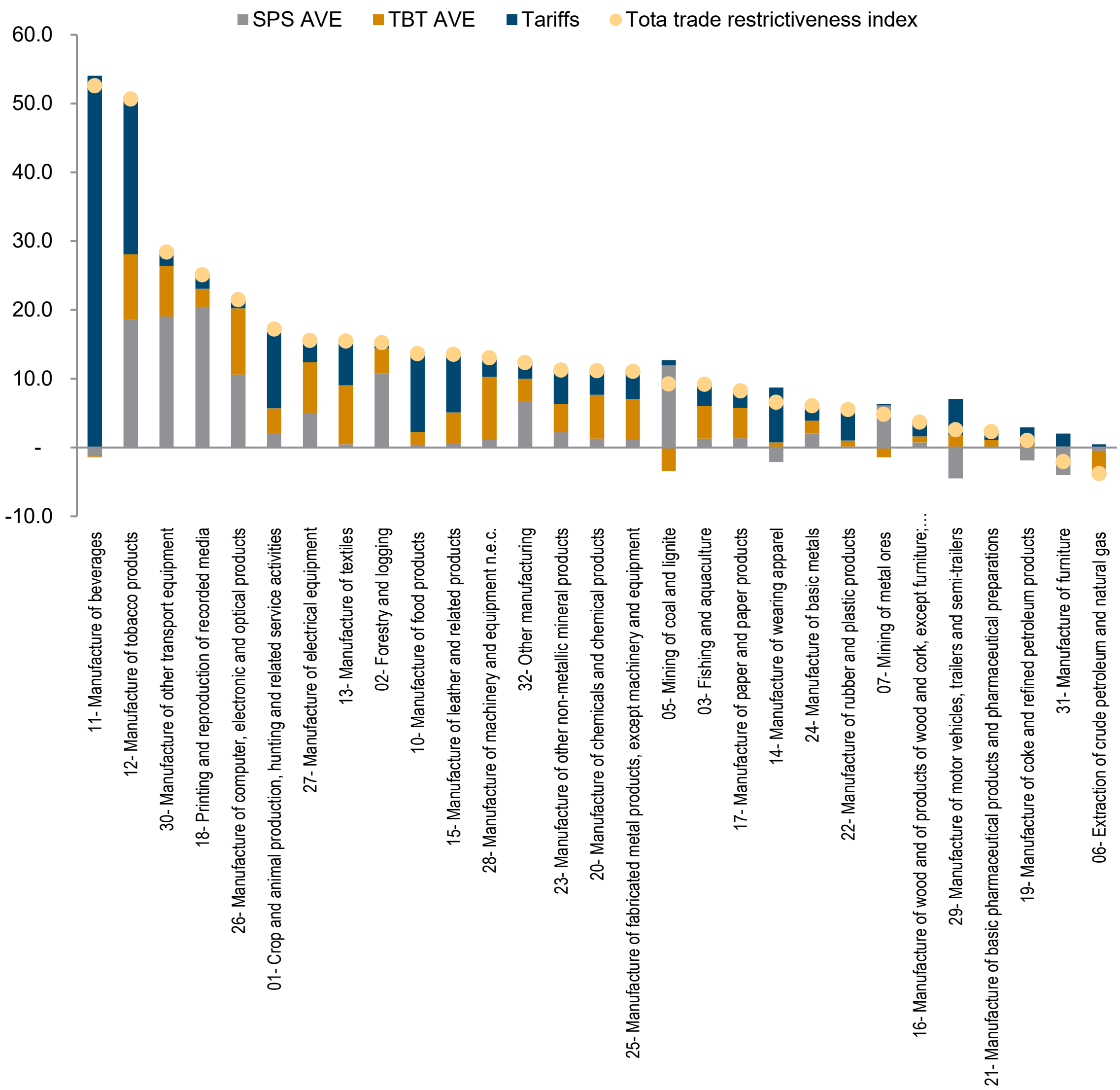
Tariffs were subject to a fairly steady decreasing trend from the beginning of the period, owing to implementation of multilateral and unilateral tariff liberalisation. This downward trend ended in 2015, when there was an upsurge owing to retaliatory tariffs imposed by the US on China. As also pointed out by UNCTAD (2022), tariff restrictiveness remains dominant in developing economies.

Unlike tariffs, the trade costs related to TBTs and SPS measures have been on the rise since the beginning of the period. Figure 1 reveals that TBTs post the highest trade costs, in comparison to SPS measures and tariffs.

9 In the Appendix, we also show Figure A1 on import average of tariffs and estimated AVEs of NTMs to demonstrate these trends, using volume of imports as weights.

When various trade costs are analysed at the industry level (Figure 2), we see that manufacture of beverages (NACE 11) is exposed to the largest barriers to trade, with a total restrictiveness index of about 52.6%, which is explained by very large protectionist tariffs equal to 54% imposed by many countries, while the trade-weighted average AVEs of TBTs and SPS measures is negative in this sector. Where a positive value for the AVE of an NTM expresses a tariff-equivalent tax, a negative AVE, in contrast, indicates the trade-enhancing effect of an NTM, functioning similarly to a subsidy. Manufacture of tobacco (NACE 12) is the second-most protected industry, with a total restrictiveness index of 50.7%, out of which only 22.6% is determined by tariffs. The industry with the next highest exposure to trade costs (although stemming more from tariffs) is manufacturing of other transport equipment, followed by printing and reproduction of recorded media, and then by manufacture of computer, electronic and optical products.

Figure 2 / Import-weighted trade restrictiveness index and its components by NACE 2-digit sectors, 1996-2020



Sources: WTO I-TIP; UN COMTRADE; WITS; authors' estimations.

In general, we see that several industries are subject to higher tariffs, namely those related to agricultural output (crop and animal production, etc.), tobacco manufacturing, food and beverages, and textile products. Although the results are an average over 25 years, the evidence indicates that food-related trade costs have recently risen sharply. According to WTO (2022), amid economic uncertainty and multiple crises, trade costs have increased, most notably for food-related products. Significant costs associated with tariffs are noticeable in the manufacturing of some products (e.g. motor vehicles, trailers and semi-trailers; rubber and plastic products, etc.) while being lower for high-tech products and for natural resources.

When it comes to TBTs and SPS measures, the industrial heterogeneity differs slightly. Of all the non-service industries, printing and reproduction of recorded media is the most exposed to TBTs. Furthermore, technical regulations, standards and procedures have a significant effect on medium- to high-tech manufacturing (such as computers and electronics, machinery and equipment) as well as tobacco manufacturing, which comes as no surprise, given the nature of production in these sectors. Industries that are highly affected by SPS measures overlap with those industries that are highly affected by TBTs.[10] Other industries that have to deal with high costs associated with SPS measures are those related to the trade of natural resources (forestry and logging, mining of cola and lignite, etc.).

[10] Industries related to mining, the tobacco industry and forestry.

5. Results

We present the results in two parts. Our first set of results (see 5.1) refers to the entire sample of MNEs operating in all non-service sectors. In this part we also investigate the role of productivity levels of subsidiaries and how the size of the network of subsidiaries of MNEs might affect the impact of trade barriers. The second set of results (see 5.2) refers to high-tech multinationals, which are an important source of growth in the context of the digital transition and the Fourth Industrial Revolution.

Each set of results presents the estimation for two samples: first, for the sample of firms with at least 50.01% foreign ownership stake; and second, the sample of firms that are 100% foreign-owned. In each case, we also cover the entire sectoral range of firms, and separately the 'high-tech' firms. As explained, we investigate two issues: how MNEs' production performance (as represented by turnover and sales) and efficiency (as represented by labour productivity) might be impacted by various trade policy measures such as tariffs and NTMs. We lag the explanatory variables, assuming that trade policy measures take time to affect MNEs' affiliates abroad. As a robustness check, we exclude multinationals operating in OFCs, which attract mainly conduit FDI. These investors, led by short-term financial motives, can hinder the real picture of cross-border investment.

The results reveal that MNEs' output and productivity performances are sensitive to changes in tariffs and non-tariff barriers, the latter having statistically and economically more significant effects. The high-tech sector is more sensitive to changing trade policy measures than the rest of the non-service sector, which has important economic implications. Multinational affiliates that are fully foreign-owned, more productive and those that operate in a wider international network of subsidiaries are more resilient to changing trade barriers. Furthermore, participation in a PTA significantly adjusts the impact of NTMs in a positive direction.

5.1. THE EFFECTS OF TRADE POLICY MEASURES ON NON-SERVICE MULTINATIONAL FIRMS

Table 1 presents the first set of results referring to the two defined samples. Panel I of Table 1 presents the results for major ownership of subsidiaries (50.01+), while panel II presents the results for the subsidiaries that are fully owned by the foreign GUO. The results reveal that different trade policies affect MNEs' turnover/sales performance differently, and these impacts are in turn differentiated given the productivity levels of the subsidiary, which supports the literature on heterogeneous effects from different policy settings (Ghodsi and Stehrer, 2022). Traditional policy barriers in the form of tariffs – levied by home or host economies – do not seem to affect MNEs' performance abroad in a statistically significant manner. On the other hand, the FDI performance (operating revenue) is (marginally) positively affected by tariffs imposed by the host economy, which is statistically significant (although only at the 10% level), suggesting that higher tariffs in the host economy encourage production abroad by multinationals. This behaviour supports the 'tariff-jumping' motive behind setting up subsidiaries. We also see that the greater effect on affiliates of MNEs stems from non-tariff barriers, in line with the growing economic importance of these measures (Adarov and Ghodsi, 2023; Ghodsi and Stehrer, 2022; Ferrantino, 2016; Laget et al., 2021).

Table 1 / PPML results: entire sample of non-service MNEs

	I			II		
	Base regression			(sample of 100% foreign-owned firms)		
Dependent variable:	O_{ft}	S_{ft}	$prod_{ft}$	O_{ft}	S_{ft}	$prod_{ft}$
$PTA_{TBT,dot-1}$	0.13	1.13***	0.26	-0.051	-0.055*	-0.25
	-0.15	-0.09	-0.17	-0.13	-0.031	-0.2
$\text{arc}\,AVE_{TBT,dost-1}$ (d against o)	0.021	-0.064	0.04	0.15	0.12	-0.91**
	-0.083	-0.084	-0.25	-0.12	-0.12	-0.36
$\text{arc}\,AVE_{TBT,odst-1}$(o against d)	-0.18**	-0.26***	0.05	-0.41**	-0.34*	-0.99*
	-0.087	-0.096	-0.24	-0.17	-0.2	-0.51
$PTA_{TBT,dot-1} \times \text{arc}\,AVE_{TBT,dost-1}$	0.016	0.11	-0.74**	0.038	-0.0063	1.00**
	-0.13	-0.16	-0.33	-0.16	-0.18	-0.39
$PTA_{TBT,dot-1} \times \text{arc}\,AVE_{TBT,odst-1}$	0.32***	0.45***	0.29	0.76***	0.61***	1.08**
	-0.11	-0.11	-0.24	-0.21	-0.23	-0.49
$PTA_{SPS,dot-1}$	-0.19	-1.21***	-0.19	0.011		0.19
	-0.15	-0.088	-0.15	-0.13		-0.17
$\text{arc}\,AVE_{SPS,dost-1}$ (d against o)	-0.14	-0.14	0.18	-0.39*	-0.33	0.057
	-0.14	-0.14	-0.38	-0.24	-0.21	-0.62
$\text{arc}\,AVE_{SPS,odst-1}$(o against d)	-0.35***	-0.44***	-0.78*	0.33	0.32	0.35
	-0.13	-0.15	-0.43	-0.21	-0.23	-0.57
$PTA_{SPS,dot-1} \times \text{arc}\,AVE_{SPS,dost-1}$	0.44*	0.17	0.066	0.52	0.6	0.04
	-0.22	-0.28	-0.51	-0.35	-0.37	-0.63
$PTA_{SPS,dot-1} \times \text{arc}\,AVE_{SPS,odst-1}$	0.74***	0.63***	0.85	0.45	0.19	-2.17**
	-0.23	-0.23	-0.54	-0.36	-0.35	-0.88
$\text{arc}\,T_{odst-1}$ (o against d)	0.12	0.14	0.19	0.66***	0.58**	2.36***
	-0.081	-0.12	-0.14	-0.24	-0.27	-0.58
$\text{arc}\,T_{dost-1}$ (d against o)	0.20*	0.23	0.25	-0.24	-0.44	0.42
	-0.11	-0.21	-0.49	-0.26	-0.5	-0.6
$prod_{ft-1}$	0.35***	0.35***		0.42***	0.41***	
	-0.031	-0.03		-0.023	-0.024	
l_{ft-1}	0.39***	0.39***	0.19***	0.44***	0.44***	0.095
	-0.032	-0.029	-0.036	-0.023	-0.025	-0.063
GDP^{sim}_{dot-1}	0.13**	0.30***	0.19	0.21**	0.22**	-1.00**
	-0.062	-0.067	-0.31	-0.11	-0.11	-0.5
HC^{dif}_{dot-1}	0.0092	0.0044	0.028*	0.018	0.020*	0.079***
	-0.0063	-0.007	-0.016	-0.011	-0.011	-0.02
KL^{dif}_{dot-1}	0.00099	0.0012	-0.041***	0.0046	-0.0066	-0.069***
	-0.0042	-0.005	-0.01	-0.0067	-0.0085	-0.017
KL_{ft-1}			0.080***			-0.023
			-0.029			-0.061
Constant	14.7***	15.1***	16.6***	13.5***	13.8***	15.8***
	-0.61	-0.59	-0.96	-0.51	-0.52	-1.64
Observations	165262	112288	156614	64785	44165	60841
Pseudo R-squared	0.989	0.989	0.97	0.988	0.988	0.963
AIC	1.17E+12	7.55E+11	4.34E+10	3.52E+11	2.55E+11	1.74E+10

Robust standard errors in parentheses; *** p<0.01; ** p<0.05; * p<0.1

NTMs in the form of TBTs and SPS measures have an important effect on the production and efficiency of multinational affiliates abroad. However, a significant difference exists with respect to whether NTMs are imposed by the home or by the host economy from the investor's point of view. The size of the coefficients reveals that NTMs imposed by the home (origin) economy against the host (destination) economy have a more significant effect on the performance of MNEs' affiliates. This could be interpreted to indicate that exporting activities (part of overall sales) of MNEs' affiliates back to the home countries are significantly affected by NTMs levied on the host economy. This can be interpreted as evidence that supports the presence of export-platform FDI (i.e. supplying goods or inputs to the MNE's home base), suggesting that a significant share of foreign subsidiaries' activities are based on exporting, which is why TBTs levied on the host economy can negatively affect subsidiaries' performance, leading also to a cut in revenues from exporting (Ekholm et al., 2007).

In line with this hypothesis, TBTs and SPS measures imposed by the home economy exert negative and significant effects on subsidiaries' performance (operating revenue and turnover), resulting from lower exports to the home countries, thereby leading to a loss of revenue/turnover from these activities. This negative effect on subsidiaries' performance also could imply lower vertical integration along the host-home economies' value chain, owing to higher NTMs.

Interestingly, the size of the negative effect of SPS measures on the production performance of subsidiaries in the host economy is twice as high as that of TBTs.[11] This implies that higher-value exports (on which SPS measures are usually imposed) are even more affected owing to more stringent bio or hygiene requirements on imports. As countries that produce already in line with the SPS measures should not be affected by these changes in regulatory NTMs, one can conclude that among the countries where MNC subsidiaries operate, there are significant non-compliers (in terms of backward sales) of imposed measures that have less capacity to cope with the standards (Ghodsi and Stehrer, 2022). The evidence points to the restrictive impact on GVCs of increased imposition of SPS measures, in line with other empirical evidence (Beghin et al., 2015).

The effect of TBT and SPS measures is, however, positive among those countries that have PTAs with TBT or SPS provisions, respectively, both of which are relevant for FDI (Laget et al., 2021). Under these PTAs, home and host economies have more aligned non-tariff policies inducing production in the host economy. This effect seems to counteract the negative effects of NTMs imposed by the home country against the host country that disincentivise supply chains. These results are in line with the growing literature on PTAs' effects on FDI (Medvedev, 2012; Baccini et al., 2017; Laget et al., 2021). Laget et al. (2021) show that increasing the scope of PTAs' coverage increases FDI by 1.4%.

TBT and SPS measures imposed by the host (destination) economy (against the home economy), do not significantly affect the performance of subsidiaries abroad (in the host economy). They will only negatively affect productivity if the home and host economies have PTAs with TBT provisions. This could be following the model described by Melitz (2003), in which larger trade costs keep the most productive firms in the market, increasing the productivity threshold, while lower trade costs induced by PTAs could reduce the productivity threshold of exporters, leading to lower productivity of subsidiaries in the sample. The insignificant effect on firm performance (sales and turnover) but the negative impact on efficiency (labour productivity) points to the mechanism via which TBTs affect firm performance – via imports of inputs.

[11] It should be noted that these are marginal effects as the variables of AVEs of NTMs are in logarithmic forms, which makes their magnitudes comparable.

Importing goods from home countries can raise the costs of the material inputs, if these are subject to higher trade costs associated with NTMs. The results show that sales (revenue and turnover) of MNEs' affiliates are not affected, but higher importing costs of inputs (and reducing the sourcing of inputs from abroad, in terms of quantity and variety) reduce firm efficiency. Possibly, many of the MNCs' affiliates have well-established supply chains with the home economy, located in a FDI host economy.

As for the control variables, they fully support previous research by Bergstrand and Egger (2013). Larger subsidiaries are more productive and have higher sales. The similarity in the home and host countries' GDPs (i.e. market size) is relevant for FDI decisions and thus for production/sales and productivity (scale effects) abroad; we referred here to the Linder effect (similarity of demand structures in similarly sized economies). Home and host country human capital differences, on the other hand, do not affect multinational production abroad, but they do affect significantly and positively its subsidiaries' productivity. This is in line with the theory of relative backwardness (Findlay, 1978) suggesting – although in the context of technologies – that the greater the technology gap between countries, the greater the scope for knowledge diffusion and the faster catch-up rate. Hence, stronger impact on productivity arising from a higher human capital gap could indicate a faster catch-up process as a result of knowledge transfers between the home (headquarters) and host (affiliate) economy. The negative effects from capital-labour differentials on productivity, on the other hand, implies different production processes being used in the home and host economies (capital-intensive vs labour-intensive); consequently the traditional neoclassical (Solovian) growth model can be referred to in that the bigger the gap in capital-labour endowments between home and host economy, the bigger also the gaps in labour productivity levels of subsidiaries in the host economy.

5.1.1. The effects on fully foreign-owned MNEs' affiliates

An alternative analysis is undertaken on the sample of the fully foreign-owned (100%) multinationals, which account for less than 40% of the entire sample, as the majority of MNEs' affiliates (60%) are established as joint ventures or through mergers and acquisitions with lower shares. The estimation results are presented in panel II of Table 1. The degree of foreign ownership can affect the nature of the subsidiary's decisions regarding trade policy measures, mainly because MNEs' headquarters have a stronger say in the decision-making process of subsidiaries in the host economy if it is fully foreign-owned (Gaur et al., 2019). These subsidiaries also tend to have superior knowledge protection to joint ventures (Javorcik and Saggi, 2010), as they choose their entry strategy to protect their intellectual property from leakage. As a consequence, they may produce higher value-added output and also have an advantage in exporting. Fully foreign-owned firms may also benefit financially from their headquarters in the home economy, which gains importance in the wake of adverse events (Vujanovic et al. 2021b). However, firms with some domestic ownership are likely to be better linked into the host country's supply chain and depend less on the supply chain with the home country.[12] These factors altogether can lead to different responses to trade policy measures. Our results confirm this.

The results show that the significance of the effects from TBTs is higher on this smaller sample, but the effects from SPS measures is lower. In other words, TBTs imposed by the home economy against the host economy reduce sales (revenue and turnover) even more when a subsidiary is missing domestic

12 Empirical evidence finds that foreign firms do not always source inputs locally, as local supplies do not meet the quality requirements necessary for the MNE's affiliate production (Damijan et al., 2013; Merlevede et al., 2014).

representation. This seems to indicate that, in the case of this sample, exporting activities are the dominant income source of MNEs' affiliates (which is why TBTs affect them greatly), strengthening our hypothesis regarding export-platform FDI or vertical integration. Partially foreign-owned subsidiaries are more likely to base their sales also on the domestic market and thus are better able to counteract the negative impact from TBTs, as borne out by the smaller size of the negative coefficient. The effect turns positive for countries that have PTAs, and the size of the effect is again larger than in the base sample, further showing the importance of the restricting impact of TBTs for export activities.

On the contrary, SPS measures in this sample affect neither the output nor productivity of fully foreign-owned subsidiaries, possibly because these MNEs already comply with phytosanitary conditions in their main markets even prior to the imposition of further measures over the estimation period. It is also important to note that SPS measures are highly concentrated in particular industries. As explained, fully foreign-owned firms tend to have superior knowledge generated either through internal R&D (within a subsidiary) or sourced from their headquarters (Gaur et al., 2019), allowing them to service products that are aligned with the quality (bio and hygiene) standards.

Tariffs imposed by the home economy on the host economy positively affect the sales (revenue, turnover) and productivity of fully foreign-owned subsidiaries. However, when we include in the sample firms with heterogeneous ownership structures, the positive and significant effect fades. The results imply that as other local firms reduce their exports (given tariff increases), fully foreign-owned multinationals can then increase their exports because they gain market shares in their country of origin. Greater market shares gained in this way counteract the losses incurred from increased tariffs that the home country imposes. The results together show that the interplay between MNEs and local firms in the host economy has an important effect on export performance when tariffs increase, as the former are likely to have a competitive advantage.

5.1.2. The role of MNE subsidiaries' productivity

It is widely known that multinationals are more productive than domestic firms, owing to various factors – such as higher R&D investment and hence greater innovation capacity, as well as better access to finance, which enables them to afford a better-qualified workforce – which lead to better production technology (Dunning and Lundan, 2008). However, productivity heterogeneity also exists among the MNEs and among subsidiaries of these MNEs, depending on differentiated technology know-how of the MNEs (or GUOs) which they can pass on to their subsidiaries; the relevance of this depends on the host country or the industry in which they operate (Yang and Driffield, 2022; Kafouros and Forsans, 2012). Traditionally, MNEs had centralised their R&D activities in their home country, but after the second world war they began to decentralise it in other developed economies and more recently, since the late 20th century, in emerging markets (Belderbos et al., 2013; Egan, 2018). In addition, not all innovative activities of MNEs' affiliates relate to R&D. Some innovations (in product specifications) are aimed at conforming to the requirements of the respective markets and thus do not necessarily take the form of R&D (Vujanovic et al., 2022). All these factors affect productivity of MNEs' affiliates and impact on the resilience to trade shocks resulting from rising trade barriers.

Table 2 / PPM results: non-service multinationals and the effects of NTMs with productivity heterogeneity

Dependent variable:	O_{ft}	S_{ft}
$prod_{ft-1}$	0.35***	0.35***
	(0.030)	(0.028)
$PTA_{TBT,dot-1}$	1.31***	2.00***
	(0.44)	(0.33)
arc $AVE_{TBT,dost-1}$ (d against o)	0.67	1.15
	(0.66)	(0.74)
arc $AVE_{TBT,odst-1}$(o against d)	-1.20**	-1.51***
	(0.53)	(0.57)
$PTA_{TBT,dot-1} \times$ arc $AVE_{TBT,dost-1}$	-2.37**	-2.10
	(1.21)	(1.58)
$PTA_{TBT,dot-1} \times$ arc $AVE_{TBT,odst-1}$	1.54**	2.08***
	(0.66)	(0.77)
$PTA_{SPS,dot-1}$	-1.04**	-1.74***
	(0.44)	(0.33)
arc $AVE_{SPS,dost-1}$ (d against o)	-1.44	-1.99*
	(0.88)	(1.02)
arc $AVE_{SPS,odst-1}$(o against d)	-0.23	-0.36
	(0.48)	(0.50)
$PTA_{SPS,dot-1} \times$ arc $AVE_{SPS,dost-1}$	-2.12	-2.83
	(1.91)	(2.76)
$PTA_{SPS,dot-1} \times$ arc $AVE_{SPS,odst-1}$	4.04**	13.0***
	(1.95)	(4.22)
$prod_{ft-1} \times PTA_{TBT,dot-1}$	-0.14***	-0.098**
	(0.040)	(0.039)
$prod_{ft-1} \times$ arc $AVE_{TBT,dost-1}$ (d against o)	-0.068	-0.13
	(0.070)	(0.079)
$prod_{ft-1} \times$ arc $AVE_{TBT,odst-1}$(o against d)	0.11*	0.14**
	(0.058)	(0.063)
$prod_{ft-1} \times PTA_{TBT,dot-1} \times$ arc $AVE_{TBT,dost-1}$	0.25*	0.23
	(0.13)	(0.17)
$prod_{ft-1} \times PTA_{TBT,dot-1} \times$ arc $AVE_{TBT,odst-1}$	-0.13*	-0.18**
	(0.072)	(0.085)
$prod_{ft-1} \times PTA_{SPS,dot-1}$	0.10***	0.062
	(0.040)	(0.039)
$prod_{ft-1} \times$ arc $AVE_{SPS,dost-1}$ (d against o)	0.15	0.21*
	(0.10)	(0.12)
$prod_{ft-1} \times$ arc $AVE_{SPS,odst-1}$(o against d)	-0.015	-0.013
	(0.053)	(0.055)
$prod_{ft-1} \times PTA_{SPS,dot-1} \times$ arc $AVE_{SPS,dost-1}$	0.29	0.35
	(0.22)	(0.32)
$prod_{ft-1} \times PTA_{SPS,dot-1} \times$ arc $AVE_{SPS,odst-1}$	-0.37*	-1.40***
	(0.22)	(0.48)
arc T_{odst-1} (o against d)	0.12	0.14
	(0.081)	(0.12)
arc T_{dost-1} (d against o)	0.25**	0.32
	(0.11)	(0.21)
l_{ft-1}	0.39***	0.39***
	(0.032)	(0.029)
GDP^{sim}_{dot-1}	0.14**	0.31***
	(0.061)	(0.065)
HC^{dif}_{dot-1}	0.0099	0.0041
	(0.0063)	(0.0070)
KL^{dif}_{dot-1}	0.00017	0.00044
	(0.0042)	(0.0050)
Constant	14.7***	14.7***
	(0.60)	(0.60)
Observations	165262	165262
Pseudo R-squared	0.989	0.989
AIC	1.16551e+12	1.16551e+12

Robust standard errors in parentheses; *** p<0.01; ** p<0.05; * p<0.1

We hypothesise that MNEs' affiliates with higher levels of productivity/efficiency are better positioned to deal with the impact of higher trade barriers. To test this hypothesis, we interact NTM variables with labour productivity levels of the subsidiary and find that more productive firms can indeed more easily absorb the trade shock following the imposition of stronger NTMs. The results are presented in Table 2. Higher productivity subsidiaries show better output performances (operating revenues and turnover) when facing increasing trade costs associated with the TBTs imposed by the home against the host economy when the two countries do not have a bilateral PTA with TBT provisions. As in the case of foreign-owned firms, higher-productivity subsidiaries gain more in revenue (and here this may come from exports to the home economy), despite increasing trade costs. This is because they can gain market shares at the cost of other (less productive) firms. When two countries have PTAs with TBT provisions, it is the lower-productivity firms that can gain from TBTs imposed by origin (home) against the destination (host). This makes sense as PTAs are designed to allow less productive firms to remain in the market (Melitz, 2003). More productive multinational subsidiaries, however, maintain a marginally better position in withstanding rising trade costs related to SPS measures, as they increase sales when facing SPS measures levied on the home economy. In the case of countries with PTAs with SPS provisions, the less productive firms can maintain sales and revenues. This again suggests that such PTAs enable lower-productivity firms to survive in markets that are covered by costly SPS measures. These results confirm the importance of interplay between different types of companies (those with higher/lower productivity) when it comes to exposure to higher trade barriers.

5.1.3. The role of multinational network size

The size of the multinational network of subsidiaries can be an important cause for productivity differences across subsidiaries affiliated with different MNEs. Buckley et al. (2014) find that the productivity differentials of MNEs depend on how well they benefit from the global 'knowledge reservoirs' of their subsidiaries abroad, especially in relation to technology and, vice versa, how subsidiaries benefit from the wider 'knowledge pool', but also from economies of scope and scale they can draw on when they are linked to a wider network. MNEs that spread their operations across many international markets will benefit more from intra-MNE knowledge exchange than those that have concentrated activities in a few locations. Moreover, MNEs tend to decentralise their R&D activities abroad too, thereby exploiting benefits from location-appropriate comparative advantages and from diversification and specialisation processes (Noailly and Ryfisch, 2015). Thus, MNEs' network size can be a significant factor impacting on their resilience in the wake of restrictive trade policies. In addition, affiliates embedded within a larger MNE network may have greater financial resources to deal with external trade shocks.

To understand what role is played by the size of an MNE network, we augmented the base regression (Table 1, panel I) by adding the variable on MNEs' network size (number of subsidiaries), which we interact with NTM variables. The results are presented in Table 3.

Table 3 / PPML results: the role of MNEs' network size

	Non-service firms		
	Op. revenue	Turnover	Productivity
$\mathbf{arc}\,AVE_{TBT,dost-1}$ (d against o)	-0.068	-0.045	0.14
	(0.089)	(0.098)	(0.26)
$\mathbf{arc}\,AVE_{TBT,odst-1}$(o against d)	-0.37***	-0.39***	0.47
	(0.12)	(0.14)	(0.31)
$\mathbf{arc}\,AVE_{SPS,dost-1}$ (d against o)	-0.022	0.028	0.39
	(0.15)	(0.15)	(0.36)
$\mathbf{arc}\,AVE_{SPS,odst-1}$(o against d)	-0.38**	-0.55***	-1.67***
	(0.15)	(0.17)	(0.52)
$NW_g \times \mathbf{arc}\,AVE_{TBT,dost-1}$	0.0026*	0.000077	-0.0083
	(0.0014)	(0.0019)	(0.0054)
$NW_g \times \mathbf{arc}\,AVE_{TBT,odst-1}$	0.0089***	0.0089***	-0.013
	(0.0027)	(0.0030)	(0.0082)
$NW_g \times \mathbf{arc}\,AVE_{SPS,dost-1}$	-0.0010	-0.0059*	-0.019**
	(0.0030)	(0.0031)	(0.0076)
$NW_g \times \mathbf{arc}\,AVE_{SPS,odst-1}$	0.0034	0.0049**	0.033***
	(0.0023)	(0.0023)	(0.0092)
$\mathbf{arc}\,T_{odst-1}$ (o against d)	0.13	0.15	0.17
	(0.082)	(0.12)	(0.14)
$\mathbf{arc}\,T_{dost-1}$ (d against o)	0.21*	0.28	0.31
	(0.11)	(0.21)	(0.50)
$prod_{ft-1}$	0.35***	0.35***	
	(0.031)	(0.030)	
l_{ft-1}	0.39***	0.39***	0.19***
	(0.031)	(0.029)	(0.036)
GDP^{sim}_{dot-1}	0.14**	0.29***	0.22
	(0.061)	(0.067)	(0.31)
HC^{dif}_{dot-1}	0.0099	0.0063	0.025
	(0.0063)	(0.0071)	(0.016)
KL^{dif}_{dot-1}	0.00073	0.0015	-0.040***
	(0.0043)	(0.0050)	(0.010)
$PTA_{TBT,dot-1}$	-0.044**	-0.052**	0.035
	(0.019)	(0.022)	(0.080)
KL_{ft-1}			0.085***
			(0.030)
Constant	14.7***	15.1***	16.6***
	(0.61)	(0.59)	(0.96)
Observations	165262	112288	156614
Pseudo R-squared	0.989	0.989	0.970
AIC	1.16571e+12	7.53858e+11	4.33392e+10

Robust standard errors in parentheses; *** p<0.01; ** p<0.05; * p<0.1

The results confirm our expectations. MNEs' subsidiaries belonging to larger networks are better able to withstand the negative trade shocks resulting from trade-restrictive TBTs levied on both home and host economies. Likewise, subsidiaries belonging to a wider international network show higher sales when an MNE's home economy levies trade-restrictive SPS measures with larger AVEs.[13] Their sales increase when facing these trade barriers, possibly through access to a larger 'knowledge pool' (related to bio and hygiene standards) and other resources from their network. This may also mean that, although regulatory NTMs restrict trade between host and home countries, the subsidiary can rely on trade relations within the network of subsidiaries or in relation to the GUO, where the impact of the trade

[13] We refer here to more trade-restrictive SPS measures, as measured by their AVEs, i.e. tariff equivalents.

restriction from regulatory measures might not be as high as the one more generally between the host and home countries. This comparative advantage shows in our estimates over other MNEs (with smaller network sizes), the output of which suffers as a result of reduced exports to home countries that levy higher NTMs (as shown by the significant negative effect). As discussed earlier, domestic firms and lower-productivity affiliates and, as now shown, MNE affiliates belonging to smaller networks may lose market share as a result of rising TBTs, to the benefit of MNEs with larger networks.

5.2. THE EFFECTS OF TRADE POLICY MEASURES ON HIGH-TECH MULTINATIONAL FIRMS

'Manufacture of basic pharmaceutical products and pharmaceutical preparations', 'manufacture of computer, electronic and optical products' and 'manufacture of air and spacecraft and related machinery' are the high-tech manufacturing sectors defined by Eurostat that are used in this part of the analysis. Eurostat's definition can only to a limited extent meet the definition of digital FDI.[14] FDI's high-tech sector covers to some extent digital FDI, which has gained momentum, but also other industries such as pharmaceuticals and medicine. According to the latest World Investment Report (UNCTAD, 2022), digital MNEs' sales have increased five times faster than those of 'traditional MNEs', and the pandemic gave them a further boost. Trentini et al. (2022) show that digital MNEs were indeed continuing to expand in the post-pandemic period, and in the wider timeframe of 2016-2021 total assets and sales of digital MNEs rose by 21%. In addition, these MNEs use fewer physical assets to reach a host destination, making this type of cross-border investment particularly appealing. These firms amount to about 12% of the non-service MNEs (Table A3), which is quite a large share and confirms the importance of this sector in FDI.

The results presented in Table 4 reveal that high-tech MNEs are more affected than the base sample by trade policy measures imposed against the host FDI economy, no matter whether these measures are in the form of tariffs or TBTs, and it is true for all our dependent variables (revenue, turnover, productivity).[15] These negative impacts are a matter of concern, as companies in high-tech sectors have been gaining importance in overall FDI as well as in economic growth. Nevertheless, if the home and host economies have a PTA with TBT provisions that could lead to harmonisation or mutual recognition, high-tech multinationals can boost their output and productivity (the latter particularly strongly). Hence, high-tech MNEs seem in this case to be able to gain an even higher share of their revenues through exporting, possibly at the cost of a shift in market shares towards them and away from other industries in which the PTA effect of moderating the negative TBT effect is less strong. The strong positive productivity effect of PTAs in these high-tech industries is an important indication of the impact of trade agreements among important trading partners even in a world where trade-restrictive TBTs are becoming more prevalent.

---

14 UNCTAD considers 'digital MNE firms' those that engage in ICT, e-commerce and internet platforms and that have some digital content (e.g. digital media). Our definition differs in that we focus on the sophistication of the technology firms use, as defined by Eurostat. These industries are the manufacture of basic pharmaceutical products and pharmaceutical preparations, the manufacture of computer, electronic and optical products, and the manufacture of air and spacecraft and related machinery (source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:High-tech_classification_of_manufacturing_industries).

15 As an alternative, we have also estimated the whole sample as presented in Table 1 and interacting the variables with a binary variable for the high-tech sectors. The results show that the effects are stronger and significantly higher for the high-tech sectors. These results are available upon request.

Table 4 / PPML results: sample high-tech manufacturing sector

	I			II		
	Base regression			(Sample of 100% foreign-owned firms)		
Dependent variable:	O_{ft}	S_{ft}	$prod_{ft}$	O_{ft}	S_{ft}	$prod_{ft}$
$PTA_{TBT,dot-1}$	0.25	-0.034	0.33	0.045	0.044	0.16
	(0.18)	(0.062)	(0.32)	(0.067)	(0.079)	(0.25)
$\text{arc}\,AVE_{TBT,dost-1}$ (d against o)	-0.094	-0.094	0.54	0.027	0.072	-1.39**
	(0.17)	(0.15)	(0.51)	(0.19)	(0.18)	(0.70)
$\text{arc}\,AVE_{TBT,odst-1}$(o against d)	-0.39***	-0.49***	-1.43**	-0.34	-0.34	-3.20***
	(0.14)	(0.15)	(0.57)	(0.23)	(0.25)	(0.87)
$PTA_{TBT,dot-1} \times \text{arc}\,AVE_{TBT,dost-1}$	0.19	0.13	-1.80***	0.22	0.21	2.33***
	(0.21)	(0.24)	(0.67)	(0.25)	(0.29)	(0.72)
$PTA_{TBT,dot-1} \times \text{arc}\,AVE_{TBT,odst-1}$	0.66***	0.68***	4.34***	0.69**	0.51	6.04***
	(0.24)	(0.24)	(0.96)	(0.34)	(0.35)	(1.36)
$PTA_{SPS,dot-1}$	-0.30*		-0.12	0	0	0
	(0.17)		(0.23)	(.)	(.)	(.)
$\text{arc}\,AVE_{SPS,dost-1}$ (d against o)	-0.12	0.029	-2.52**	-1.24**	-0.76**	-2.03*
	(0.39)	(0.30)	(1.22)	(0.49)	(0.34)	(1.13)
$\text{arc}\,AVE_{SPS,odst-1}$(o against d)	-0.40*	-0.40*	-0.42	0.41	0.73**	3.02***
	(0.21)	(0.21)	(0.82)	(0.36)	(0.37)	(1.00)
$PTA_{SPS,dot-1} \times \text{arc}\,AVE_{SPS,dost-1}$	0.097	-0.42	3.95*	2.74***	2.15***	-0.41
	(0.79)	(1.01)	(2.06)	(0.86)	(0.78)	(2.85)
$PTA_{SPS,dot-1} \times \text{arc}\,AVE_{SPS,odst-1}$	0.52	0.10	-0.32	0.78	0.10	-9.07***
	(0.45)	(0.41)	(1.35)	(0.68)	(0.57)	(2.42)
$\text{arc}\,T_{odst-1}$ (o against d)	-3.44**	-2.46	-24.9**	-1.72	-0.56	1.89
	(1.43)	(1.54)	(11.0)	(1.92)	(2.06)	(6.01)
$\text{arc}\,T_{dost-1}$ (d against o)	0.80	0.70	10.2**	0.22	-0.61	-5.00
	(0.88)	(0.96)	(4.73)	(1.10)	(1.16)	(5.44)
$prod_{ft-1}$	0.38***	0.35***		0.44***	0.43***	
	(0.040)	(0.041)		(0.044)	(0.043)	
l_{ft-1}	0.42***	0.39***	0.23**	0.47***	0.45***	-0.13
	(0.041)	(0.042)	(0.098)	(0.045)	(0.043)	(0.18)
GDP^{sim}_{dot-1}	0.42***	0.47***	0.35	0.39	0.30	-3.64***
	(0.16)	(0.15)	(0.86)	(0.28)	(0.27)	(1.09)
HC^{dif}_{dot-1}	0.016	0.017	0.16***	0.14***	0.10**	0.13*
	(0.022)	(0.020)	(0.055)	(0.047)	(0.040)	(0.064)
KL^{dif}_{dot-1}	0.0075	0.018	-0.19***	-0.0031	0.0064	-0.39***
	(0.014)	(0.017)	(0.049)	(0.024)	(0.029)	(0.081)
KL_{ft-1}			0.082			-0.27
			(0.083)			(0.18)
Constant	15.4***	15.9***	20.4***	14.2***	14.1***	21.0***
	(0.95)	(0.95)	(3.10)	(1.30)	(1.18)	(5.11)
Observations	19218	14537	18030	8417	6597	7789
Pseudo R-squared	0.985	0.985	0.975	0.981	0.982	0.956
AIC	4.18452e+11	3.20803e+11	1.48347e+10	1.58694e+11	1.32348e+11	7.70E+09

Robust standard errors in parentheses; *** p<0.01; ** p<0.05; * p<0.1

Trade-restrictive SPS measures imposed by origin (home) against the destination (host) pose a lesser threat to the production and productivity performances of MNEs in high-tech industries, as the effects are lower in significance and size. Hygiene and bio standards are more likely to affect other non-service industries, i.e. those that involve food, plant or animal life in their production processes. Fast-growing FDI happens to be specifically in the information and communications technology (ICT) sector and the manufacture of electronics and spacecraft that are less affected by SPS measures (although the pharmaceutical sector, which is also part of the group of high-tech industries, is highly exposed to SPS measures). However, while SPS measures imposed by the host had no statistically significant impact on the output (turnover, revenue) variables in the whole sample, they show a strongly negative impact on the productivity of high-tech subsidiaries. In fact, when the trade costs associated with the SPS measures imposed by host against home increases by 1%, the productivity of the high-tech subsidiary in the host decreases by about 2.52%. This means that any host economy that seeks to attract pharmaceutical investors should reduce the trade costs of SPS measures to offer a conducive environment.

The productivity of fully (100%) foreign-owned high-tech multinationals' subsidiaries (about 44% of all MNEs' subsidiaries in high-tech industries with diverse ownership structures) is even more sensitive to TBTs. Irrespective of whether imposed by the home or the host economy, trade-restrictive TBTs decrease the productivity of fully foreign-owned high-tech manufacturing subsidiaries, as these firms seem to be highly embedded in GVCs (through importing and exporting), which is why their performance declines so much on the imposition of TBTs. This negative effect is circumvented greatly once the home and host economies have PTAs that aim to recognise bilateral TBTs, in which case productivity is further enhanced, and significantly more so than in the overall sample of high-tech firms. Thus, these companies – with a much stronger control of their subsidiaries – benefit particularly from PTAs, which can translate their relative strength into enhanced productivity performances.

Hence, although the literature points out that high-tech trade is in principle more resilient to shocks and outperforms overall goods trade (Miller and Wunsch-Vincent, 2021), we show that there are strong impacts of TBTs (and tariffs) in high-tech industries. These, however, become strongly moderated through PTAs, and multinationals with full ownership control of subsidiaries derive a greater benefit from these (specifically in productivity terms).

5.3. ROBUSTNESS CHECK

For a robustness check, we exclude OFCs that predominantly represent conduit FDI, driven by favourable financial (tax) motives (Vujanovic et al., 2021a) from both samples, non-service firms and high-tech multinationals.[16] The results are presented in the Appendix. Investors exploiting OFCs are not led by the economic rationale of MNEs' production and investment decisions, and thus we expect that the inclusion of these countries may distort the results. Our initial sample includes only about 7% of non-service multinationals involved in OFCs, and about 9% of multinationals in high-tech industries. When we exclude MNE subsidiaries in these OFCs, the significance levels, as well as the size of the parameter estimates, increase, especially for trade policy measures. The effects of various trade policies on firm performance and efficiency increase in statistical and economic significance too when we exclude country outliers that attract more special purpose entities,[17] rather than MNEs contributing to the country's growth and trade (UNCTAD, 2019). This implies that the economic rationale behind investors' location choices, reacting to trade policy measures, strengthens when we exclude OFCs, as expected.

[16] We use the UNCTAD definition of OFC countries.

[17] Special purpose entities (SPEs) are legal entities that MNEs establish in a location to serve a certain short-term purpose such as avoiding financial risks. It is important to note that SPEs usually have zero employment. Because we exclude multinationals with zero employment in the base regression, many SPEs are eliminated even from our base sample. Therefore, these new sets of estimation serve as a further robustness check.

6. Conclusion

This paper presented an analysis of the impact of tariffs and of two types of NTMs, namely TBTs and SPS measures, on performance indicators of MNE subsidiaries. The performance indicators selected for this analysis were ‘output’ or ‘sales’ (proxied by ‘turnover’ and ‘operating revenue’) and ‘labour productivity’. The analysis undertaken for this paper went through a number of different stages. It described the methodology to estimate AVEs for NTMs based on the use of the highly disaggregated HS 6-digit product-level database within a gravity modelling framework. This allowed a very detailed computation of time-varying AVEs for NTMs by country and sector. It then used these AVEs to study the impact of NTMs on MNE subsidiary performance (operating revenue, turnover and productivity) as it analysed the impact of the imposition of NTMs in ‘host’ and ‘home’ locations.

The analysis yielded a range of interesting results. NTMs pose a greater challenge to MNE affiliates’ activity and performance than tariffs do. High-tech manufacturing subsidiaries of foreign MNEs are particularly vulnerable to these NTMs, as they suffer higher regulatory losses. However, multinational affiliates that have higher productivity, full foreign ownership of their subsidiaries, and those that are embedded within a larger international network of subsidiaries can turn these trade challenges to their advantage. Furthermore, ‘deep’ PTAs (including provisions for the recognition of regulatory frameworks) among trading partner countries can similarly turn the impact of increased severity of NTMs in a strongly positive direction. Following the literature on ‘heterogeneous firms’ (Melitz, 2003), we also look at differentiated impacts of NTMs along firm productivity distributions. This shows that the higher-productivity firms/subsidiaries can shield themselves better from the negative impact of more restrictive NTMs.

References

Adarov, A. and M. Ghodsi (2023), 'Heterogeneous effects of nontariff measures on cross-border investments: Bilateral firm-level analysis', *Review of International Economics*, Vol. 31(1), pp. 158-179.

Anderer, C., A. Dür and L. Lechner (2020), 'Trade policy in a "GVC world": Multinational corporations and trade liberalization', *Business and Politics*, Vol 22(4), pp. 639-666.

Anderson, T.W. and H. Rubin (1949), 'Estimation of the parameters of a single equation in a complete system of stochastic equations', *The Annals of Mathematical Statistics*, Vol. 20(1), pp. 46-63.

Baccini, L., P.M. Pinto and S. Weymouth (2017), 'The distributional consequences of preferential trade liberalization: Firm-level evidence', *International Organization*, Vol. 71(2), pp. 373-395.

Baier, S.L. and J.H. Bergstrand (2007), 'Do free trade agreements actually increase members' international trade?', *Journal of International Economics*, Vol. 71(1), pp. 72-95.

Baldwin, R. (2016), *The Great Convergence: Information Technology and the New Globalization*, Harvard University Press, Cambridge, Massachusetts.

Beghin, J.C., M. Maertens and J. Swinnen (2015), 'Nontariff measures and standards in trade and global value chains', *Annual Review of Resource Economics*, Vol. 7(1), pp. 425-450.

Belderbos, R., B. Leten and S. Suzuki (2013), 'How global is R&D? Firm-level determinants of home-country bias in R&D', *Journal of International Business Studies*, Vol. 44(8), pp. 765-786.

Bellamy, M.A., S. Ghosh and M. Hora (2014), 'The influence of supply network structure on firm innovation', *Journal of Operations Management*, Vol. 32(6), pp. 357-373. doi: 10.1016/j.jom.2014.06.004

Bellemare, M.F. and C.J. Wichman (2020), 'Elasticities and the inverse hyperbolic sine transformation', *Oxford Bulletin of Economics and Statistics*, Vol. 82(1), pp. 50-61.

Bergstrand, J.H. and P. Egger (2007), 'A knowledge-and-physical-capital model of international trade flows, foreign direct investment, and multinational enterprises', *Journal of International Economics*, Vol. 73(2), pp. 278-308.

Bergstrand, J.H. and P. Egger (2013), 'Shouldn't physical capital also matter for multinational enterprise activity?', *Review of International Economics*, Vol. 21(5), pp. 945-965.

Blind, K. and A. Jungmittag (2005), 'Trade and the impact of innovations and standards: The case of Germany and the UK', *Applied Economics*, Vol. 37(12), pp. 1385-1398.

Blonigen, B.A., K. Tomlin and W.W. Wilson (2004), 'Tariff-jumping FDI and domestic firms' profits', *Canadian Journal of Economics*, Vol. 37(3), pp. 656-677.

Bora, B., A. Kuwahara and S. Laird (2002), 'Quantification of non-tariff measures', United Nations Conference on Trade and Development (Division on International Trade in Goods and Services, and Commodities, Trade Analysis Branch), Geneva.

Bratt, M. (2017), 'Estimating the bilateral impact of nontariff measures on trade', *Review of International Economics*, Vol. 25(5), pp. 1105-1129.

Buckley, P.J., M.I Kafouros and J. Clegg (2014), 'The effects of global knowledge reservoirs on the productivity of multinational enterprise: The role of international depth and breadth', in: P.J. Buckley (ed.), *The Multinational Enterprise and the Emergence of the Global Factory*, Palgrave Macmillan, Basingstoke, pp. 220-254.

Cadestin, C., K. De Backer, I. Desnoyers-James, S. Miroudot, D. Rigo and M. Ye (2018), 'Multinational enterprises and global value chains: the OECD analytical AMNE database', OECD Trade Policy Papers, No. 211.

Cardamone, P. and M. Scoppola (2012), 'The impact of EU preferential trade agreements on foreign direct investment, *The World Economy*, Vol. 35(11), pp. 1473-1501.

Casella, B. and L. Formenti (2018), 'FDI in the digital economy: a shift to asset-light international footprints', *Transnational Corporations*, Vol. 25(1), pp. 101-130.

Cole, M.T. and R.B. Davies (2011), 'Strategic tariffs, tariff jumping, and heterogeneous firms', *European Economic Review*, Vol. 55(4), pp. 480-496. doi: 10.1016/j.euroecorev.2010.07.006

Damijan, J.P., M. Rojec, B. Majcen and M. Knell (2013), 'Impact of firm heterogeneity on direct and spillover effects of FDI: Micro-evidence from ten transition countries', *Journal of Comparative Economics*, Vol. 41(3), pp. 895-922.

Davidson, R. and J.G. MacKinnon (1993), *Estimation and Inference in Econometrics*, Oxford University Press, Oxford and New York.

Du, L., A. Harrison and G. Jefferson (2014), 'FDI spillovers and industrial policy: The role of tariffs and tax holidays', *World Development*, Vol. 64, pp. 366-383. doi: 10.1016/j.worlddev.2014.06.005

Dunning, J.H. and S.M. Lundan (2008), *Multinational Enterprises and the Global Economy*, Edward Elgar Publishing, Cheltenham.

Egan, P.J.W. (2018), Globalizing Innovation: State Institutions and Foreign Direct Investment in Emerging Economies, MIT Press, Cambridge, Massachusetts.

Egger, P. and M. Pfaffermayr (2005), 'The determinants of intrafirm trade: in search for export-import magnification effects', *Review of World Economics*, Vol. 141(4), pp. 648-669.

Ekholm, K., R. Forslid and J.R. Markusen (2007), 'Export-platform foreign direct investment', *Journal of the European Economic Association*, Vol. 5(4), pp. 776-795.

Feenstra, R.C., R. Inklaar and M.P. Timmer (2015), 'The next generation of the Penn World Table', *American Economic Review*, Vol. 105(10), pp. 3150-3182.

Ferrantino, M.J. (2016), 'Non-tariff measures', in: S. Woolcock and K. Heydon (eds), *The Ashgate Research Companion to International Trade Policy,* Routledge, Abingdon, pp. 117-132.

Findlay, R. (1978), 'Relative backwardness, direct foreign investment, and the transfer of technology: A simple dynamic model', *The Quarterly Journal of Economics*, Vol. 92(1), pp. 1-16.

Fontagné, L., G. Orefice, R. Piermartini and N. Rocha (2015), 'Product standards and margins of trade: Firm-level evidence', *Journal of International Economics*, Vol. 97(1), pp. 29-44.

Gaur, A.S., H. Ma and B. Ge (2019), 'MNC strategy, knowledge transfer context, and knowledge flow in MNEs', *Journal of Knowledge Management*, Vol. 23(9), pp. 1885-1900.

Gereffi, G., H.-C. Lim and J. Lee (2021), 'Trade policies, firm strategies, and adaptive reconfigurations of global value chains', *Journal of International Business Policy,* Vol. 4(4), pp. 506-522. https://doi.org/10.1057/s42214-021-00102-z

Ghodsi, M. (2020a), 'How do technical barriers to trade affect foreign direct investment? Tariff jumping versus regulation haven hypotheses', *Structural Change and Economic Dynamics*, Vol. 52, pp. 269-278.

Ghodsi, M. (2020b), 'The impact of Chinese technical barriers to trade on its manufacturing imports when exporters are heterogeneous', *Empirical Economics*, Vol. 59(4), pp. 1667-1698.

Ghodsi, M. and R. Stehrer (2016), 'Non-tariff measures trickling through global value chains', Productivity, Non-Tariff Measures and Openness (PRONTO) Working Paper, The Vienna Institute for International Economic Studies (wiiw), Vienna.

Ghodsi, M. and R. Stehrer (2022), 'Trade policy and global value chains: tariffs versus non-tariff measures', *Review of World Economics*, Vol. 158(3), pp. 887-916.

Head, K. and T. Mayer (2014), 'Gravity equations: workhorse, toolkit, and cookbook', in: G. Gopinath, E. Helpman and K. Rogoff (eds), *Handbook of International Economics, Vol. 4*, Elsevier, Amsterdam, pp. 131-195.

Helpman, E., M.J. Melitz and S.R. Yeaple (2004), 'Export versus FDI with heterogeneous firms', *American Economic Review*, Vol. 94(1), pp. 300-316. doi: 10.1257/000282804322970814

Hofmann, C., A. Osnago and M. Ruta (2017), 'Horizontal depth: a new database on the content of preferential trade agreements', World Bank Policy Research Working Paper, No. 7981. Available at SSRN: https://ssrn.com/abstract=2923535

Ito, T. (2013), 'Export-platform foreign direct investment: Theory and evidence', *The World Economy*, Vol. 36(5), pp. 563-581.

Javorcik, B.S. (2004), 'Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages', *American Economic Review*, No. 94(3), pp. 605-627.

Javorcik, B.S. and K. Saggi (2010), 'Technological asymmetry among foreign investors and mode of entry', *Economic Inquiry*, Vol. 48(2), pp. 415-433.

Kafouros, M.I. and N. Forsans (2012), 'The role of open innovation in emerging economies: Do companies profit from the scientific knowledge of others?', *Journal of World Business*, Vol. 47(3), pp. 362-370.

Kano, L., E.W.K. Tsang and H.W.-C. Yeung, (2020), 'Global value chains: A review of the multi-disciplinary literature', *Journal of International Business Studies*, Vol. 51(4), pp. 577-622.

Kee, H.L., A. Nicita and M. Olarreaga (2008), 'Import demand elasticities and trade distortions', *The Review of Economics and Statistics*, Vol. 90(4), pp. 666-682.

Kee, H.L., A. Nicita and M. Olarreaga (2009), 'Estimating trade restrictiveness indices', *The Economic Journal*, Vol. 119(534), pp. 172-199.

Kim, I.S., S. Liao and S. Miyano (2023), 'Why FDI and trade politics should be studied together'. Accessed from https://stevenliao.org/uploads/fditrade.pdf

Kosová, R. (2010), 'Do foreign firms crowd out domestic firms? Evidence from the Czech Republic', *The Review of Economics and Statistics,* Vol. 92*(*4), pp. 861-881.

Laget, E., N. Roch and G. Varela (2021), 'Deep trade agreement and foreign direct investments', World Bank Policy Research Working Paper, No. 9829.

Lee, I.H., E. Hong and S. Makino (2020), 'The effect of non-conventional outbound foreign direct investment (FDI) on the domestic employment of multinational enterprises (MNEs)', *International Business Review*, Vol. 29(3), 101671.

Linder, S. (1961), *An Essay on Trade and Transformation*, John Wiley and Sons, New York.

Markusen, J.R. (2002), *Multinational Firms and the Theory of International Trade*, MIT Press, Cambridge, Massachusetts.

Markusen, J.R. (2013), 'Multinational firms', in: D. Bernhofen, R. Falvey, D. Greenaway and U. Kreickemeier (eds), *Palgrave Handbook of International Trade*, Palgrave Macmillan, London, pp. 236-262.

Martínez-San Román, V., M Bengoa and B. Sánchez-Robles (2016), 'Foreign direct investment, trade integration and the home bias; evidence from the European Union', *Empirical Economics*, Vol. 50(1), pp. 197-229.

Mayer, T. and S. Zignago (2011), 'Notes on CEPII's distances measures: The GeoDist database', CEPII Working Paper, No. 2011-25. http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=6

Medvedev, D. (2012), 'Beyond trade: the impact of preferential trade agreements on FDI inflows', *World Development*, Vol. 40(1), pp. 49-61.

Melitz, M.J. (2003), 'The impact of trade on intra-industry reallocations and aggregate industry productivity', *Econometrica*, Vol. 71(6), pp. 1695-1725.

Merlevede, B., K. Schoors and M. Spatareanu (2014), 'FDI spillovers and time since foreign entry', *World Development*, Vol. 56, pp. 108-126.

Miller, J. and S. Wunsch-Vincent (2021), 'High-tech trade rebounded strongly in the second half of 2020, with new Asian exporters benefiting', World Intellectual Property Organization. https://www.wipo.int/pressroom/en/news/2021/news_0001.html

Mullahy, J. and E.C. Norton (2022), 'Why transform Y? A critical assessment of dependent-variable transformations in regression models for skewed and sometimes-zero outcomes', National Bureau of Economic Research Working Paper, No. 30735. doi: 10.3386/w30735

Navaretti, G.B., G. Felice, E. Forlani and P.G. Garella (2018), 'Non-tariff measures and competitiveness', Centro Studi Luca d'Agliano Development Working Paper, No. 438. Available at SSRN: https://ssrn.com/abstract=3285104 or http://dx.doi.org/10.2139/ssrn.3285104

Niu, Z., C. Liu, S. Gunessee and C. Milner (2018), 'Non-tariff and overall protection: evidence across countries and over time', *Review of World Economics*, Vol. 154(4), pp. 675-703.

Noailly, J. and D. Ryfisch (2015), 'Multinational firms and the internationalization of green R&D: A review of the evidence and policy implications', *Energy Policy*, Vol. 83, pp. 218-228.

Pananond, P., G. Gereffi and T. Pedersen (2020), 'An integrative typology of global strategy and global value chains: the management and organization of cross-border activities', *Global Strategy Journal*, Vol. 10(3), pp. 421-443.

Reed, R., C. Lira, L. Byung-Ki and J. Lee (2016), 'Free trade agreements and foreign direct investment: The role of endogeneity and dynamics', *Southern Economic Journal*, Vol. 83(1), pp. 176-201. doi: 10.1002/soej.12136

Ryan, P., G. Buciuni, M. Giblin and U. Andersson (2020), 'Subsidiary upgrading and global value chain governance in the multinational enterprise', *Global Strategy Journal*, Vol. 10(3), pp. 496-519.

Santos Silva, J.M.C. and S. Tenreyro (2006), 'The log of gravity', *The Review of Economics and Statistics*, Vol. 88(4), pp. 641-658.

Trentini, C., J. de Camargo Mainente and A. Santos-Paulino (2022), 'The evolution of digital MNEs: an empirical note', *Transnational Corporations,* Vol. 29(1), pp. 163-187.

UNCTAD (2012), 'International classification of non-tariff measures', United Nations Conference on Trade and Development, Geneva and New York. https://unctad.org/system/files/official-document/ditctab20122_en.pdf

UNCTAD (2013), 'GVCs and development: Investment and value-added trade in the global economy', United Nations Conference on Trade and Development, Geneva and New York.

UNCTAD (2016), 'Trade and Development Report 2016: Structural transformation for inclusive and sustained growth', United Nations Conference on Trade and Development, Geneva and New York.

UNCTAD (2019), 'World Investment Report 2019: Special economic zones', United Nations Conference on Trade and Development, Geneva and New York.

UNCTAD (2020), 'World Investment Report 2020: International production beyond the pandemic', United Nations Conference on Trade and Development, Geneva and New York.

UNCTAD (2022), 'World Investment Report 2022: International Tax Reforms and Sustainable Investment', United Nations Conference on Trade and Development, Geneva and New York.

Van Beveren, I. (2012), 'Total factor productivity estimation: A practical review', *Journal of Economic Surveys*, Vol. 26(1), pp. 98-128.

Voegtlin, C. and A.G. Scherer (2017), 'Responsible innovation and the innovation of responsibility: Governing sustainable development in a globalized world', *Journal of Business Ethics*, Vol. 143(2), pp. 227-243.

Vujanović, N., B. Casella and R. Bolwijn (2021a), 'Forecasting global FDI: a panel data approach', *Transnational Corporations,* Vol. 28(1), pp. 97-125.

Vujanović, N., N. Stojčić and I. Hashi (2021b), 'FDI spillovers and firm productivity during crisis: Empirical evidence from transition economies', *Economic Systems*, Vol. 45(2), 100865.

Vujanović, N., S. Radošević, N. Stojčić, M. Hisarciklilar and I. Hashi (2022), 'FDI spillover effects on innovation activities of knowledge using and knowledge creating firms: Evidence from an emerging economy', *Technovation*, Vol. 118, 102512.

WTO (2022), 'Overview of developments in the international trading environment. Annual report by the Director-General', WT/TPR/OV/25 Trade Policy Review Body, World Trade Organization, Geneva. https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=q:/WT/TPR/OV25.pdf&Open=True

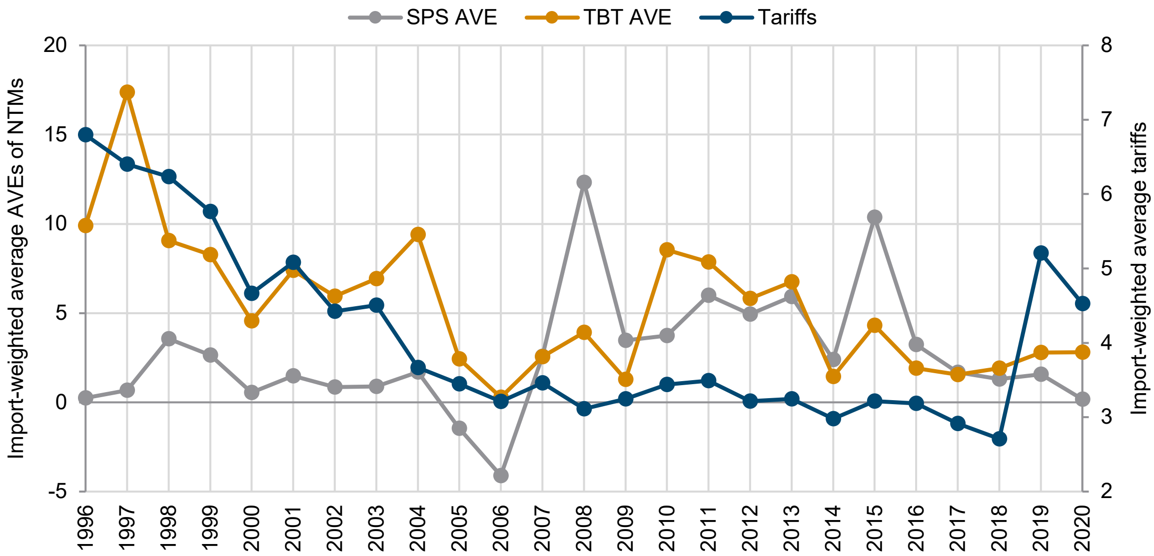
Yang, Y. and N. Driffield (2022), 'Leveraging the benefits of location decisions into performance: A global view from matched MNEs', *Journal of Business Research*, Vol. 139, pp. 468-483.

Yeung, H.W.-C. (2018), 'The logic of production networks', in: G.L. Clark, M.P. Feldman, M.S. Gertler and D. Wojcik (eds), *The New Oxford Handbook of Economic Geography*, Oxford University Press, Oxford, pp. 382-406.

Yotov, Y.V., R. Piermartini, J.A. Monteiro and M. Larch (2016), 'An advanced guide to trade policy analysis: The structural gravity model', World Trade Organization, Geneva. https://www.wto.org/english/res_e/booksp_e/advancedwtounctad2016_e.pdf

Appendix

Figure A1 / Import average of tariffs and estimated AVEs of NTMs (excluding zero trade flows)



Sources: WTO I-TIP; UN COMTRADE; WITS; authors' estimations.

Table A1 / PPML results: non-service and high-tech multinationals outside OFCs

	Non-service firms outside OFCs			High-tech firms outside OFCs		
Dependent variable:	**Op. revenue**	**Turnover**	**Productivity**	**Op. revenue**	**Turnover**	**Productivity**
$PTA_{TBT,dot-1}$	0.12	1.10***	0.29*	0.35*	0.015	0.43
	(0.17)	(0.096)	(0.17)	(0.20)	(0.068)	(0.28)
$\text{arc}\, AVE_{TBT,dost-1}$ (d against o)	0.026	-0.044	-0.12	-0.063	0.0079	0.016
	(0.085)	(0.088)	(0.28)	(0.18)	(0.16)	(0.59)
$\text{arc}\, AVE_{TBT,odst-1}$(o against d)	-0.22**	-0.27***	-0.080	-0.44***	-0.46***	-1.60***
	(0.094)	(0.10)	(0.27)	(0.15)	(0.16)	(0.60)
$PTA_{TBT,dot-1} \times \text{arc}\, AVE_{TBT,dost-1}$	0.074	0.26	-0.74**	0.10	0.14	-1.42*
	(0.14)	(0.18)	(0.36)	(0.24)	(0.33)	(0.74)
$PTA_{TBT,dot-1} \times \text{arc}\, AVE_{TBT,odst-1}$	0.35***	0.43***	0.15	0.72***	0.59**	4.97***
	(0.11)	(0.12)	(0.25)	(0.25)	(0.26)	(1.09)
$PTA_{SPS,dot-1}$	-0.18	-1.18***	-0.22	-0.34*		-0.35**
	(0.17)	(0.094)	(0.15)	(0.19)		(0.16)
$\text{arc}\, AVE_{SPS,dost-1}$ (d against o)	-0.29*	-0.33**	0.61	-0.95	-0.43	-0.94
	(0.16)	(0.16)	(0.38)	(0.77)	(0.45)	(1.31)
$\text{arc}\, AVE_{SPS,odst-1}$(o against d)	-0.20	-0.24	-0.59	-0.18	-0.14	0.018
	(0.13)	(0.15)	(0.44)	(0.21)	(0.21)	(0.83)
$PTA_{SPS,dot-1} \times \text{arc}\, AVE_{SPS,dost-1}$	0.50**	0.38	-0.37	1.99**	2.29*	2.79
	(0.24)	(0.32)	(0.54)	(0.94)	(1.37)	(2.51)
$PTA_{SPS,dot-1} \times \text{arc}\, AVE_{SPS,odst-1}$	0.62***	0.49**	0.64	0.44	0.025	-1.02
	(0.22)	(0.23)	(0.55)	(0.43)	(0.40)	(1.40)
$\text{arc}\, T_{odst-1}$ (o against d)	0.12	0.086	0.19	-1.37	-1.21	-30.0***
	(0.081)	(0.12)	(0.14)	(1.57)	(1.84)	(11.0)
$\text{arc}\, T_{dost-1}$ (d against o)	0.24**	0.37**	0.32	1.21	1.19	11.5**
	(0.11)	(0.19)	(0.49)	(0.87)	(0.92)	(4.93)
$prod_{ft-1}$	0.36***	0.34***		0.38***	0.35***	
	(0.026)	(0.031)		(0.041)	(0.043)	
l_{ft-1}	0.41***	0.38***	0.20***	0.41***	0.39***	0.26**
	(0.025)	(0.030)	(0.039)	(0.043)	(0.044)	(0.11)
GDP^{sim}_{dot-1}	0.12**	0.29***	0.29	0.25	0.32**	0.42
	(0.062)	(0.069)	(0.32)	(0.15)	(0.15)	(0.93)
HC^{dif}_{dot-1}	0.0080	0.0029	0.0073	0.021	0.017	0.15***
	(0.0062)	(0.0071)	(0.017)	(0.023)	(0.024)	(0.058)
KL^{dif}_{dot-1}	0.0029	0.0034	-0.037***	0.011	0.016	-0.22***
	(0.0043)	(0.0052)	(0.011)	(0.015)	(0.018)	(0.055)
KL_{ft-1}			0.090***			0.11
			(0.032)			(0.096)
Constant	14.3***	15.0***	16.6***	14.8***	15.4***	20.4***
	(0.51)	(0.61)	(0.99)	(0.91)	(0.95)	(3.37)
Observations	156144	104814	147444	17552	13322	16375
Pseudo R-squared	0.988	0.988	0.970	0.983	0.984	0.975
AIC	1.02816e+12	6.93666e+11	4.06116e+10	3.66117e+11	2.96579e+11	1.40372e+10

Robust standard errors in parentheses; *** p<0.01; ** p<0.05; * p<0.1

Table A2 / Summary statistics of variables in the samples of estimations, 2004-2020

Year	Total assets of foreign-owned subsidiaries (USD trn)	Operating revenue (turnover) of foreign-owned subsidiaries (USD trn)	No. of employees of foreign-owned subsidiaries (million)	No. of firms with a non-missing value on total assets	No. of firms with a non-missing value on turnover	No. of firms with a non-missing value on number of employees	No. of firms with a non-missing value on any of the three variables	Average total assets (USD m)	Average turnover (USD m)	Simple average labour productivity of foreign-owned subsidiaries	Average no. of employees	No. of GUOs in sample	Aggregate labour productivity (USD 000)
2004	0.1	0.1	0.3	192	194	194	194	298	339	658	1,355	161	250
2005	0.1	0.1	0.4	259	261	248	261	324	336	1,218	1,565	207	226
2006	0.1	0.1	0.6	603	605	590	605	197	243	41,861	1,047	500	238
2007	0.1	0.2	0.8	906	906	891	906	153	169	838	893	724	193
2008	0.3	0.3	1.3	1,495	1,495	1,475	1,495	174	174	650	899	1,105	196
2009	0.3	0.3	1.7	2,194	2,195	2,179	2,195	131	136	1,279	802	1,517	171
2010	0.7	0.8	3.3	5,123	5,124	5,075	5,124	140	164	1,431	649	2,708	256
2011	1.9	2.3	6.8	13,961	13,968	12,838	13,969	139	161	2,838	530	6,819	331
2012	2.3	2.5	6.8	15,790	15,803	15,302	15,806	143	160	12,398	442	7,609	374
2013	2.5	2.7	7.3	16,679	16,698	14,617	16,699	149	159	1,515	496	8,093	366
2014	2.6	2.6	7.9	16,942	17,008	16,338	17,011	156	154	681	483	8,432	333
2015	2.8	2.6	9.8	18,971	19,050	18,519	19,051	148	136	558	529	9,429	265
2016	2.9	2.6	9.9	20,537	20,622	20,169	20,625	141	127	466	492	10,140	264
2017	3.4	3.3	10.3	21,985	22,011	21,389	22,013	156	149	609	483	10,819	316
2018	3.8	3.7	11.6	23,685	23,875	23,382	23,878	159	153	1,025	497	11,771	315
2019	3.6	3.6	11.0	22,428	23,054	22,515	23,061	161	156	814	489	11,431	327
2020	2.7	3.2	9.3	16,708	20,300	19,495	20,300	160	158	664	480	10,387	342

Table A3 / Summary statistics of variables in the samples of estimations, 2018-2019 averages

NACE	Technology	Sector description	Total assets of foreign-owned subsidiaries (USD trn)	Operating revenue (turnover) of foreign-owned subsidiaries (USD trn)	No. of employees of foreign-owned subsidiaries (million)	No. of firms with a non-missing value on total assets	No. of firms with a non-missing value on turnover	No. of firms with a non-missing value on number of employees	No. of firms with a non-missing value on any of the three variables	Average total assets (USD m)	Average turnover (USD m)	Simple average labour productivity of foreign-owned subsidiaries (USD 000)	Average no. of employees - right axis	No. of GUOs in sample
C01	Agriculture	Crop and animal production, hunting and related service activities	0.0	0.0	0.2	1,519	1,521	1,490	1,522	21	13	151	107	1,098
C02	Agriculture	Forestry and logging	0.0	0.0	0.0	73	74	71	74	48	22	571	78	65
C03	Agriculture	Fishing and aquaculture	0.0	0.0	0.0	94	94	88	94	32	27	429	50	73
C05	MIN	Mining of coal and lignite	0.2	0.1	0.1	83	83	80	83	1,858	935	8,130	933	43
C06	MIN	Extraction of crude petroleum and natural gas	0.1	0.1	0.0	153	153	147	153	983	483	3,831	233	111
C07	MIN	Mining of metal ores	0.1	0.1	0.2	131	131	128	131	924	473	3,731	1,457	92
C08	MIN	Other mining and quarrying	0.0	0.0	0.0	267	267	260	267	128	51	252	137	193
C10	LT	Manufacture of food products	0.2	0.3	0.9	1,958	1,979	1,936	1,979	112	136	447	482	1,079
C11	LT	Manufacture of beverages	0.1	0.1	0.3	438	440	429	440	209	150	643	584	229
C12	LT	Manufacture of tobacco products	0.0	0.0	0.1	42	42	41	42	530	647	1,513	1,423	12
C13	LT	Manufacture of textiles	0.0	0.0	0.1	386	392	388	392	50	50	273	323	305
C14	LT	Manufacture of wearing apparel	0.0	0.0	0.2	442	444	437	444	35	30	277	363	390
C15	LT	Manufacture of leather and related products	0.0	0.0	0.2	173	176	173	176	20	35	134	1,074	148
C16	LT	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.0	0.0	0.1	467	468	457	468	31	25	397	130	399
C17	LT	Manufacture of paper and paper products	0.1	0.1	0.2	465	474	466	474	203	165	407	528	226
C18	LT	Printing and reproduction of recorded media	0.0	0.0	0.0	243	244	238	244	23	23	216	136	195
C19	MLT	Manufacture of coke and refined petroleum products	0.1	0.1	0.0	88	91	90	91	1,039	1,084	13,766	327	58
C20	MHT	Manufacture of chemicals and chemical products	0.4	0.3	0.6	1,970	2,013	1,967	2,013	196	150	1,081	319	944
C21	HT	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.3	0.2	0.4	530	549	542	549	575	440	1,195	666	265
C22	MLT	Manufacture of rubber and plastic products	0.1	0.1	0.5	1,505	1,529	1,497	1,530	69	65	311	310	977
C23	MLT	Manufacture of other non-metallic mineral products	0.1	0.1	0.3	901	907	892	908	116	77	312	302	549
C24	MLT	Manufacture of basic metals	0.2	0.2	0.5	551	558	547	559	291	291	696	851	380
C25	MLT	Manufacture of fabricated metal products, except machinery and equipment	0.1	0.1	0.4	1,678	1,706	1,668	1,706	57	46	315	241	1,234
C26	HT	Manufacture of computer, electronic and optical products	0.6	0.8	2.9	2,082	2,148	2,104	2,148	292	384	3,661	1,391	1,181
C27	MHT	Manufacture of electrical equipment	0.1	0.2	0.7	1,207	1,248	1,213	1,248	123	135	382	571	713
C28	MHT	Manufacture of machinery and equipment n.e.c.	0.2	0.2	0.8	2,498	2,543	2,485	2,544	94	93	516	309	1,409
C29	MHT	Manufacture of motor vehicles, trailers and semi-trailers	0.3	0.5	1.2	1,577	1,623	1,588	1,623	194	288	735	756	652
C30	MHT	Manufacture of other transport equipment	0.1	0.0	0.2	379	383	376	383	190	124	632	479	255
C31	LT	Manufacture of furniture	0.0	0.0	0.1	251	255	247	255	23	25	189	243	219
C32	LT	Other manufacturing	0.1	0.1	0.3	913	936	912	936	84	81	644	343	689

IMPRESSUM

Herausgeber, Verleger, Eigentümer und Hersteller:
Verein „Wiener Institut für Internationale Wirtschaftsvergleiche“ (wiiw),
Wien 6, Rahlgasse 3

ZVR-Zahl: 329995655

Postanschrift: A 1060 Wien, Rahlgasse 3, Tel: [+431] 533 66 10, Telefax: [+431] 533 66 10 50
Internet Homepage: www.wiiw.ac.at

Nachdruck nur auszugsweise und mit genauer Quellenangabe gestattet.

Offenlegung nach § 25 Mediengesetz: Medieninhaber (Verleger): Verein "Wiener Institut für Internationale Wirtschaftsvergleiche", A 1060 Wien, Rahlgasse 3. Vereinszweck: Analyse der wirtschaftlichen Entwicklung der zentral- und osteuropäischen Länder sowie anderer Transformationswirtschaften sowohl mittels empirischer als auch theoretischer Studien und ihre Veröffentlichung; Erbringung von Beratungsleistungen für Regierungs- und Verwaltungsstellen, Firmen und Institutionen.

wiiw

wiiw.ac.at

https://wiiw.ac.at/p-6732.html